Snow Snakes and Science Agency: Empowering American Indian Students through a Culturally-Based Science, Technology, Engineering, and Mathematics (STEM) Curriculum

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Dedication

This dissertation is dedicated to my wife Stacy who has been my most ardent supporter on this journey.

Abstract

Mainstream curricula have struggled to provide American Indian students with meaningful learning experiences. This research project studied a novel approach to engaging students with science, technology, engineering, and mathematics (STEM) content through a culturally-based context. The traditional American Indian game of Snow Snakes (shushumeg in Ojibwe) presented a highly engaging context for delivering STEM content. Through the engaging context of snow snakes, the designed STEM curriculum explicitly applied mathematics (scaling and data), and science (force and motion) to an engineering prototype iteration that used available materials and tools (technology) for success. It was hypothesized that by engaging students through the carefully integrated STEM curriculum, driven by the culturally based context of snow snakes, students would exhibit an increase in science agency and achievement. The overarching research question explored for this study was: *How does a culturally-based and integrated STEM curriculum impact student's science agency*? Associated sub-questions were: 1) *What does science agency look like for 6th grade students*? 2) *What key experiences are involved in the development of science agency through a culturally-based STEM curriculum context*? And 3) *What* a*re the impacts on the community associated with the implementation of a culturally-based STEM curriculum*?

A case study research design was implemented for this research. Yin (2003) defines a case study as investigating a phenomenon (e.g. science agency) which occurs within authentic contexts (e.g. snow snakes, Adventure Learning, and Eagle Soaring School) especially when the boundaries between phenomenon and context are unclear.

For this case study Eagle Soaring School acted as the bounded case with students from the 6th grade class representing the embedded units. Science agency was the theoretical framework for data analysis. Major findings were categorized as science and STEM learning, agency, and community impact. Concerning agency, students displayed science agency through: connecting snow snake experiences to outside contexts; students emerging as leaders; and students commanding a facility with science. This research lays the foundation for future inquiry into the development of science agency in students using culturally-based contexts.

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CHAPTER ONE: INTRODUCTION

Rationale

The purpose of this study was to understand the experiences of Ojibwe upper elementary school students with a culturally-based and integrated science, technology, engineering, and mathematics (STEM) curriculum and its impacts on students' science agency and the community. The focus on science agency was twofold. First, the identification of agency in students was deemed an important indicator of future engagement and achievement in students. And second, there exists a void in the literature on the topic, regardless of setting. Another impetus for this study can be defined as cultural. The game of snow snakes has not been played for nearly 100 years in the region that the curriculum and activities were implemented. Ergo, there is a very real possibility for a rejuvenation of the traditional American Indian game for the benefit of both students and communities.

According to Lee and Luykx (2006), culturally relevant instruction, curriculum, and science are made possible when careful consideration is given to relevant and meaningful contexts within culture, language, and cognition. When a subject like science, which has heretofore been promoted through a Western academic paradigm, is connected to students' familiar culture, language, and ways of knowing, they more easily engage with the content. The content that is delivered is then more easily integrated into paradigms common and familiar to students.

Using culturally-based and relevant contexts to promote science learning may not only be a fruitful route for American Indian students, it could also be a meaningful route

by which U.S. science reform initiatives may be met for all students (Kawagley & Barnhardt, 1999; Kawagley, Norris-Tull, & Norris-Tull, 1998). Given the charge that all students should be able to learn science through meaningful contexts (American Association for the Advancement of Science, 1989), utilizing places and objects of import for students is a logical starting point.

Science, technology, engineering, and mathematics (STEM) as an integrated construct and an indigenous way of knowing have similar foundational paradigms. For example, STEM stands on the foundation that a problem can be solved in unique and meaningful ways by utilizing the knowledge sources associated with the STEM disciplines collectively. Generally speaking, an indigenous way of knowing is inherently integrative and holistic (Barnhardt & Kawagley, 2005; Cajete, 2005, 2008). Although there are a myriad of subtle and not so subtle differences among American Indian peoples, this study hypothesizes that the seemingly similar epistemological grounds of STEM and an indigenous way of knowing will provide a compelling model of culturally-based STEM education.

This study has potential significance for a variety of fields. First, regarding culturally relevant pedagogy and science education, having a working understanding of what science agency is will provide a foundation for future studies around this important paradigm. Secondly, STEM education as an integrated approach within K-12 academic structures is just now emerging. Also, light will be shed on potentially fruitful directions for implementing STEM content with culturally-based and relevant contexts by providing research outcomes associated with an explicitly integrated STEM education curriculum.

Statement of Problem

Historically American Indian populations have struggled academically within a predominantly Western education system (Baker, 2003; McKinley, 2007); this is also true in Minnesota (Graves & Ebbott, 2006) and particularly the White Earth Indian Reservation. In a 2007 study of American Indian/Alaska Native (AI/AN) 4th and 8th grade reading and mathematics abilities, AI/AN students scored lower than non-AI/AN students (Moran, Rampey, Dion, & Donahue, 2008). Along with academic achievement struggles, opportunities to learn are often limited among reservation communities in part due to a lack of resources in reservation schools and the need for curricular innovations that connect content knowledge to students' experiences and identities.

There are a number of issues or problems that this study attempts to address. The overarching problem has to do with American Indian student engagement and consequent achievement in schools which operate through a Western philosophical design. There is also a concern for the success of American Indian students in STEM fields. The current educational paradigms do not necessarily mobilize pedagogies that support the aforementioned success (Kawagley & Barnhardt, 1999). From these problems the study delves into more specific issues related to context and content. For example, we need to better understand how culturally-based contexts can be used to teach common content such as science and mathematics.

Research on student agency in STEM fields is very limited. Turner's (2003) dissertation looking at critical mathematical agency serves as a powerful entry point for agentive inquiry. Building upon Turner's work, Basu, Barton, Clairmont, and Locke

(2009) shift the paradigm to accommodate a critical science agency lens. Basu et al. found an increase in individual student's critical science agency after success in a conceptual physics class. The Basu et al. study does not explore how culturally based contexts affect science agency. Beyond these two studies there is a dearth of literature on the topic. There is no work looking at the science agency of American Indian youth. Therefore this study will contribute to filling a very important gap as it currently stands in the relevant literature.

Little is known about the practicalities of K-12 integrated STEM education. Much has been said recently about the importance of science, technology, engineering, and mathematics in K-12 education (Kuenzi, Matthews & Mangan, 2006; National Academies, 2006; National Governors Association, 2007; Sanders, 2009). There are a variety of reasons for integrating STEM, and engineering in particular, in more meaningful ways into the K-12 classroom. Some of the reasons offered include: potential for improved student learning and achievement; an increase in awareness and interest in engineering; and an increase in literacy around technology (Katehi, Pearson, & Feder, 2009).

One of the ways in which STEM has been discussed is to highlight the natural connections between STEM disciplines (Katehi, Pearson, & Feder, 2009). Through the use of engineering concepts, STEM disciplines can be showcased for authentic content explorations. The current structure of schools do not allow for these connections to be made easily. Schools have traditionally "siloed" topical areas and taught subjects such as science and mathematics in isolation without drawing upon the organic connections

between the two, as well as with engineering and technology principles. The increased visibility of technology stands to be an extremely important avenue by which to explore the interconnectedness of STEM disciplines (Katehi, Pearson, & Feder, 2009).

For the purposes of this research, STEM is posited as a unification of science, technology, engineering and mathematics. The snow snake curriculum purposely used a STEM focus because of the associated underlying philosophy. According to Katehi, Pearson, and Feder (2009), STEM has emerged as an important curricular approach given the current rapidity of change in global spaces. Students will need to address a multitude of new problems and situations; therefore having the ability to create new products and skills through a STEM approach is paramount. A shift towards a more integrative approach to traditional academic disciplines consistent with STEM philosophies may be fortuitous when considering a culturally-based curricular approach. STEM accordingly could be considered more consistent with an indigenous way of knowing, in other words, STEM could be more consistent and subsequently more accessible to students that have a world view consistent with a traditional ecological knowledge (Snively & Corsiglia, 2001).

The negotiation of culturally-based contexts for traditional K-12 school spaces has also posed complications (Lipka, Mohatt, & The Ciulistet Group, 1998). For example, the colonial nature of existing school structures does not readily make spaces for the exploration of culture. By melding STEM integration philosophies with culturally-based contexts it is hypothesized that powerful learning experiences and outcomes can be realized for students. Local settings and cultures have the potential to provide meaningful

contexts for students to engage with content (e.g. STEM, Literacy, Social Studies, etc.). By looking at one context and one location in particular, conclusions can be drawn that have implications beyond this specific study. For these reasons, the study looks at the impacts of a culturally-based and integrated STEM curriculum upon students' science agency to answer the following question and associated sub-questions: How does a culturally-based and integrated STEM curriculum impact student's science agency?

1) What does science agency look like for 6th grade students?
2) What key experiences are involved in the development of science agency through a culturally-based STEM curriculum context?
3) Are there impacts on the community associated with the implementation of a culturally-based STEM curriculum?

Overview of Following Chapters

The remaining chapters will begin with an in-depth look at the relevant literature. This will be followed by setting the stage for the study in the form of research design and methods followed by a chapter describing the relevant contexts associated with curriculum development and implementation. The findings of this study and related analysis will command a separate chapter; and the final chapter will wrap up by discussing the research questions and the implications therein.

Beginning with chapter two, appropriate literature will be explored. Presented first will be literature that supports the theoretical framework of agency through the lenses of critical theory, personality development, and Bandura's social cognitive theory (2001). The following section will look at American Indian student achievement and

contexts. An overview of the historical structures that have led to achievement struggles as well as activities that have attempted to curb the trend such as culturally responsive schooling approaches will be taken into account. Literature building a foundation for the discussion of STEM integration will also be included. Agency literature specific to science and mathematics research will come next and will lay the foundation for later discussions and representations of agency. A word of caution will conclude and balance the literature review.

In chapter three the research design and methods will be presented. Beginning with the context of the study, an explanation of the Reach For The Sky program historically through to the delivery of the curriculum associated with this study will be shared. Once this information is in place an explanation of the research design and methods including data collection, data analysis, and validity will be discussed. The background of the researcher will be highlighted including involvement with the RFTS program, and previous academic and professional experiences. The chapter will conclude with a presentation of the limitations associated with the study as recognized by the researcher.

In chapter four the case of Eagle Soaring School will be developed. To do this, the contexts of the case and curriculum will be presented for the purposes of defining the case of Eagle Soaring School for this study. From an overarching to a more fine grained lens, the case will be presented as follows: The physical site of Eagle Soaring School and the figured world therein, the curricular attention given to science at Eagle Soaring School, historical snow snake experiences at Eagle Soaring School and the greater White

Earth community, and a overview of the curriculum as developed through an Adventure Learning framework. The curriculum explanation and how it was used comes from the teachers' perspectives within the bound case. Curricular extensions will also be included.

Chapter five will encompass the findings of the study. The impacts of the snow snake curriculum as they emerged from the data will be showcased in three sections: Science and STEM learning, agency, and community impact. Within each section relevant data will be presented as it was naturalistically coded for the purposes of answering the research questions. Each section has varied and nuanced sub-categories that highlight the complex nature of the data for this study.

Finally, in chapter six a discussion around the major findings of the study will take place, with explicit connections being drawn between the data and the originally stated research questions. There will also be discussion around the implications that emerged. The chapter will begin with a review of the study purpose, followed by a restating and answering of research questions. The remainder of the thesis document will discuss suggestions for future research, and draw appropriate conclusions.

CHAPTER TWO: REVIEW OF THE LITERATURE

This research was the result of a highly coordinated effort that included the construction and implementation of a culturally-based and integrated STEM curriculum. Interest existed in understanding the development of science agency in American Indian students as it related to culturally-based curricular experiences. The overarching research question associated with this study was: How does a culturally-based and integrated STEM curriculum impact a student's science agency? This chapter will review the literature that informed the research questions posed for this study. To do this, an in-depth look will be taken of the agency literature from multiple perspectives including: critical theory, personality development, and Bandura's social cognitive theory (2001). This look into agency literature will provide the working theoretical framework on which this study is based.

Building on the theoretical foundation of agency, the literature review will then look at research that connects American Indian youth and science education in K-12 settings. This will be done by considering historical and contemporary academic achievement of American Indian students. A brief foray will then be taken into foundational literature associated with culturally-based curricular implementations, specifically those that promote culturally-based pedagogies for American Indian youth. STEM as an integrated construct will be explored for its relevance both to this study and American Indians in particular.

Although interdisciplinary, integrated STEM education and its enactment in K-12 classrooms is just emerging in the literature, it will be important to look at what has been

done and how scholars are operationalizing STEM. At this point in the literature review, agency will be revisited, but this time with an explicit focus on STEM. The literature review will conclude with a word of caution concerning the use of culturally-based contexts and the implications that can result when an overemphasis is placed on culture that may lead to undesirable outcomes.

Theoretical Framework

At a very basic level, "agency" can be defined as "the state of being in action or of exerting power" (Agency, 2009). Agency as it relates to science agency can be explained as how a student leverages the discipline of science to affect change in his/her personal world. Exploring work done in a similar vein in other fields, in this case mathematics, will shed further light on the possibilities of science agency. According to Turner and Font (2003), critical mathematics agency can be defined as:

> Viewing the world with a critical mindset and engaging in action aimed at personal and social transformation through developing deep and rigorous understandings in mathematics, through participation in a novel mathematics program focused both on standards and on real world concerns (Basu et al., 2009, p. 356).

Inden (1990) further defines agency as:

> The realized capacity of people to act upon their world and not only to know about or give personal or intersubjective significance to it. That capacity is the power of people to act purposively and reflectively, in more or less complex

> interrelationships with one another, to reiterate and remake the world in which they live. (p. 23)

An important point to make regarding agency, especially when talking about science agency in students, is that agency can be expressed towards one subject clearly and be completely absent from other aspects of a student's life. In other words, a student may express a strong sense of science agency within the context of the school setting and also assume a very passive, powerless stance in other settings and subjects (Holland, Lachicotte, Skinner, & Cain, 1998). Content specific agentic literature will be revisited in later sections of this literature review. But first, the construct of "agency" will be framed and grounded based on critical and psychological theory.

Agency

Critical theory

A succinct definition of critical theory has been elusive. This is partly due to the foundational precepts of critical theory that avoid specificity, are dynamic in nature, and the multiplicity of critical theories in existence (Kincheloe & McLaren, 2005). To situate this study, the definition of critical pedagogy offered by Denzin and Lincoln (2008) will be considered, it states: "To performatively disrupt and deconstruct these cultural practices in the name of a more just, democratic and egalitarian society" (p. 8). From this definition the aspects associated with supporting students to act in meaningful ways that move toward equality are of most interest, especially those that deal with identity and action.

Many scholars credit Paulo Freire with the pedagogical foundations that support agentic actions in the classroom. Freirean pedagogical theory supports the development of "academic competencies, critical awareness, analytical skills and agency" (Pruyn, 1999, p. 6). Although Freire and other "critical" scholars such as Apple (1982), Giroux (1984), and McLaren (1994), have done much to advance our understanding of agency, it has been done under the auspices of a "critical" paradigm. For the purposes of this study it will be important to gain a clear understanding of agency, but without the consideration of an explicit "critical" paradigm. To do this, literature as it pertains to agency in accordance with the purposes of this study will be considered. Critical agency literature will be considered inasmuch as it provides the foundational information needed for this study. A full inclusion of "critical" literature would confound the goals and objectives of this study beyond the originally intended purposes.

Marc Pruyn, in his text *Discourse Wars in Gotham-West: A Latino Immigrant Urban Tale of Resistance and Agency* (1999) surveys the field of critical, poststructural and postmodern theory to provide a balanced look of the theoretical underpinnings behind agency. Although the ways in which Pruyn uses the literature to support the use of agency ultimately seek ends different from this study, there is value in considering some of the things he has to say on the subject.

Early on in the Pruyn text he states that agency can be defined as "purposeful action taken by a student" (Pruyn, 1999, p. 15). Although this definition is simple, it provides a starting point for further inquiry into the forces that affect a student's ability to take action. One of the scholars that Pruyn relies heavily on for his conceptualization of

agency is Gramsci and his famous *Selections from the Prison Notebooks* (1971). In this text, Gramsci posits hegemony as a primary force that dictates an individual or groups ability to act agentically. Therefore counter-hegemonic efforts provide the impetus for agentic acts by individuals or groups that represent resistance and subsequent action that is purposeful. Pruyn explains that a look into Gramscian theorizing around hegemony and counter-hegemony is important to the modern debate around agency. I would agree that Gramsci has provided important insight into agency through his early theorizing but I would limit the influence of Gramscian perspective just short of resistance.

I draw from Gramsci's notion of what learning means to individuals who are marginalized economically, culturally, politically, and linguistically. Gramsci advocates for education that engenders critical thinking capabilities in individuals from marginalized groups. He further posits that education of the critical kind empowers marginalized individuals to use their intellectual abilities to better themselves or the group that they are associated with through economic gain, political position, and participation in intellectual activities that benefit them. Therefore in this study I find Gramsci's idea of education helpful in explaining why American Indian students' participation in an integrated STEM curriculum is a way to develop critical thinking skills with application to their own cultural knowledge in the context of non-Native STEM knowledge. Assuredly there are hegemonic structures influencing student actions in this study such as the authority of non-Native teachers and administrators along with a Western education structure. Therefore the resistance associated with agentic actions is sound in so far as it positions students to affect change in their individual life. The scope

of this study is not interested in looking at resistance but to look at agency as a generative disposition that has positive effects on identity and consequently, future actions.

Gramsci is considered one of the early critical theorizers who mobilized agency in important ways for future research and action. From Gramsci's work, Pruyn (1999) elaborates on his original simplistic conception of agency:

> I define it here as purposeful action taken by an individual, or group of individuals, in order to bring about change. Understood from a Gramscian perspective, agency could be seen as purposeful action taken by an individual, or group of individuals, to facilitate the creation of counter-hegemonic practices and institutions. Even more specifically, I will use the term "critical student agency" to refer to purposeful action taken by a student, or group of students, to facilitate the creation of counter-hegemonic pedagogical practices. (p. 20)

For this study, counter-hegemonic practices were not of interest. This study was interested in the development of science agency in students for the purpose of taking action that calls upon a content understanding in STEM as an integrated construct. The actions a student takes as a result of experiencing the curriculum in this study are not counter-hegemonic in the sense Gramsci and Pruyn articulate. The actions of interest demonstrate a facility with STEM content that have implications for future engagement and achievement in traditional academic structures and beyond. For example, students, through their understanding of the interconnectedness of the STEM disciplines will more easily make connections between school/home contexts with ways in which STEM content can be used to gain meaning and potentially solve problems.

A brief foray into critical pedagogy presents further understanding associated with agency development. Paulo Freire is considered the most influential critical education proponent worldwide (Pruyn, 1999). His landmark text *Pedagogy of the Oppressed* (1970) has influenced countless critical theorists. There are aspects of Freirian pedagogy that are important to understanding agency as it is conceptualized for this study and there are aspects that are not. Concerning the latter, Freirean pedagogy seeks to liberate students from oppressive realities (Freire, 1970). Although there are assuredly oppressive realities at play in individual student lives, the implementation of the culturally-based STEM curriculum for this study did not seek the elimination of oppression in an explicit way. What is more helpful to this study is the Freirean pedagogical goals of "the development within students of attitudes and capacities to view themselves as capable of taking action on their world in order to change it, and the enhancement of student "literacies" and "academic achievement"" (Pruyn, 1999, p. 29). Through experiencing a culturally-based STEM curriculum this study hypothesizes that students will develop attitudes and capacities that mobilize STEM content in ways that not only increase academic achievement but also affect positive changes in a student's individual life.

Psychological theory

Psychological theory in general is a vast field that encompasses a myriad of lenses that can be placed on the human experience. Taking a closer look at what select psychological theorists have to say about agency will be helpful to the conceptualization of agency for this study. The two primary lenses by which agency will be considered

within psychological theory are that of social cognitive theory offered by Bandura (2001); and claims within the field of personality development.

By no means will this foray into psychological theory literature be exhaustive, but it is important to get a sense of how scholars in these fields conceptualize agency. Bandura (2001) begins his text on an agentic perspective with the offering: “To be an agent is to intentionally make things happen by one’s actions” (p. 2). In terms of cognitive development literature, agency is defined as “the ability to select and take actions toward goals of a person’s own choosing” (Walls & Kollat, 2006, p. 232). This sentiment is furthered by the fundamental assumption that “humans are the “authors” and active contributors to their behavior and development” (Little, Snyder, & Wehmeyer, 2006, p. 61). Each of these comments on the nature of agency places the individual in control of their ability to affect change and be proactive in their life.

This view of agency is simplistic and deserves a deeper look into its complexities. In reality those factors contributing to an individual’s sense of agency on a topic are complex. Little et al. (2006) comments that “different individuals with differing experiences and differing predispositions….will yield varying profiles of hope because the sense of agency is a multifaceted and striated system of needs, motives, goals, beliefs, and behaviors” (p. 63). Therefore, because of this complexity, individuals can either act agentically or not due to the interplay of forces that support a sense of self, the agentic self. Thus, individuals can be classified as agentic or non-agentic and the resultant behaviors support these dispositions. For example an agentic individual is characterized by positive dispositions and resilience in situations where a setback has been dealt.

Agentic individuals also believe that they can affect change in their lives through their actions. Non-agentic individuals tend to display apathetic and cynical dispositions that place outcomes in the hands of powers beyond their control. The disposition displayed by individuals can therefore dictate future achievement or lack thereof (Little et al., 2006).

Bandura (2001) conceptualized personal agency into four core features that attempt to reveal the qualities of humanness. These four core features are: intentionality, forethought, self-reactiveness, and self-reflectiveness. Similar to what has already been discussed concerning human or personal agency, Bandura's (2001) conceptualization engages a dynamic human experience where individuals shape and are shaped by environmental stimuli. The human experience is not just reactive but also proactive towards the environment in which an individual exists. The four core features of personal agency "address the issue of what it means to be human" (Bandura, 2001, p. 6) and below I will discuss each as it relates to this study.

Intentionality. To be intentional is to project a future course of action on a matter for personal or group outcomes. "Agency refers to acts done intentionally" (Bandura, 2001, p. 6). Intentionality is not just action that hopes for a desired outcome, but it is a calculated course of action that seeks to gain specific ends. In the case of snow snakes, students displaying agentic dispositions take actions that will put them in a position to be successful in specific tasks associated with the culturally-based STEM curriculum. For example, students might act intentionally towards the engineering design activities to ensure that their snow snake prototype has characteristics, derived from a scientific understanding, which will prove successful during testing. Intentionality is a key feature

of personal agency because it displays the ability of an individual to take action for a purpose significant to them (Bandura, 2001).

Forethought. Forethought is an exercise that motivates and guides actions towards future ends (Bandura, 2001).The snow snake curriculum was delivered with an understanding that a culminating event would take place at the end of all activities. This culminating event, the snow snake festival, acted as a motivator for students to not only act intentionally towards ends that would make them successful in the event, but it also called upon forethought as conceptualized by Bandura (2001). With the snow snake festival as an understood and desired future event, forethought is engaged as "anticipatory self-guidance, behavior is motivated and directed by projected goals and anticipated outcomes rather than being pulled by an unrealized future state" (Bandura, 2001, p. 7). The snow snake festival, and to a lesser extent the testing of snow snake prototypes, provide the motivation to engage in curricular activities that promote forethought. Without these motivating activities/events prescribed as part of the snow snake curriculum a student's ability to engage foresight towards future ends would be difficult.

Self-Reactiveness. With intentionality and forethought in place, agentic actions also require self-reactiveness on the part of an individual to secure desired outcomes. A connection needs to be made between the thoughts associated with intentionality and forethought to actions that are deliberately undertaken. A self-reactiveness motivates and regulates a course of action that when executed will bring the agent the outcomes desired (Bandura, 2001). The snow snake curriculum supports students in self-reactiveness

through scaffolding experiences. Scaffolds are support mechanisms that are designed in such a way that students, although agents of their own actions, are supported to act purposefully towards the goals of the curriculum that are of interest. This is done in the snow snake curriculum through mechanisms such as the prototype design iteration and the collection of traditional ecological knowledge around snow snakes that provide self-satisfaction, pride and self-worth (Bandura, 2001).

Self-Reflectiveness. Bandura's (2001) fourth core feature of personal agency is self-reflectiveness. Concerning self-reflectiveness Bandura states that "people are not only agents of action but self-examiners of their own functioning" (p. 10). To be self-reflective is to engage the capability of metacognition, essentially thinking about the thoughts one has engaged for the purposes of taking action. It is here that Bandura presents the roll of efficacy in an individual to conduct agentic actions. Efficacy is defined as the "capacity for producing a desired result or effect" (Efficacy, 2010). Little, Snyder, and Wehmeyer (2006) offer that efficacy can be looked at as an organizing construct of agency and not a confounding paradigm. Self-reflectiveness and efficacy are closely linked and provide the foundation for a student's beliefs around being able to be successful in a task. According to Bandura, "efficacy beliefs are the foundation of human agency" (p. 10). Therefore, through snow snake curricular scaffolds, students build capabilities that increase their efficacy towards being successful in the formative (e.g. prototype activities building efficacy towards full scale snow snake construction) and summative activities (e.g. the snow snake festival). Efficacy development and agentic action may not happen equally for all students. Depending on the interplay of the core

features of personal agency as offered by Bandura, students will either emerge with strong agentic inclinations or align with a more non-agentic individualism (Little et al., 2006).

Through this brief look into the psychology literature informing agency development, a closer look has been taken of the foundational paradigms motivating agentic behavior in students. Behavior occurs within socially constructed environments or worlds. To ascertain what agency is for students associated with this study it will be important to gain a sense of how the figured world in which a student lives affects their ability to act agentically.

Figured Worlds

Agency and the figured worlds in which students exist are of interest to this study in lieu of standard achievement constructs. This study hypothesizes that student science agency and the figured worlds in which agency is enacted will provide a more foundational indicator of why students do or do not engage and consequently achieve in classroom settings. Therefore, along with the foundational precepts of personal agency discussed in the previous section, the role of the figured world in the development of personal agency will be discussed. It will be important to consider the figured world in the development of science agency in students within the bounded case of this study.

In an attempt to clearly set the stage for what a figured world means, and excerpt from Holland, Lachicotte Jr., Skinner, and Cain (1998) will be shared where they use a context familiar to individuals reading this study, that of academia.

> What if there were a world called academia, where books were so significant that people would sit for hours on end, away from friends and family, writing them? People have the propensity to be drawn to, recruited for, and formed in these worlds, and to become active in and passionate about them. People's identities and agency are formed dialectically and dialogically in these "as if" worlds. (p. 49)

When academia is described as a figured world, expressed through an objective lens, the reality of how academicians are shaped comes into focus. Similarly, the figured worlds of K-12 institutions and the micro-cultures therein shape individual students.

To operationalize a figured world for use in this study we will again call upon Holland et al. (1998) for their succinct definition. A figured world is therefore "a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (Holland et al., 1998, p. 52). For this study, the bounded case represents a figured world and can be articulated through text associated with Holland et al. (1998) as follows: "The figured world of [Eagle Soaring School] acquired motivating force as the students developed mastery of it, and their mastery, in turn depended upon their development of a concept of themselves as actors in the world of [Eagle Soaring School]" (p. 99). Although the bounded case of Eagle Soaring School represents the figured world in operation for this study, it is the influence of the historical implications of snow snakes in addition to the micro-cultural mediators (e.g. student/teacher dynamics

and a school's philosophical underpinnings) that influence the actors in this particular figured world.

As could be expected, figured worlds are complex social constructs that are influenced by a myriad of factors. Holland et al. (1998) provides some key points to understanding the development of figured worlds that will be articulated in relation to the figured world associated with the bounded case of this study. There are four points that are made when articulating the essence of figured worlds. Each point is derived from the understanding that

> persons develop more or less conscious conceptions of themselves as actors in socially and culturally constructed worlds, and these senses of themselves, these identities…The identities that concern us are ones that trace our participation, especially our agency, in socially produced, culturally constructed activities – what we call figured worlds… (Holland et al., 1998, p. 40)

The first point building from the above understanding of figured world development is that figured worlds are "develop[ed] through the works of their participants" (Holland et al., 1998, p. 41). The historical association of Eagle Soaring School with the game of snow snakes and the culturally-based STEM curriculum are important factors. When considering the "works of participants" it is important to recognize that students at Eagle Soaring School competed in historical (previous) snow snake festival competitions and were successful in doing so (1st and 2nd places). This prior success acted as a point of pride, an important factor in the figured world of Eagle Soaring School and the behaviors of the participants therein.

The second point is that “participants’ positions matter” (Holland et al., 1998, p. 41). If participants in the figured world of Eagle Soaring School had only competed in historical snow snake activities and did not experience the success that they did, the overall figured world and the identity development and expectation of success would have been much different as it unfolded in this study. For example, because Eagle Soaring School was the school where the defending snow snake champion and runner-up attended, their presence in classrooms and the value placed on that success by peers and school staff created a point of pride and determination towards future snow snake competitions. The point in time for this study is also of note because before students experienced success, the figured world of Eagle Soaring School was very different.

The third point is that figured worlds are “socially organized and reproduced” (Holland et al., 1998, p. 41). As participants experience success they are positioned socially and therefore act in ways that seek to reproduce successful outcomes. In the case of Eagle Soaring School the social interplay of the participants sought to not only reproduce success at a macro level (school winning the travelling snow snake trophy) but also the micro level (individual champions and podium finishes).

The fourth point is that figured worlds give “the landscape human voice and tone” (Holland et al., 1998, p. 41). With this conception of the figured world, it is not only a physical place but also the dynamic social construction that mediates behavior of participants and gives each individual an implicit or explicit role. In the case of Eagle Soaring School, the voice and tone of the landscape predicts success towards snow snake activities and gives students positions as knowledge keepers for this cultural practice.

In further support of this notion of figured worlds, Jackson (2003) provides insight into how identity-sensitive education can promote the development of figured worlds that support student engagement and learning. An identity-sensitive education takes into account the lived experiences students bring to a classroom setting (Jackson, 2003). In this way students that have struggled to reconcile their culture with the paradigms associate with a K-12 education are able to more fully engage with the learning process. Jackson explains that by taking into consideration a student's identity, typical pedagogical structures can still be pursued. There are three models that support identity-sensitive education. For the purpose of this study the third model, "the small school, intellectual hothouse" (p. 583), is recognized as consistent with aforementioned figured world conceptualization. Jackson explains the intellectual hothouse as promoting "a distinctive scholarly image and a sheltered environment in which intense teacher/student relationships can be built around a shared academic focus" (p. 583). In the case of Eagle Soaring School the academic focus is the STEM content associated with the snow snake curriculum. Through the intellectual hothouse/figured world at Eagle Soaring School that has grown out of historical snow snake experience and success, the case study site has emerged as the "place to be' in the social map of student peer cultures" (Jackson, 2003, p. 583).

Student agency and figured worlds are important foundational concepts for this study. With this theoretical framework in place, we can now look at details specific to the contexts of this study and the literature that will assist in understanding historical educational paradigms and the resultant achievement of American Indian students.

American Indian Student Achievement and Contexts

Historically American Indian populations have struggled academically within a predominantly Western Eurocentric education system (Baker, 2003; McKinley, 2007); this is especially true in Minnesota (Graves & Ebbott, 2006), and particularly the White Earth reservation. Unfortunately the current education model has failed to incorporate knowledge fundamental to American Indian being and understanding (Cajete, 1994, 1999). As one result of this situation, American Indian students have experienced a disproportionately large dropout rate in high school, and subsequent low enrollment into college due to poor academic performance (Hill, 1991; Nelson-Barber & Estrin, 1995). In addition, American Indian/Alaska Native students are two and three times as likely to score at the lowest level of literacy and mathematics assessments respectively than White peers on National Assessment of Educational Progress (NAEP) assessments (Freeman & Fox, 2005).

The No Child Left Behind (NCLB) act has also factored into the achievement of American Indian students. NCLB has heightened the atmosphere around standardized testing therefore placing additional pressures on schools and teachers to focus on math and reading through curricular structures aligning with basal readers and rote memorization, effectively limiting the ability to develop and implement culturally-based curricula for the students that need it most (Castagno & Brayboy, 2008). In addition, “the values, ideas, and priorities embedded in NCLB are not necessarily shared within tribal nations and Indigenous communities” (Brayboy & Castagno, 2009, p. 34). For example, standardized testing that isolates content into decontextualized categories and is

associated with a high stakes environment make education something very different from an environment that fosters and celebrates culture and place. Consequently, there is concern that efforts made through the development and implementation of culturally-based curricula will be endangered through the high stakes environment produced by NCLB and the necessity of schools to make adequate yearly progress (Brayboy & Castagno, 2009).

For a final brush stroke on the picture of American Indian student achievement we look to a report by the U.S. Commission on Civil Rights (2003). In this report the plight of American Indian students is described.

> As a group, Native American students are not afforded educational opportunities equal to other American students. They routinely face deteriorating school facilities, underpaid teachers, weak curricula, discriminatory treatment, and outdated learning tools. In addition, the cultural histories and practices of Native students are rarely incorporated in the learning environment. As a result, achievement gaps persist with Native American students scoring lower than any other racial/ethnic group in basic levels of reading, math, and history. Native American students are also less likely to graduate from high school and more likely to drop out in earlier grades. (p. xi)

To adequately meet the educational needs of American Indian youth, Cajete (1994) noted a complete and thorough restructuring is needed. This would require an indigenization of the current K-12 educational paradigm as it relates to American Indian students (Deloria & Wildcat, 2001). Deloria (1992) succinctly explained indigenous

knowledge as revolving around the idea that everything is interconnected. Cajete (2005) further explained this sentiment by recalling the Lakota phrase, *Mitakuye Oyasin* (we are all related), which conveys that American Indian peoples look at the world as fundamentally interrelated. This holistic and interrelated approach to knowing stems from intimate interactions with the world for the purposes of survival (Cajete, 1994, 1999). Consequently, this same view is equally related to American Indian students' approaches and perceptions of education. Traditionally, American Indian education is informal and holistic, taking into account all aspects of everyday life. Education then becomes "education for life's sake" (Cajete, 2005, p. 70) where the approach to, and the components of education play seamlessly into how a student interacts with the various facets of life. According to Deloria and Wildcat (2001), it is the holistic nature of an American Indian world view that was labeled as "savage superstition" (p. 1) by Western authorities in favor of individual subject areas. Thus, there have been challenges when American Indian students are forced to make a decision between their culture and Western educational structures.

Culturally-Based STEM Curriculum

Culturally-Based

It will be important to keep in mind the fundamental epistemological views that American Indian peoples have as discussed in the previous section. It stands to reason that a careful look at American Indian epistemologies would garner fruitful curricular development considerations. Much has been said about culturally-relevant learning experiences for American Indian youth (Castagno & Brayboy, 2008). To begin, a

consideration of the terms frequently used when discussing this type of educational approach needs to be made. A distinction will be made between what it means for something to be culturally-based as well as what it means for something to be culturally-relevant in the context of this study. Castagno and Brayboy (2008) surveyed the literature on what they term *culturally responsive schooling* or CRS. Within their literature review they comment on the multiple ways CRS has been operationalized. For example, culturally responsive, culturally relevant, culture-based, and multicultural education all refer to efforts to make schooling more applicable to the lived experience of students (Castagno & Brayboy, 2008). For this research a distinction will be made between culturally-based and culturally-relevant. Snow snakes is the cultural context by which the STEM content was delivered for this study. The use of snow snakes was based on cultural understandings and the expressed needs of the community. This does not reflect the students experiencing the curriculum in any way. The context of snow snakes is culturally-based regardless of a student's background even if their background was other than that of an American Indian cultural paradigm. Concerning cultural-relevance, for something to be culturally relevant for a student it needs to align with the cultural paradigms that resonate with them. Snow snakes for this study was both culturally-based and culturally-relevant because all of the students experiencing the curriculum were from an Ojibwe cultural paradigm. To stay consistent throughout this thesis, the phrase *culturally-based* will be used because it makes the most sense to how the snow snake context was used for curriculum development. To gain a depth of understanding about

this idea of culturally-responsive schooling it will be necessary to delve into the literature further.

The idea of integrating culture into traditional Western educational practices is not a new idea (Castagno & Brayboy, 2008). There have been calls to do so ever since the *Meriam Report* of 1928 (Meriam, Brown, Cloud, Dale, Duke, Edwards, et al., 1928; Prucha, 2000). Although the idea of a culturally-based education for American Indian youth has been around for the better part of a century, in practice it has yet to materialize in a widespread, systematic way. This could be attributed to the fact that to incorporate culture in meaningful ways into the educational setting is difficult to do and requires effort in getting to know students and the local community and understanding their needs for the development of meaningful learning experiences. In the case of the culturally-based and integrated STEM curriculum utilizing the context of snow snakes, the community had originally expressed a desire to rejuvenate the culturally important game. It was only through the relationship that had been developed with the community and the individuals therein that the context of snow snakes emerged as a viable and necessary context to pursue.

Understandably with all of the terms used to describe culturally-based curriculum there are consequently a variety of attempts to define and operationalize the phrase. For the purposes of this study the definition offered by Belgrade, Mitchell, and Arquero (2002) fits best with the goals and objectives of the culturally-based STEM curriculum designed for this study. Therefore, a culturally-based curriculum "generally validates the cultures and languages of students and allows them to become co-constructors of

knowledge in the school setting…infus[ing] the curriculum with rich connections to students' cultural and linguistic backgrounds within family and community contexts" (p. 43). The STEM curriculum enacted for this study had the culturally-base context of snow snakes as an integral theme throughout. By building the curriculum around this context, the Ojibwe culture was affectively validated through its use along with the inclusion of the Ojibwe language. Concerning co-construction of knowledge, students actively sought the knowledge of their respective families and community to bring a richness of understanding to the classroom around the context of snow snakes and what that has meant for the Ojibwe people in that area.

Why should educators consider culturally-based curricula? According to Castagno and Brayboy, (2008) students from traditionally underrepresented groups have a fundamental conflict with the hegemonic culture of schools in comparison to their understood and lived culture as represented in their home and affiliated community. This dichotomy between school and home life forces students to live in two worlds that often times requires a complicated back and forth negotiation for success. A culturally-based curriculum therefore strives to incorporate familiar contexts for students that do not come from the dominant social group (Klug & Whitfield, 2003). By incorporating culturally-based contexts, students are better able to negotiate the cultures associated with their home and community with the culture of their school for greater academic success and achievement (Pewewardy & Hammer, 2003). Other benefits of using a culturally-based curriculum with American Indian students include enhanced student engagement and the reduction of classroom management issues (Cleary & Peacock, 1998; Gilliland, 1995;

Rhodes, 1994); “improved academic performance, decreased dropout rates, improved school attendance rates, decreased clinical symptoms, and improved personal behavior” (Demmert, 2001, p. 17).

What should be considered when developing culturally-based curricula? Demmert and Towner (2003) have defined six critical elements that are evident in culturally based curriculum/education programs:

1. Recognition and use of Native American (American Indian, Alaska Native, Native Hawaiian) languages.
2. Pedagogy that stresses traditional cultural characteristics, and adult-child interactions.
3. Pedagogy in which teaching strategies are congruent with the traditional culture and ways of knowing and learning.
4. Curriculum that is based on traditional culture and that recognizes the importance of Native spirituality.
5. Strong Native community participation (including parents, elders, other community resources) in educating children and in the planning and operation of school activities.
6. Knowledge and use of the social and political mores of the community. (p. 8)

The culturally-based STEM curriculum for this study sought to integrate these elements in the spirit by which they were promoted by Demmert and Towner. To refine the six critical elements even further it could be stated that a culturally-based curriculum should

consider language, culture, and community dynamics through classroom and pedagogical structures that promote both Indigenous and Western epistemologies (Barnhardt & Kawagley, 2005; Kawagley & Barnhardt, 1999). In further considering a culturally-based education, a closer look must be taken of the community and spiritual aspects associated with a culturally-based curriculum. The associated community and spirituality therein represent important factors when developing culturally-based curricula because by doing so the holistic notion of Indigenous knowledge is honored.

Community. Throughout the literature on culturally-based curricular initiatives there are consistent references to the incorporation of community (Castagno & Brayboy, 2008; Demmert & Towner, 2003; Morrison, Robbins & Rose, 2008). In order for a culturally-based curriculum initiative to be successful, the local community associated with the curricular initiative needs to be a vested, integral partner therein. By bringing the community alongside curricular design and development efforts, the resultant implementation stands to motivate students to learn because the context of learning is familiar to them and useful to the livelihood of the community (Battiste, 2002; Kawagley, 1995; Lipka, Mohatt, & The Ciulistet Group, 1998). In return, communities associated with culturally-based curricular implementations generally experience positive effects (Cleary & Peacock, 1998; Pewewardy, 1998; U.S. Department of Education, 2001).

The culturally-based STEM curriculum designed and implemented for this study partnered with families and tribal elders from the community to ensure that the initiative resonated with the community. Families were called upon for their pre-existing knowledge on snow snakes. This knowledge could either be technical in the form of

traditional ecological knowledge gleaned over time through a close relationship with the natural world; or it could be cultural in the form of oral tradition. Tribal elders were sought as partners to provide language and cultural expertise that would bring authenticity and meaning to curricular efforts. Without the community investment in the culturally-based STEM curriculum delivered for this study, there would seemingly be little difference from other decontextualized curricular offerings that students experience. The implications for this are important according to Brayboy and Castagno (2009) when they say "the support and buy-in of parents and the local tribal community are critical and can assist schools in providing valuable resources and support" (p. 48) for culturally-based curricular initiatives.

By legitimatizing tribal epistemological foundations through culturally-based curricular initiatives, the associated school setting becomes a clearinghouse for community traditions and culture (Brayboy & Castagno, 2009). The coupling of important community cultural traditions and cultural representation with challenging and high-quality content, such as can be found within STEM, has the potential to support students when they are faced with negotiating cultural situations for both the dominant culture, or culture other than that which they are familiar with; and their home culture (Brayboy & Castagno, 2009). As can be seen, the associated local community represents a critical partner in culturally-based curricular design and implementation.

Spirituality. Spirituality is also a matter that should not be lost when culturally-based curricula is implemented into conventional school structures. When matters of spirituality are discussed there is usually an air of mysticism to those uncomfortable with

the construct. At the base of spirituality is the need and expression of relationships. These relationships can be between individuals and places and should be considered when designing and implementing culturally-based STEM curricula. This being said, Castagno and Brayboy (2008) comment that "it is important for teachers to be aware of and treat appropriately the connections many indigenous peoples make between spirituality and science" (p. 967). The culturally-based STEM curriculum for this study using the context of snow snakes had important spiritual implications relating to the role snakes play in the conceptualization of seasonal medicine along with the deep meanings associated with specific tree species such as the maple. To further disarm objections to the inclusion of spiritual matters in the classroom, Klug and Whitfield (2003) offer this logical consideration:

> If we remember that spirituality is the way we form relations with a universal higher power and all of Creation, including our relationships with others, we can readily determine that there is a place in education for spirituality and ceremonies cementing those relationships for American Indian students. (p. 161)

STEM Integration

For the purposes of this study "STEM integration" will mean the design of curricular experiences that seek to seamlessly meld science, technology, engineering, and mathematics in pragmatic and meaningful ways for the purposes of reaching a predetermined end goal. For example, for this study students' acquired STEM knowledge that they then applied to successfully throw a snow snake down an ice track. Through the engaging context of snow snakes, the STEM curriculum explicitly applied mathematics

(scaling and data), and science (force and motion) to an engineering prototype iteration that used available materials and tools (technology) for success.

The role of science, technology, engineering, and mathematics (STEM) in K-12 education has become a very important issue with millions of dollars following this initiative (Kuenzi, Matthews & Mangan, 2006; National Academies, 2006; National Governors Association, 2007; Sanders, 2009). There are a variety of reasons for the integration of STEM in more meaningful ways into the K-12 classroom which include: the potential for improved student learning and achievement; an increase in awareness and interest in engineering; and an increase in technology literacy (Katehi, Pearson & Feder, 2009). One approach to integrating STEM has been to highlight the natural connections between STEM disciplines (Katehi, Pearson, & Feder, 2009). Unfortunately, the current structure of schools does not allow for these connections to be easily made. Schools have traditionally "siloed" topical areas and taught the STEM subjects in isolation without drawing upon the organic connections between them (Czerniak, Weber, Sandmann, & Ahern, 1999; Katehi, Pearson, & Feder, 2009; Sanders, 2009).

Up front it will be necessary to make a distinction between STEM and STEM education. STEM has heretofore represented science, technology, engineering, and mathematics and their individual epistemologies and cultures (Sanders, 2009). STEM education is a much newer phenomenon with functional operationalization still being defined. For this study STEM education is viewed as an integrated construct that highlights the interconnections between STEM disciplines within authentic contexts for curricular experiences. The idea of curriculum integration unifies previously separate

subject matter through a contextually rich problem that resonates with students (Beane, 1995). The inherent connections between STEM disciplines and the myriad of problems that can be framed through the STEM disciplines make curricular integration an organic endeavor. STEM integration therefore holds great promise given Beane's conclusion that a separate-subject approach has a deadening effect on student lives. Beane delves further into the essence of curriculum integration highlighting why it makes sense for students.

> In curriculum integration, knowledge from the disciplines is repositioned into the context of the theme, questions, and activities at hand. Even when teaching and learning move into what looks like discipline-based instruction, the theme continues to provide the context and the motivation. It is here that knowledge comes to life, has meaning, and is more likely to be "learned." Particular knowledge is not abstracted or fragmented, as is the case when its identity and purpose are tied only to its place within a discipline or school subject area. (p. 620)

For this study the context of snow snakes represents a culturally meaningful theme that requires an understanding of STEM for successfully solving the problem of how to craft a snow snake that will work well in competition, in other words, how to make the best snow snake from both an artistic standpoint and performance wise.

As noted previously, STEM education and the integration of STEM disciplines for meaningful learning experiences have only recently been conceptualized in their current form. Integration efforts within the sciences (McComas & Wang, 1998), as well as between mathematics and science (Berlin & Lee, 2005; Frykholm & Glasson, 2005;

Furner & Kumar, 2007; Koirala & Bowman, 2003), have been discussed at length for many years. STEM and STEM education on the other hand have more recently been placed in the national spotlight through mainstream attention due to waning student achievement and concern over students entering the "STEM pipeline" to ensure U.S. prominence in international competition (Bybee, 2010; National Academies, 2007).

Blended science instruction is a term that includes previous conceptualizations of integrated, unified, and coordinated science (McComas & Wang, 1998). Blended science instruction, much like what has already been discussed for curriculum integration and STEM education, seeks to take important contextual scenarios for students and apply scientific understanding. A justification for blending the sciences is that nature does not isolate science disciplines as they are represented in K-12 school structures. Therefore by blending multiple science disciplines, a more authentic depiction of how science can be used to understand the natural world will be experienced by students. Consequently, students will command a richer intellectual understanding of how science works (McComas & Wang, 1998).

Although it continues to be unclear exactly how integrated STEM education will work in practice, much has been said and done concerning the integration of two of the STEM education components, science and mathematics (Berlin & Lee, 2005; Frykholm & Glasson, 2005; Furner & Kumar, 2007; Koirala & Bowman, 2003). The earliest literature recommending the aforementioned integration dates back to 1905 in *School Science and Mathematics* (Berlin & Lee, 2005). In more modern times support for the integration of science and mathematics has been evidenced by national professional

organizations and national reform documents including contributions from: The American Association for the Advancement of Science, the International Technology Education Association, the National Council of Teachers of Mathematics, the National Research Council, and the National Science Teachers Association (Berlin & Lee, 2005). More specifically, excerpts from select reform documents highlight how mathematics and science integration is being conceptualized. Beginning with the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993), insight can be made into how mathematics, science, and other disciplines should be integrated and the value therein:

> It is the union of science, mathematics, and technology that forms the scientific endeavor and that makes it so successful. Although each of these human enterprises has a character and history of its own, each is dependent on and reinforces the others. (p. 3)

Furthermore, discipline specific reform documents are explicit in their support for connecting mathematics and science to contexts that are familiar to students for the purpose of meaningful learning:

> School mathematics experiences at all levels should include opportunities to learn about mathematics by working on problems arising in contexts outside of mathematics. These connections can be to other subject areas and disciplines as well as to students' daily lives. (National Council of Teachers of Mathematics, 2000, p. 65)

Also

> The science program should be coordinated with the mathematics program to enhance student use and understanding of mathematics in the study of science and to improve student understanding of mathematics. (National Research Council, 1996, p. 214)

And

> The opportunity for students to experience mathematics in a context is important. Mathematics is used in science, the social science, medicine, and commerce. The link between mathematics and science is not only through content but also through process. The processes and content of science can inspire an approach to solving problems that applies to the study of mathematics. (National Council of Teachers of Mathematics, 2000, p. 66)

Throughout each of these documents it is clear that by taking a contextually rich problem that is meaningful to students, there is potential to inspire students to engage with the content in ways not possible through conventional means of decontextualized instruction.

Integrated STEM education in essence builds upon the calls for reform in the science and mathematics integration literature by adding engineering and technology in more explicit ways. As noted previously integrated STEM education has just recently become an oft used construct in both mainstream discourses as well as in the K-12 forum (Bybee, 2010; Clark & Ernst, 2007; Sanders, 2009). Engineers by nature are problem solvers. With the call in reform documents to include contextually rich problems that resonate with students it is reasonable to make a case for engineering design structures within the already called for integration of science and mathematics. This is in part

evidenced through the inclusion of the disciplines of engineering and technology within the draft Framework for Science Education by the National Academies (Bybee, 2010) which is slated to be in final form in early 2011; as well as existing science and engineering standards adopted by states such as Massachusetts and Minnesota (Massachusetts Science and Technology/Engineering Curriculum Framework, 2006; Minnesota Academic Standards in Science, 2009).

Sanders (2009) makes a strong case for integrated STEM education. Similar to integration strategies discussed previously, Sanders (2009) promotes "problem-based learning that purposefully situates scientific inquiry and the application of mathematics in the context of technological designing/problem solving" (p. 21). What makes Sander's thesis different is his explicit intent upon mirroring the practices of engineering solutions to real-world problems. Granted, the fundamental differences between integrated STEM education and that of other integration strategies in the literature are slight. One of the reasons why STEM education has produced the buzz it has is because heretofore engineering has not been a mainstream content area in the K-12 classroom. Sanders is very clear that STEM education should not command its own curricular space as a stand-alone subject area, rather, STEM education should be infused with content areas where it has logical epistemological connections. Sanders does not mince words when talking about the potential to motivate students around STEM content associated with curricular efforts when he says that "integrative STEM education would add enormously to American education, culture, and global competitiveness" (p. 25).

It is not surprising that there are common themes throughout the literature in regard to curriculum integration, blended science instruction, mathematics and science integration, and STEM education. All approaches to teaching students recommend the identification of a problem or context that is relevant to students. All approaches recommend using appropriate content that supports solving problems and/or exploring contexts. In so doing, students see the relevance of the content and its applicability and are more likely to learn (Beane, 1995).

From an Indigenous epistemological perspective there are very compelling connections to be made between the philosophical views of integrated STEM education as it is currently conceived in the literature and conceptualized for this study, and those of an Indigenous world view. As mentioned previously, epistemologically an Indigenous world view is holistic, taking into account the myriad of interconnections between living and natural entities (Costagno & Brayboy, 2008). A similar thing could be said for a STEM integration construct and making meaningful connections between the individual disciplines. Students that grow up in a holistic cultural environment have identities and dispositions that mirror this epistemological paradigm. The implications for schooling should then be considered within conventional academic structures. For instance, traditional academic structures compartmentalize content such as mathematics and science. This compartmentalization is an impediment to American Indian students' ability to engage, given a holistic epistemology and valuing learning from direct experiences (Barnhardt & Kawagley, 2005).

What does an Indigenous epistemology have to do with STEM? Given the similar epistemological paradigms between the two, there are important implications for teaching and learning. Individuals responsible for teaching American Indian students "must realize and appreciate that in modern scientific and educational endeavors, mathematics, science, and technology are interrelated with all other disciplines" (Kawagley & Barnhardt, 1999, p. 133). In conventional classroom settings, finding ways to interrelate subject matter may be difficult to do. Understanding a concept from many different aspects can be promoted through learning experiences that utilize multiple learning modalities along with the inherently engaging contexts associated with the local community and possible needs therein (Cleary & Peacock, 1998; Hall, 1996; Rhodes, 1994).

With the foundation in place for some of the historical issues associated with American Indian education, along with a review of the literature around culturally-based curricula, and STEM integration; we can now revisit agency in more explicit terms in regards to this study. Specifically we will delve into the literature around critical science and mathematical agency and how the literature on these topics can inform our understanding of science agency for this study.

Critical Mathematics and Science Agency

At this point we will revisit notions of agency, but this time it will be through a content specific lens. Literature specific to mathematics and science agency is very limited. The existing literature on the subject invariably incorporates a critical lens. Concerning critical mathematical agency the dissertation by Turner (2003) defined critical mathematical agency as having three elements. First, students need to have an

understanding of mathematics in order to act upon that understanding. Second, students need to identify themselves as being mathematically inclined and able to mobilize their mathematical understanding in ways that would serve them. And lastly, with mathematical understanding in place and the belief that they can use mathematics on their behalf, students then exercise their mathematical understanding in transformative ways for themselves as well as others (Turner, 2003).

Critical science agency was first conceptualized by Basu, Barton, Clairmont and Locke (2009). In their study of 9th grade physics students, critical science agency was highlighted in two students who also acted as coauthors on the paper. In the paper Basu et al. promote the thesis that a student views

> the world with a critical mindset and envisions how to advance in the world or change the world into a more socially just and equitable place with and through science, while considering oneself as [a] powerful scientific thinker and doer of science. (p. 345)

As a result of this study, Basu et al. present three claims concerning the development of critical science agency in students. First, that there is a close relationship between agency and identity development; second, that expressions of critical science agency call upon available resources for the benefit of the agent or group; and third, that the development of critical science agency is dynamic and requires continual conceptualization of self within the context of the science education structures. Referring back to the previous discussion on agency broadly speaking, the critical lens offered by Basu et al. was not pursued for this study because, although social justice and equity are of great importance,

their inclusion through encompassing a critical science agency lens versus just science agency would confound the goals and objectives of this study. Therefore science agency was viewed as parsimonious and manageable for this study while at the same time meeting the stated goals and objectives.

Agency literature specific to mathematics and science has been focused exclusively on urban settings (Barton & Tan, 2010; Basu, Barton, Clairmont & Locke, 2009; Olitsky, 2006; Turner, 2003). There remains a void in the literature around content agency development in students from rural or non-urban settings, particularly with students associated with underrepresented populations. This is particularly true for American Indian students and therefore provides part of the impetus for this study.

The most recent work on science agency comes from Barton and Tan (2010). In their study they looked at the development of agency in low-income urban youth aged 10-14 through participation in an informal science program highlighting green energy technologies. From this study Barton and Tan found that students displayed science agency when they were allowed the freedom to author their own understanding of science through cultural structures that were familiar to them such as language, place, and inquiries that disarm traditional power structures. For this study and the use of a culturally-based context for the purpose of infusing STEM content, there is a difference in that it used a context identified as a need for the community versus the study by Barton and Tan where a context was used (e.g. green technologies) that was conceptualized and prescribed by the curriculum developers. Regardless, students in the Barton and Tan study displayed science agency through authoring an investigation given the context

prepared for the informal science setting and situating themselves as content experts. This was done through a blending of scientific understanding and the dynamic nature of identity development. Barton and Tan argue that students assert their scientific knowledge within the figured world of the informal science program and through this knowledge are able to take action.

There are many factors that contribute to the development of mathematical and science agency, including the figured world by which students experience content, student identity development, students' ability to author spaces within conventional content structures of a K-12 environment, and the allowance of a student's familiar culture and ways of knowing. Agency therefore is believed to be "an important construct in advancing our understanding of science literacy and even the learning sciences" (Basu et al., 2009, p. 369).

Caution

Although culturally-based STEM curricula presents some needed and important considerations in the right direction for American Indian youth and their academic achievement, caution should be taken when depicting culturally based STEM curricula as a silver bullet solution. When culture is highlighted in the K-12 school setting it has all too often been placed in isolation much like conventional school subjects such as science, social studies, and mathematics. By doing this, the culture a student is familiar with, a culture that infiltrates all manner of living and being has now been isolated into a structure that is difficult to relate to, much like the conventional school subjects (Hermes, 2000). By isolating culture, it fundamentally changes how "culture" is perceived by

students. In this way, the advice of one of the tribal elders in the study conducted by Belgarde, Mitchell and Arquero (2002) eloquently defines how culture should be used in culturally-based curricula by saying: “Do not teach our children our culture. Use our culture. Use our culture to teach them” (p. 42).

Conclusion

In this chapter we explored tenets associated with agency; historical and contemporary issues associated with American Indian achievement and engagement; culturally-based curricular initiatives and their relation to Indigenous knowledge; integrated STEM education; content specific agency, in particular mathematics and science; and a note of caution when considering implementing culturally-based contexts into K-12 curricular structures. Each of these literature bases was important to explore for the purposes of setting the foundation for this study. With this foundation in place the conceptualization of this study can move forward into how each of the aforementioned elements were carefully structured within the culturally-base and integrated STEM curriculum and the outcomes associated with its implementation for students and the community. The next chapter will delve into the research design and methods used for this study with ample explanation and justification.

CHAPTER THREE: RESEARCH DESIGN and METHODS

Study Context

The *Reach For The Sky* (RFTS) program was an afterschool/summer STEM program for youth, ages 11 to 14. The program in recent years was funded through the National Science Foundation as part of an Innovative Technology Experiences for Students and Teachers (ITEST) grant. A majority of program activities took place within the White Earth reservation. The White Earth reservation is home to the Anishinaabeg/Anishinaabe people of the Ojibwe tribe (LaDuke & Alexander, 2004; White Earth Reservation Curriculum Committee, 1989). There is a rich history related to the RFTS program that is worth noting. The following paragraphs will provide a brief synopsis of the RFTS program highlighting aspects that are notable for this study.

In 1999 the White Earth Science and Math Summer program was launched in an attempt to curb academic achievement struggles and the erosion of traditional skills and knowledge of Ojibwe culture for American Indian youth on the White Earth Reservation. The overarching mission for the summer program was to recognize that the natural resources of the White Earth Reservation can be used to instill respect and appreciation for the traditional way of life while functioning as a vast laboratory in which to learn about the disciplines of science and mathematics. Curricular experiences developed as an outgrowth of this mission statement which included topics in: water quality through stream sampling, soil science, forestry topics including tree identification and ecology, traditional and local foods, GPS technologies, basket and canoe construction, and many more.

In 2007 the White Earth Science and Math Summer program evolved into its current iteration known as RFTS. The RFTS program sought to maintain and enhance topics that were previously taught during the summer program while infusing a greater level of technology and integrated STEM content to the organic contexts found within the natural laboratory of the White Earth Reservation. As part of the RFTS program, an afterschool component was added to the on-going summer programming. Much like the summer component, the focus was on culturally-based and relevant contexts that could be highlighted to deliver STEM content. It was within the afterschool portion of the RFTS program that snow snakes, as related to this study, was born.

Eagle Soaring School was one of the schools that traditionally participated in the White Earth Science and Math Summer program and RFTS program since 1999. Eagle Soaring School was one of the primary schools in which the snow snake curriculum was delivered both during the pilot program and the iteration that this thesis is a result of. The full case of Eagle Soaring School will be presented in the following chapter. For now, it is important to have a fuller sense of the background leading up to the development of the snow snake curriculum and the identification of Eagle Soaring School as the bounded case site.

Research Design

The purpose of this case study was to understand the experiences of American Indian upper elementary students within a culturally-based and integrated science, technology, engineering, and mathematics (STEM) curriculum and its impacts on student science agency. Science agency in students was defined as a student's expressed behavior

that illuminates positive dispositions toward STEM as an integrated construct for the purposes of taking action in a student's individual life.

The primary research question for this project was: *How does a culturally-based and integrated STEM curriculum impact student's science agency*? Associated sub-questions were: 1) What does science agency look like for sixth grade students?; 2) What key experiences are involved in the development of science agency through a culturally-based STEM curriculum context?; and 3) Are there impacts on the community associated with the implementation of a culturally-based STEM curriculum? The overarching question and three sub-questions guided all aspects of research methods including interview protocol development and conduction, observational lenses, document collection, and data analysis.

The research design encompassed approximately twelve focused weeks of data collection with the corresponding snow snake curriculum and implementation couched within that time span. Research commenced during the third week of December 2009 and concluded shortly after the snow snake festival, in mid-March 2010. Of the twelve total weeks of research, I was physically on site for part of four different weeks. During each of the months of December, January, February, and March I traveled to the research site.

A case study research design was used for this project and was chosen for a number of reasons. Yin (2003) defines a case study as investigating a phenomenon (e.g. science agency) which occurs within authentic contexts (e.g. snow snakes, AL, and Eagle Soaring School) especially when the boundaries between phenomenon and context are unclear. The research project was designed to gain insight into how students experienced

the coupling of snow snakes with STEM content. From this research lens it was hypothesized that by gaining access into a student's lived experience, insight into a student's science agency could be seen.

There were two elements that bounded the case for this study. The first element was that of one entire school. An entire school emerged as the bound case for a couple of reasons. First, the particular school site was identified for its administrative and community support for snow snake curriculum implementation. Second, Eagle Soaring School is a K-6 institution with a 100% American Indian student population. Since the dynamic interactions that make up Eagle Soaring School during a given time period could in some way effect students' perceptions around snow snakes, the entire school was selected therefore ensuring that a full and accurate case would be developed. The second element binding the case was time. Twelve weeks were defined for the bounded case. This length of time was deemed as being adequate for capturing snow snake activities in their entirety.

Embedded Case Study Design

Within this single case design there were multiple embedded units of analysis in the form of students (Yin, 2003). Yin offers four types of case study design. The case study design implemented for this study is considered a Type 2 with a single case having embedded units. Using this type of case study, the embedded units include nine students, eight students from the sixth grade classroom at Eagle Soaring School and one student from the fifth grade class. The sixth grade embedded units include six males and two females. The fifth grader included in this study is a female. The justification for this

configuration will be explained in depth in later chapters along with data representation. For now, it is important to know that the sixth grade class and the embedded units therein were of primary interest to the case. The single embedded unit from the fifth grade class was included because of this student's hypothesized science agency prior to curriculum implementation and research efforts.

Informants

Along with the embedded units there were a number of individuals that were important to the research design because of their ability to provide insight into the experiences students (embedded units) were having around the snow snake curriculum. Each informant beyond the embedded units was either directly involved with the case study site, (e.g. employed there and working directly with students) or had direct involvement with students (e.g. parents) and/or the snow snake curriculum (e.g. tribal elder). For this study informants included: Dean, Administrator at Eagle Soaring School; Parker, 6th grade teacher at Eagle Soaring School; Bruce, 5th grade teacher at Eagle Soaring School; Misty and Ronald, parents of students (embedded units) at Eagle Soaring School; and Regal, White Earth tribal elder and snow snake expert. Informants and students were interviewed on three separate occasions. Details and justification of the interview structures will be discussed in the following section.

Data Collection

The data secured for this case study took on a variety of forms. These forms included: Interviews, observational field notes, a reflexive journal, blog entries, and student produced curricular documents. Data was then organized into primary and

secondary sources for analysis purposes. Primary data included all interview transcripts from the students and the aforementioned participants (administrator, teachers, and community members). Secondary data included observational field notes, a reflexive journal, blog entries, and student produced curricular documents.

The primary data sources were secured as prescribed by Seidman (2006). Semi-structured interviews took place with students (embedded units), an administrator, teachers (two), parents (two), and a tribal elder on three occasions. The first interviews took place prior to formally beginning snow snake activities (January 4th-8th, 2010); the second interviews took place approximately at the mid-curriculum point (February 16th-19th, 2010); and final interviews were conducted at the conclusion of all snow snake activities (March 15th-16th, 2010). Interviews took place at the case study site for students, teachers, and the administrator. For the tribal elder and parents, the interviews were conducted at the respective home locations, generally around a kitchen table or a living room setting.

An interview protocol was developed for each interview. For example, a unique interview protocol was used for the initial student interview, mid-curriculum interviews, and final interviews. Interviews conducted with the administrator, teachers, parents, and tribal elder each had their own unique interview protocols consistent with the aforementioned student interview design (see Appendix A for interview protocols). For student interviews, the protocols addressed science understanding and agency towards the utilization of STEM in students' everyday thinking and problem solving. The logic in conducting administrator, teacher, parent, and tribal elder interviews was to provide yet

another layer(s) of support for what was observed and expressed by students regarding the development of science agency within the bound case. A total of 39 interviews were conducted encompassing approximately 12 hours of audio that were then transcribed verbatim (see Table 1).

Table 3.1
Interview descriptive statistics

	# of interviews	Total time	Min.	Max.	Mean
Student (9)	24	5:09:08	6:22	24:08	12:42
Teacher (2)	6	1:45:57	9:41	24:31	17:40
Administrator (1)	3	34:22	7:41	18:28	11:27
Parent (2)	3	2:03:21	37:04	48:31	41:07
Elder (1)	3	2:24:59	25:20	1:02:59	48:20
Total	39	11:57:47			

The secondary sources of data were secured throughout the twelve week research window. Observation field notes were guided by the lenses offered by Bogdan and Biklen (2003). Both descriptive and reflective field notes were taken on the setting, subjects, and events/activities. The reflective aspects of the field notes provided fodder for a reflexive journal that I kept as a result of physically being on site. Reflective field notes focused on personal speculations, feelings, problems, ideas, hunches, prejudices, and mistakes.

The Adventure Learning online environment which will be discussed in the following chapter afforded another suite of student derived artifacts. Student artifacts in the form of blog entries, chat transcripts, video and digital photo uploads of student produced materials were secured. Students were asked to blog weekly about a particular snow snake topic within the project environment at http://snowsnakeden.ning.com/.

Along with the weekly blog directive, students were encouraged to upload media such as digital photos and video. Also secured were the expert chat transcripts.

A final form of secondary data secured as part of the implementation of the snow snake curriculum was formative and summative assessments associated with the STEM content being learned. For example students collected data using a data sheet that informed conclusions about the types of variables to manipulate for desired snow snake outcomes. Student produced curricular documents in the form of worksheets, data tables, snow snake prototypes, and full scale snow snakes were considered valuable anecdotes alongside primary data sources for triangulation purposes.

Data Analysis

Techniques presented by Miles and Huberman (1994) guided data analysis. The general analysis framework utilized was that of data reduction, data display, conclusion drawing and verification. By using this approach, rich descriptions were elicited that captured the essence of the phenomenon in question from substantial raw data sources. To begin the analysis, a gestalt lens was placed against all data to note patterns and themes manifest in the construction of a set of naturalistic codes. Interest was given to items that "jumped out" as being relevant and valuable in answering the research questions. From the identification of an overarching set of codes, a finer lens was then applied to build a logical chain of evidence that supported notions of science agency in students. This finer lens was employed initially during the second reading of the data; data which was already coded to a specific naturalistic code. All of the aforementioned sequence is considered the data reduction phase of analysis; basically taking the extensive

and cumbersome raw data and reducing it to the important pieces. An explanation of the codes will be presented in detail in a later section of this chapter and in chapter five as they are associated with research findings. Data reduction, displaying, conclusion drawing and triangulation were done in part through the use of NVivo software. NVivo is a qualitative data analysis software that allows the researcher to transform data in a myriad of ways that assist in data analysis.

Explanation of Coding Activities

All data, both primary and secondary sources, were uploaded into NVivo after appropriate manipulations had been made. For example, all of the audio was transcribed into a Microsoft Word document and the observational field notes were transcribed from handwritten text. Data was organized into an appropriate folder system, e.g. Student Interview Transcripts, Field Notes & Reflexive Journal, Misc., etc. Each piece of data, beginning with student interviews was read and considered in its entirety. Given the research question and the associated theoretical framework, naturalistic codes were developed that had descriptive titles and associated in-depth descriptions. The in-depth descriptions assisted me in making sure data coded to a specific naturalistic code was similar in tone and spirit to other data coded as such. The naturalistic codes were organized into categories as multiple codes emerged from the data. These categories evolved over the course of the analysis as more data were considered and the analytical lens of the research deepened around the data (see Appendix B – codes from NVivo).

Validity

Validation strategies were guided by Creswell (2007) and include two techniques. The first validation strategy was triangulation. There were multiple sources of data as noted previously. Each source of data was analyzed from a gestalt perspective as outlined in the analysis section. As codes emerged within one data source, these codes were considered against other data sources to verify or refute the validity of the naturalistic code, essentially triangulating the code against multiple data sources. The second validation strategy used was to provide readers with a rich, thick description. By providing a rich, thick description, a level of transparency was presented that rendered validity by giving the reader/audience adequate information to draw their own conclusions. Of the possible validation strategies, Creswell recommends using at least two which I have outlined here.

Researcher Background

My professional experiences have provided me with valuable insights that have been important to my development as a researcher and scholar. Prior to pursuing my Ph.D., I was an 8th grade science teacher at Douglas Middle School in Box Elder, South Dakota for 6 years. As an 8th grade science teacher in western South Dakota I continually sought engaging and meaningful experiences for my students. One example of this would be the design and construction of arguably one of the first ever disc golf arboretums. Through the generous support of a Toyota Tapestry grant for science teachers which was administered through the National Science Teachers Association (NSTA) I was able to

highlight the natural flora and fauna in South Dakota by engaging students in the popular game of disc golf.

Also while teaching middle school science in western South Dakota I was moonlighting as a co-PI on a National Science Foundation Research Experience for Teachers (RET) in Engineering grant. Through this grant, STEM teachers participated in fundamental engineering research and as a result, developed ways in which their experience could be transferred back to students in their respective classrooms for meaningful and transformative learning. Although I loved teaching middle school science I was taken with the flexibility and limitless potential in pursuing innovative ideas that could transform the way science teachers taught; and the ways science students learned. This experience, in part, led to my pursuit of graduate school and a quest for a terminal degree.

Involvement with RFTS

Upon acceptance into the graduate program in science education at the University of Minnesota I was welcomed onto the RFTS project team to work with professors and fellow graduate students to develop and implement culturally-based and relevant STEM experiences for American Indian youth. During my tenure on the RFTS project I was involved with a myriad of activities. I have developed curriculum for after-school and summer project components including snow snakes, three wheeled velocipedes, and water. I have taught the aforementioned curricula to students as well as provided in-service professional development training to teachers from the schools the RFTS project has partnerships with. I mention this in part to denote the time I have been involved with

the White Earth Reservation community and the organic relationships that have developed with students, teachers, administrators, community members, and tribal elders. Without these relationships this thesis could not have been conceptualized in its current form nor would I want it to be. It is my experience and understanding that relationships are paramount.

Role of Researcher

As a researcher I took on a hybrid role of participant observer. This role began entirely as an observer as I collected observational field notes to develop a rich description of the case and the associated dynamics that came into play during the implementation of the snow snake curriculum. As observer I spent time in the 6th grade classroom of interest, observing student and teacher relational dynamics. During this time I began to seek those pathways which fostered a rapport with students. Interactions included simple conversations to participation in school wide activities. Caution was given to my perceived authority and reason for being in class. As opportunities presented themselves, I maintained transparency regarding the reasons for being in class through fielding questions and interacting in ways that put students at ease with the help of the teacher.

My role evolved once the snow snake curriculum entered the implementation stages. As the author of the curriculum I assisted teachers in planning for instruction. As it was necessary, my role as observer transitioned into participant through the teaching of portions of the snow snake curriculum when I was onsite for data collection purposes. As

the snow snake implementation progressed, I seamlessly moved in and out of participant and observer roles.

Limitations

Throughout this study a number of limitations emerged and will be recognized in the following paragraphs. According to Wolcott (1990) expressing the limitations of a study is necessary because each study has a unique nature that affects the types of data collected and the analysis therein. By explicitly stating the recognized limitations, the stage is then set, eliminating the need to revisit limitations in later sections and chapters of the thesis. There are four primary limitations that will be discussed. Each limitation is important to consider for the overall study because of its impact on how the study proceeded and the resultant implications for conducting the study.

The first limitation deals with my proximity to the research site and the subsequent limitation of my time on-site conducting research. From my residence to Eagle Soaring School it is an approximate 4 hour and 30 minute drive, around 250 miles. Couple this fact with the general inclemency of winter weather conditions during the months of December through March, making frequent trips challenging. Distance and weather aside, costs associated with traveling that distance on a frequent basis were also limiting. The implications for this limitation are connected to a different limitation that will be discussed later in this section, that of curriculum fidelity.

A second limitation was the complicated semantics associated with “science” and “STEM”. Originally this research was conceptualized to look at the development of STEM agency in students as a result of experiencing the culturally-based STEM

curriculum. Upon careful consideration, STEM agency was not pursued due to its problematic nature. Science is a subject that students should have a general understanding of the basic precepts, accurate or otherwise, after having spent a modicum of time in a K-12 school setting. STEM on the other hand is a relatively new acronym with essentially no history in the K-12 education setting. It was determined that in order to elicit the data sought, clarity would have to be paramount when interacting with students via interviews or otherwise, ergo “science” instead of “STEM”.

A third limitation was the fidelity in which the snow snake curriculum was implemented. Due to the limiting factor of my proximity to the case study site, the depth of observation around curriculum implementation is not there. Thus, I had to rely upon interview answers from teachers to questions about curriculum implementation and the closeness by which they followed the curriculum as it was authored and originally intended. Although responses to interview questions on the topic of curriculum implementation were insightful, upon further reflection a deeper probing was warranted to gain a greater sense of the fidelity of implementation. This is important to consider given the experiences students have with the curriculum is critical to the findings of this study.

A final limitation to discuss associated with this study deals with the nature of the context (snow snakes) and its cultural relevancy or lack thereof. Harkening back to the literature review, a culturally relevant curriculum accepts and affirms the cultural identity of students (Ladson-Billings, 1995). Although the snow snake curriculum does this for this study, it is a result of all students having a cultural identity grounded in an Ojibwe

heritage. Students experiencing this curriculum that are not of an Ojibwe cultural heritage would potentially have a much different experience.

My understanding of cultural relevancy experienced a foundational paradigm shift at a workshop where I was presenting the snow snake curriculum to a room full of educators that were predominately Native American. A major concern I had while authoring the snow snake curriculum was that it would be culturally relevant for students experiencing it. I thought there would be no better place to get an answer to this question than with the audience I had at this workshop. The following passage is a reflective excerpt from a field notes journal.

> I was concerned about my curriculum being culturally relevant. Since I had a room full of thoughtful Ojibwe/Anishinaabeg educators I decided to pose the questions. Dwight (workshop coordinator) proffered an incredibly eloquent answer that went something like this: When we (as in the Teaching Relevant Inquiry Based Environmental Science (TRIBES) program) talk about cultural relevance we strive to create experiences where everyone has a place, a safe place to integrate and share their culture. This comment was a major paradigm shift for me. I went in thinking that I wanted the snow snake curriculum to be as spot on culturally for Ojibwe people as possible. Although I think I was close to this end for Ojibwe students, a Somali, Hmong or White student would struggle to make the same cultural connections with this curriculum. My understanding had shifted here to be more accurate and to better meet student needs, Ojibwe or otherwise.

To do this, two considerations should be made when developing curriculum: 1) Set up ways to invite culture in; and 2) do not force a definition of culture on anyone. What this limitation means for this study is that caution should be taken when generalizing findings for classroom settings that have a more heterogeneous student population.

In the next chapter the contexts and curriculum developed for this study will be introduced and explained. In other words, the bounded case for this study will be developed that will provide adequate background for expressing the findings in chapter five.

CHAPTER FOUR: CONTEXTS and CURRICULUM DEVELOPMENT

In this chapter the case of Eagle Soaring School will be presented with ample material to form a picture of the bounded case. This picture will include the associated figured world that has emerged through past snow snake experiences, and the fundamental values of the case study site. A thorough look into the curriculum will be taken with a preceding consideration given to the types of science experiences students have had at Eagle Soaring School. The context by which the culturally-based STEM curriculum was developed, that of snow snakes, will be explained to understand the value of the context within culture and place. Evidence for the implementation of the curriculum including curricular extensions will be presented to balance the curricular narrative as it was explained through the Adventure Learning framework. The chapter will conclude with a look into the value different audiences placed on the curriculum. Upon reading this chapter a thorough understanding will be secured of the prominent contexts along with the Adventure Learning curriculum enacted for this study.

Case Description

Eagle Soaring School is a K-6 institution located in a small community within a reservation boundary in Minnesota. Eagle Soaring School has been in operation for five years in its current form serving American Indian students in the local community. Eagle Soaring School represents the bounded case for this study. Along with the physical structure and the individuals operating within Eagle Soaring School, the case will also be bound by time. The time component was dictated by the duration of snow snake curriculum implementation, from approximately January 11th to March 13th, 2010.

Within the bound case the embedded units were 6th grade students who participated in the snow snake curriculum and activities. A total of eight students from the 6th grade class and one student from the 5th grade class at Eagle Soaring School were selected and interviewed for this study, making a total of nine students. Among the 6th grade students chosen, all students consented to be interviewed with the exception of one student who declined. There were six boys and two girls from the 6th grade classroom. In the 5th grade, there was only one student (female) of interest due to this student's past experience with snow snakes and the hypothesized existence of agency this student had prior to snow snake activities beginning. Since the snow snake curriculum was aligned to 5th and 6th grade standards in science (Minnesota Academic Standards in Science 2009 and American Indian Standards for Science Education); both 5th and 6th grade classrooms experienced the snow snake curriculum. For parsimony of the study design, only the 6th grade classroom students with the one noted exception would encompass the embedded units. Also, due to the close nature by which both classroom teachers (5th and 6th grades) work together and share curricular resources, both individuals were included as part of the study for their insight into the delivery of the snow snake curriculum.

Parker's 6th grade classroom is unique in many ways. For example, the small number of students is atypical to many modern classrooms. Also, the educational philosophy, to be discussed in a later section, is also unique and allows Parker to design curricular experiences that are meaningful to the specific student population. The following is an excerpt from the reflexive journal I kept during the study:

Parker's room is long and somewhat thin, maybe 15x30. Tables are used instead of desks. Typical things on walls but not excessive: Fish of MN, student work, white boards, cabinets. Parker's desk is in the northwest corner. Blue carpet. Parker rules with a soft and somewhat sarcastic hand. I don't see students as malicious but definitely given to being off task. The pace is not rushed, laid back. Parker manages his classroom without giving full attention to any one matter. Students are in various states of engagement with the day's activities. The pace of the lesson seems slow. Periodically students act out, such as pounding on table or yelling. Again, Parker uses sarcasm in his management style. Names and points are placed on board when students misbehave. Christopher has a soda pop in class. There are three pairs of shoes on floor. Parker is talking constantly it seems. Students answer questions, but it is not a student driven dialogue. Students look to make noise and speak out whenever they want. Vaughn (culture teacher) comes in for culture/language time (15 minutes given each day to Ojibwe culture and language within regular classroom). Kids begin coloring animal pictures. Vaughn never gives directions, just acts and students follow.

Eagle Soaring School itself is an older school with modern additions (somewhat modern). The school is well taken care of, albeit old and showing its age. Architecture seems a bit labyrinthine, three floors in main building with short stairways to mini rooms. There is a wing of the school upon walking in the front doors that is newer and only has a single floor. Staff support, camaraderie, and technology are notable. For example, Eagle Soaring School has a devoted

> technology person and what feels like more staff for students than other schools in the area. The camaraderie and rapport between staff is supportive and caring.

Both Parker (6th grade) and Bruce (5th grade) have been teaching at Eagle Soaring School for less than four years. Both are white males that do not live in the community in which they teach. Both graduated from institutions associated with the Minnesota State Colleges and Universities system. Parker has taught at both the 3rd grade and 6th grade levels. Prior to coming to Eagle Soaring School, Bruce worked in the non-profit sector and did substitute teaching.

Since Eagle Soaring School is categorized as a charter school, there is flexibility in the types of experiences the teachers and administrators design for their students. According to one of the administrators at Eagle Soaring School the mission of the school is twofold: "One is that they [students] will do four or more community service projects every year. And the other is to learn the Ojibwe language and culture and history." Beyond this charge it would appear that "grad standards" (State standards) guide the curricular experiences of students throughout grades K-6. Teachers have a high level of autonomy in creating a learning environment that they deem suitable to meeting learning objectives as prescribed by the grad standards. According to Bruce,

> Eagle Soaring doesn't actually have a science curriculum. We go off of the grad standards and just teach straight to the grad standards. We don't have science books. Everything that we find is basically anything that we have ordered possibly or internet, you know, or book related that we can, outside resources. We

> don't actually have a curriculum here. So, you know, as long as it's talking about, you know, movement and friction and all that, it's all part of the standards so, you know, it's [snow snake curriculum] going to fit in just fine because we are so open and that's some of the positive things that we can do here at a charter school because of not having a curriculum. We can do things like this and incorporate them pretty easily.

This environment provided an ideal location by which to introduce the snow snake curriculum in hopes of it being adopted into existing school structures during the academic day.

Historically science has been placed in a less prominent role during the academic day at Eagle Soaring School. Given the atmosphere associated with testing and meeting adequate yearly progress according to the NCLB act, mathematics and reading have taken on a greater focus at Eagle Soaring School over the past several years as evidenced by Bruce's description of events:

> Last year we were focused more on our math and our reading than we were science. So science really took a backburner last year. We had the one science day; I think we did it for two days. And then, you know, then it was we did the science fair. So there really wasn't a lot of, you know, time put on science. And then this year it's been, you know, a lot of the same, only we have added more in the classroom. We usually only do science two days a week. At this point we've

only gotten as far as really talking about the scientific method and things like that. It's really something that we need to do a lot more of.

Given the focus of the snow snake curriculum as seamlessly combining a culturally-based context (snow snakes) with STEM content, it appeared at the outset that it would meet the need as expressed by the school administrator in learning about Ojibwe culture, language and history; and it would also strengthen their science which had been given little attention in recent years.

Figured World of Eagle Soaring School

Very closely associated with some of the aforementioned pragmatic details that make up the case for this study are those components that define the culture or figured world of Eagle Soaring School. According to Holland, Lachicotte, Skinner, and Cain (1998), a figured world is "a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (p. 52). Therefore, the figured world of Eagle Soaring School could be considered a micro-culture within the greater community associated with Eagle Soaring and the White Earth Reservation. The figured world of Eagle Soaring School has been impacted by contemporary snow snake activities and is important to consider when looking at the development of science agency in students as a result of snow snake curriculum experiences. The figured world at Eagle Soaring School as it was primarily experienced by students and teachers, and also administrators, support staff and parents can be attributed to a variety of factors which will be explained in the following sections as subcategories.

When coding for “Figured world of Eagle Soaring School” the following definition guided analysis of data: “the culture, norms, and conscious efforts of students and staff to make an atmosphere that aligns with the stated mission of the school and personally held convictions of what education at Eagle Soaring School should reflect. This material can also be looked upon as integral to Eagle Soaring School case development.” To further parse out the aforementioned factors that make up the figured world, subcategories were developed and then the data was coded again with the subcategories in mind. There are four subcategories that will be explained in the following sections. They are: Eagle Soaring School’s relationship to snow snakes, pride, structure of school activities, and staff/student dispositions.

The titles of the subcategories for “Figured world of Eagle Soaring School” are descriptive. Where more clarification was necessary a definition was provided within NVivo to guide analysis. For example, for the code “pride” the description of “any expression of pride related to snow snake performance or outcomes” guided analysis. For the code “structure of school activities”, “any expression that talks about the structure of activities or the school day at Eagle Soaring School that could be pointed to as having positive or negative impacts on school atmosphere,” guided analysis. All of the figured world subcategories are important to the whole and therefore have clear similarities or overlap with the other subcategories. In explaining the subcategories and the data that supports these categories, the subtleties will be revealed to provide a greater depth of understanding of what makes up the figured world at Eagle Soaring School.

Relationship to Snow Snakes

The first figured world subcategory is “relationship to snow snakes”. During the winter of 2009 the original snow snake curriculum was piloted in an afterschool setting as part of the RFTS project. Eagle Soaring School was one of the sites for curriculum implementation in the after-school setting. Due to Eagle Soaring School’s involvement in the original iteration of the snow snake curriculum, a number of students, staff, and administrators were generally aware of the effort. What solidified Eagle Soaring School’s involvement and subsequent figured world around snow snakes came during the first annual snow snake festival. The festival was held at a location very close to Eagle Soaring School. The location was chosen for its centrality to other participating schools and the facilities that were available for putting on such an event. With the close proximity to Eagle Soaring School, attendance at the event by students, parents, and community was greater for individuals associated with Eagle Soaring School than for other participating schools.

At the festival, the competition was set up using traditional tournament style brackets. There was a male division and a female division with competitors moving forward in the bracket when they would win a head to head competition. Once female and male champions were crowned, the two competitors went head-to-head to see who the overall snow snake champion was. The overall snow snake champion would be recognized and a traveling snow snake trophy would be awarded to their school for the following academic year and then competed for again during the following year’s snow snake festival. During the first annual snow snake festival the overall snow snake

championship round was played out in dramatic fashion by Catherine and Christopher Blue from Eagle Soaring School. The brother against sister championship round went into extra throws with Catherine emerging victorious. Regardless of the outcome the overall championship and traveling trophy would be going to Eagle Soaring School.

By combining the experiences of the afterschool curriculum delivery and the positive experiences by individuals associated with Eagle Soaring School at the first annual festival, with students from Eagle Soaring School competing and securing first and second place; the positive relationship to snow snakes for Eagle Soaring School was solidified , with momentum for future efforts.

Pride

Concerning pride, there is a close relationship with the aforementioned relationship to snow snakes. The administrator at Eagle Soaring School epitomizes how pride factors into the figured world by saying: “I think there’s pride in having the winner and runner-up not only from Eagle Soaring School but also the same family. So I think there’s a value especially in the setting of self esteem or the desire to participate and achieve. And that will run over into other areas. I think that’s the biggest thing that comes.”

Structure of School Activities

The structure of school activities at Eagle Soaring School played a role in its figured world. Snow snakes and associated activities were received with open arms and highlighted as an important activity. Student successes with snow snakes were recognized by the entire school during “circle times” that open and close every week. The school

administrator shared that by recognizing student achievement, there are positive affects not only for the successful participants but also for other students:

> …and then when we had our morning circle yesterday, and honored the first, second, and third, actually fourth place winners, all of the kids had, a, they brought their trophy and their snow snakes to circle and we acknowledged them and there was a lot of self satisfaction and pride I think displayed. And the kids were excited in general, the whole student body.

Parker, one of the teachers closely involved with delivering the snow snake curriculum shared that they "talked about it a lot when the school got together and cheered and applauded those who took part, so we had momentum going into this year that maybe other places didn't have."

Dispositions

The staff and student dispositions as a result of prior snow snake success are notable. Parker's disposition and natural competitive spirit played heavily into the figured world of Eagle Soaring School. For example, when it came time for students to attend the 2nd annual snow snake festival Parker shared that:

> everybody was involved and the sixth grade class I told them that they would be there. I didn't make it an optional thing. Well, it was an optional thing but they didn't know that. I just told them that we were all going. And I really believe that they all wanted to go anyway. So that's probably why they were all there.

Not only did Parker expect participation from his students, he also believes in them individually and holistically. In Parker's mind the traveling trophy would call Eagle Soaring School home for a second year in a row at the conclusion of the 2nd annual snow snake festival. Beyond the competition aspect, Parker used language that supported disposition development in students around some of the important content within the snow snake curriculum. For example, Parker shared that "these kids have so many different ideas this year, and we might have some pretty crazy looking snow snakes. But, that's good because everyone has their own designs and everyone's their own engineer, see what works." Parker's use of engineering and believing that each student was their own engineer in developing snow snake designs is an important aspect of the figured world that was constructed at Eagle Soaring School, especially in the 6th grade class.

Students also displayed dispositions that were important to the picture in place around the figured world at Eagle Soaring School. Parker shared a couple observations that were very telling during the course of snow snake activities. The first:

> Students are really excited about snow snakes. I don't know what it is, whether it's the competitive part, whether it's all of the hands on part, whether it's the success that we had last year. I don't know, I can't put my finger on it but it's something that's really picked up and the kids are enjoying every part of that. I can't exactly put my finger on what it is but it seems like their motivation is high for the snow snake project. And if they are enjoying what they are doing then they are obviously learning a lot more too, because they are wanting to do it.

And the second:

> So it's all very interesting and they all have that smile on their face when we do it and they feel proud because they have a little bit of knowledge in the snow snake department. And then also the kids that were at the competition last year, being in that afterschool thing we even had a few young kids that will be coming up that aren't even old enough to do it this year with the fifth and sixth graders doing it. But some fourth graders waiting in the wings next year. And I know that they are excited to do it. But also that we had successful competitors last year. Even at conference time or whenever I run into their parents or families they still talk about snow snakes. It had a positive effect for everybody.

Both of these anecdotes were shared prior to snow snake activities fully beginning during the winter of 2010. What this shows is that the figured world was in place prior to snow snake activities that encompass this research and that previous snow snake experiences and the attention given to snow snakes by Eagle Soaring School played a big role in the development and sustaining of the figured world at Eagle Soaring School.

Science at Eagle Soaring School

Science experiences at Eagle Soaring School prior to the snow snake curriculum were limited and in some cases non-existent as reported by students. One of the questions during the initial student interview was asking students about previous science experiences. Answers to this question varied greatly with few common themes. The strongest common theme was found in science fair experiences. Over the past two years there has been an effort to have a local science fair competition for schools on the White

Earth Reservation. Students invariably expressed positive experiences with their science fair projects. For example:

> Brant: Do you feel like you are good at science?
>
> Coco: No
>
> Brant: How come?
>
> Coco: Wait, yeah.
>
> Brant: You do?
>
> Coco: Mmhmm, cause at the science fair I won a trophy and I talked loud enough so they could hear me and I did the board all by myself. Me and Christopher experimented the laminates and they were weaker than a regular block of wood.

And also: “Me and friends we did a science experiment and then I just after the whole thing was done I just wanted to do more and more and more.” Because of the efforts to promote the science fair at White Earth schools, teachers have been inclined to support these efforts within their respective classrooms. The event itself has been a success with students as evidenced by the previous quote. There are many reasons why the science fair could be looked upon as favorable by students and teachers. For the purpose of highlighting it within this study, it should be noted that science fair activities represent one of the few things students have previously done for science.

Other references to previous science experiences related to working out of science readers or text books, referred to memorable science experiences in the past with little depth of understanding, watching science, and having no recollection of experienced any science. For example, when discussing previous science activities one student expressed

that “We have to look up stuff for the science buddies and then we have to get the stuff for it. That’s all I know.” This particular example represents the extent of science recall for this particular student. Another student shared that she “hasn’t really done science, just watching, straight math.” This same student continued on later in the interview by saying: “Because I have never really done anything with science. Last year it was just like watching science. We never really had science towards the end of the year because we had a math teacher. And she just taught us math, math, math. We didn’t do reading or spelling or anything, just straight math.” In some ways this corroborates sentiments shared by the administrator when he shared about the pressures and atmosphere around mathematics and reading achievement and the consequent reality of science receiving less attention than the aforementioned.

The remaining data secured from students about their previous science experiences relates to memorable activities or demonstrations. For example, one student shared this when asked to recall previous science experiences:

> Zeke: In third grade, yeah. Can’t remember what it was. I just remember it had to do with something with grass and soil and water too.
>
> Brant: And you’re in sixth grade now?
>
> Zeke: Yup
>
> Brant: Have you done any science since third grade?
>
> Zeke: Yeah I think so, just can’t remember what else.

Another student's recollection included this excerpt about a memorable science demonstration: "my old teacher she had a plate and she put milk on it and she put food dye in it and she had a q-tip and it will go up and you put it in dish soap and will explode. That's what I got into."

Closely related to previous science experiences are how students define science. Science definitions from students came out of a question that provided a context by which to explain science. Generally speaking students were asked the question "What would you say to your little brother or sister or someone younger if he or she were wondering what science was?" From this question student responses were a combination of reiterations on what they have heard the value of science to be; as well as surface understandings of scientific components. For the former, students expressed definitions of science from the interview question that said science was important for getting a job, for going to college, and necessary if you wanted to be a scientist. For the latter, students defined science as figuring stuff out, creating stuff, inventing stuff, and that science uses hypotheses, guessing, and experimenting. Students also said that in science you test stuff and write results. The following is a quote from one student when asked to define science: "Experimenting, how to create stuff. And figuring stuff out." At no point within the data from this question did student relate a definition of science to personal experience.

When asked if they were good at science, approximately half of the students responded with a sentiment aligning with not being good at science. Three students' sentiments could be categorized as being "a little bit" good at science; with the remaining

two students' sentiments around this question showing positively towards their science ability. Interesting excerpts around science ability are as follows. One student shared that they were "not really good at science, just a beginner", in a similar vein another student share that they are "not good at science, it is hard." Other negative sentiments are similar in tone. Those students that feel they are "a little bit" good at science say as much with thin reasoning for that feeling. Students that expressed positive science ability prefaced this ability with an understanding of the magnitude of science knowledge. The following sentiments display this: "OK at science with a lot to learn", or "Sometimes good at science". Math ability was attributed to both struggling in science as well as being successful. Considering the latter one student had this to say when asked the science ability question: "Mm, I think so cause I know science has to do with math and I'm good at math."

The purpose for expressing student definitions of science and associated ability/sentiment was to lay a foundation for later considerations of science agency that will build from this baseline data. We will now look at the context of interest for this study, snow snakes.

Snow Snakes

The driving context for the culturally-based STEM curriculum was snow snakes. "Snow snakes" is both a traditional American Indian game played throughout North America in tribal communities where the climate is conducive to such winter time activities; and a physical item. A snow snake is a carved piece of wood that is said to emulate snakelike movements as it travels down an ice/snow track. Historically each tribe

had unique variations for the game of snow snakes but the basic rules of competition were the same throughout the various traditions. The most basic of rules being that the farthest snow snake to travel down an ice/snow track is recognized the winner (Culin, 1975). Today, active snow snake traditions are less pronounced. Some tribes maintain a vibrant tradition where others have become dormant.

Through the context of snow snakes, the curriculum integrates scientific content and inquiry, technological solutions, engineering design principles, and mathematical reasoning within a distance education environment. The curriculum is prescribed for a set duration with a snow snake festival culminating the efforts and activities of students. The snow snake curriculum was piloted during the winter of 2009.

There are no published accounts of the playing of snow snakes at White Earth historically. Unlike other reservations in close proximity (see also Reagan & Waugh, 1919), White Earth must rely on oral tradition alone for a retelling of any historical snow snake activities. It would appear that there are knowledgeable individuals of snow snakes that are associated with the White Earth reservation and the students attending Eagle Soaring School. One of the valuable outcomes of the partnership developed between tribal elder Regal and myself was Regal's ability to secure important cultural information about snow snakes from individuals who were well versed in traditional Ojibwe culture. The information was not readily available, therefore Regal inquired about snow snakes with individuals he knew that may hold some of the traditional cultural understanding about the game. Regal shared the following when talking about reactions to his inquiry of snow snakes at White Earth:

> Kind of what I am hearing out there as I try and loosen up this information and there's a lot of people who got to remember back, 25 or 30 or 40 or 50 years since somebody even brought some of this stuff up where we are even talking about it now. I mean some of these conversations haven't happened for 30 or 40 years. As near as I can tell…

By a many accounts snow snakes was played at White Earth historically, more than likely hundreds of years prior all the way up until a few generations ago.

Accounts from reservation communities within close proximity reveal a much more contemporary understanding of the game. For example one of the teachers interested in the snow snake curriculum shared a story at a snow snake curriculum workshop where as a kid he and some friends would harvest willow saplings for use as hockey sticks. Where a willow comes out of the ground the trunk makes a 90 degree angle as it reaches skyward. After becoming bored with playing hockey on the frozen river, the willow saplings went from hockey sticks to snow snakes. Impromptu snow snake competitions would ensue and wintertime recreation would be had.

One of the first parts of the snow snake curriculum had students seek historical accounts of snow snakes from their homes and communities. By doing this a knowledge base around local snow snake efforts would be created that could be called upon not only for using traditional ecological knowledge developed over time around snow snakes but also to begin developing an active oral and documented account of snow snakes that is meaningful to students' sense of place. Although it was hoped that student inquiries

would reveal a rich description of prior snow snake efforts, in reality what was found was less revealing, which corroborates what Regal had found with his inquiries with elders and our general sense of snow snakes at White Earth. What was found were isolated accounts of snow snake recollections. Bruce shared that some of his students had found success when inquiring about snow snakes at home as evidenced by the following interview excerpt:

> Brant: So some of your students had found success in finding people who'd heard of snow snakes or who had actually played?
>
> Bruce: I believe that we had one that had actually played, and we had a couple that had heard of it before, that, they had heard stories passed down from their grandparents or parent, but never had the chance, but had seen snow snakes like in the garage, you know, but never really knew what they were until the question came up, "hey dad what is this or hey grandpa what is this?"

Parker shared a similar example from student sentiment he had heard in his class by saying "Well, I've gotten 'My grandma's heard of them, and if my grandpa was still alive he knew about them'". Beyond this level of detail there was very limited or nonexistent information about snow snakes historically at White Earth.

In the early 1990's snow snake interest and efforts emerged in a heretofore unmatched inquiry. It is unclear the impetus for the game of snow snakes being sought at White Earth in the early 90's but it is during this time that the seed that has now blossomed into snow snake efforts as they are known today at White Earth was planted. The following excerpt from my reflexive journal on November 14th, 2009 describes one

of the many retellings I have heard Regal make around his involvement and subsequent snow snake efforts at White Earth:

> Regal shared his story about how he got involved with the snow snake business. Back in the early 90's Regal began talking to folks about snow snakes after being encouraged by community members that this was something to look into and possibly rekindle at White Earth. Regal was cognizant of the fact that sometimes things go away for a reason. As a result of these efforts snow snakes had a place at Unity School for [one] winter…. Regal became an obvious partner to seek when developing the snow snake curriculum.

Each time the account was shared by Regal, another layer of the story would emerge. For example, during one retelling Regal shared that snow snakes were a part of a winter festival at a local resort. Prior retellings had stayed the course of the community of White Earth seeking out Regal as a person that could look into bringing snow snakes back as a traditional wintertime activity in some kind of meaningful way. This resulted in snow snakes being constructed at a local school and an impromptu competition taking place on the school grounds during a school day.

Since the early 90's and the one successful snow snake project at Unity School, snow snakes again went dormant. No school sanctioned activities took place over the approximately 15 to 20 years prior to this latest snow snake iteration by which this study is based. There were no meaningful accounts of the game of snow snakes being played of any consequence around White Earth. Then in 2007, grant funding was secured through the National Science Foundation to deliver an after school and summer science,

technology, engineering, and mathematics (STEM) program to the upper elementary/middle school youth of White Earth. As part of the grant proposal, snow snakes was proposed as one of the traditional contexts that could be explored for curriculum development and programming. As a result, the first iteration of snow snake activities associated with this study was unveiled during the 2008/2009 school year as an after-school curriculum with associated activities, including the first annual snow snake festival. From this initial experience the curriculum was revamped and fortified for inclusion into the school day curriculum. During the 2009/2010 school year the snow snake curriculum was integrated into existing curricular structures at the case study site.

Curriculum

The snow snake curriculum was developed as a novel approach to engaging upper elementary/middle school students with science, technology, engineering, and mathematics (STEM) content through a culturally-based and relevant game. In an attempt to engage students in meaningful ways, the framework used for curriculum development contained three carefully integrated elements: (1) a culturally-based game/context, (2) an explicit integration of STEM content, and (3) a hybrid educational approach known as Adventure Learning (AL) which utilizes both online and face-to-face learning environments.

The game of snow snakes was identified as the culturally-based context by which to develop the curriculum around for a few reasons. First, snow snakes had been identified as a cultural practice that should be brought back into a more prominent role for wintertime recreation options according to tribal elders at White Earth. Secondly,

snow snakes is a game and therefore is inherently engaging. And lastly, snow snakes was deemed to be a robust context that could easily incorporate STEM content. This curriculum sought to integrate scientific content and inquiry, technological solutions, engineering design principles, and mathematical reasoning under the auspices of the snow snake context in part through an AL environment.

STEM, for the purposes of this research, was viewed as an integrated construct where each discipline works in unison providing students with the opportunity to solve content-specific problems through an engaging context. The acquired STEM knowledge was applied to help students successfully throw a snow snake down an ice track. Through the engaging context of snow snakes, the STEM curriculum explicitly applied mathematics (scaling and data), and science (force and motion) to an engineering prototype iteration that used available materials and tools (technology) for success.

Engineering design principles took on a prominent role during the preparatory period of the snow snake curriculum sequence. To highlight the application of science and mathematics content, an engineering prototype design iteration activity was conducted. The prototype curricular component provided students with the experience of testing a multitude of variables which elicited meaningful data that could then be scaled up for the full size snow snake to be used in competition.

The snow snake curriculum was aligned to the 5^{th} and 6^{th} grade Minnesota Academic Standards in Science (2009) and the American Indian Standards for Science Education (Bureau of Indian Affairs, 1996) (See Appendix C for curriculum). The science experiences prescribed by the snow snake curriculum took on the form of both

content and process. The scientific content components are most strongly found in phase two, parts two and three. In phase two, part two the rationale/goal for the section is explained thusly:

> Having an understanding of the scientific concepts of force and motion will enhance students' ability to apply sound design decisions to their snow snake prototype and subsequently their full scale snow snake. The goal for this part is to have students recognize and understand concepts of force and how force affects motion; and to use data to support these understandings. A final goal will be to differentiate between mass and weight.

Similarly in phase two, part three the rationale/goal states: "The goal for this part of the snow snake project is to illustrate potential and kinetic energy through snow snake prototypes." Both parts and the related scientific content were couched within the prototype phase of the snow snake curriculum. Therefore students' explored concepts and principles associated with force and motion, and potential and kinetic energy through a prototype design activity.

Much of the remaining curriculum delves into aspects of scientific processes. For example, in phase two, part four students collect data around their snow snake prototypes looking specifically at design variables that affect performance. By quantifying and qualifying aspects of the snow snake prototype and the subsequent testing therein; students were able to draw conclusions about how variables affect performance.

Adventure Learning

Adventure Learning (AL) as defined by Doering (2006, 2007; Doering & Veltsianos, 2008) is a hybrid distance education approach that provides students with opportunities to explore real-world issues through authentic learning experiences within collaborative learning environments. For this project the objective was to localize the adventure via snow snakes by utilizing the AL framework to engage students, teachers, experts and the greater reservation community. The adventure learning framework was used in writing the curriculum and will be used as the lens by which further details of the curriculum will be explained.

The purpose of the snow snake AL environment and curriculum was to foster historic cultural contexts while at the same time promoting modern STEM content. To do this, an online environment was developed where a highly interactive web-based environment was coupled with face-to-face components bringing a highly contextual real-time experience to students who participated in the study. The original AL framework included seven principles. The seven principles are:

1. A researched curriculum grounded in problem-solving,
2. Collaboration and interaction opportunities between students, experts, peers, and content,
3. The utilization of the Internet for curriculum and learning environment delivery,
4. The enhancement of curriculum with media and text from the field in a timely manner,
5. Synched learning opportunities with the AL curriculum,

6. Pedagogical guidelines of the curriculum and online learning environment, and
7. Education that is adventure-based (Doering, 2006).

To extend the viability of the AL framework to educators, researchers and places outside of the original context of an arctic dog sledding expedition, the framework expanded to include (a) the identification of an issue and respective location of exploration, and (b) exploration of the issue, environment, local population, culture, and additional relevant factors that provide an authentic narrative for students and teachers to follow (Doering & Miller, 2009). It is this AL 2.0 framework that was utilized for the development of the snow snake curriculum and the highly coordinated undertaking of delivering an AL experience to students in part through an online environment.

The online environment provided a place for students and teachers to interact and collaborate with other schools participating in the snow snake adventure. There were many collaboration opportunities for the schools involved with the program which included the case study site of Eagle Soaring School. The following narrative will look specifically at how the snow snake curriculum utilized the AL framework and some of the outcomes of this interweaving.

Snow Snake AL Overview

AL principle #1. The first principle within the AL framework is "a researched curriculum grounded in problem-solving" (Doering, 2006, p. 200). The curriculum acts as the foundation for all AL activities. The goal of the snow snake curriculum was to infuse grade level appropriate STEM content with the culturally-based context. The curriculum was organized into five phases. Each phase represents a unique yet important

component in the sequence students followed towards meeting learning objectives associated with the snow snake “adventure”. Within each phase, sub-categories are referred to as “parts” and represent individual lesson components that are guided by a central question or questions. The five phases of the snow snake curriculum are as follows:

1. Background – Shushumeg (Snow Snakes)
2. Prototype Construction and Testing
3. Full Size Design and Construction
4. Body Mechanics
5. Shushumay Festival

Driving the curriculum were the learning outcomes. The learning outcomes for students are as follows: 1) Students will be familiar with STEM content associated with the context of snow snakes. The STEM content associated with the curriculum was derived from the context and identified as appropriate for the level of students. For example the physical science concepts associated with force and motion include Newton’s laws of motion, friction, pressure, weight, surface area, etc.; and 2) Students will be familiar with the traditional game of snow snakes played during the winter months. Students will be able to collect appropriate wood blanks from the forest, design and craft wood into a snow snake, and skillfully throw the snow snake down an ice track. As a result of these learning outcomes, the curriculum and associated adventure began to take shape. Each part within the five phases was guided by one or more central questions. For example, the first part of phase two had three central questions:

1. What is a prototype?
2. Why use prototypes?
3. What scientific principles from preexisting technologies can inform the development of snow snake prototypes?

The central questions then guided and dictated the types of experiences students had within each part, working toward the answering or solving of the question or problem respectively. With the learning goals and central questions in place, the adventure then became the progression towards the Snow Snake Festival and the progress made from the selection of snow snake material to the decorating and wielding of the snow snake itself. Ergo, the overarching problem students set out to solve could be stated as: "How do you make the best snow snake possible?" Each of the lessons within the curriculum appealed to a part of this question, with all parts leading to a whole, the ultimate judging and competition of snow snakes at the festival. The Snow Snake Festival signifies the end of snow snakes for the winter season.

AL principle #2. The second principle in the AL framework states that an "AL education provides collaboration and interaction opportunities between students, experts, peers, and content" (Doering, 2006, p. 202). If the curriculum is the foundation of the AL experience then the ability for participants to collaborate could be considered the "heart of the educational experience" (Doering, 2006, p. 202). Consistent with this view of the second principle, the snow snake AL program thrived when the collaborative opportunities were realized between students, teachers, and experts.

The collaborative opportunities within the Snow Snake AL environment could be found through photo and video uploads, blogging (text and/or audio), and expert chats. The online environment known as the “snow snake den” was the designated place where students, teachers and experts could interact in meaningful ways as prescribed by the snow snake curriculum driven by the AL framework. Throughout the snow snake curriculum there were carefully embedded instructions for teachers that encouraged “Website Interaction”. A common directive within the pedagogical guidelines portion of any given part read thusly:

> Make time to interact with the project website. Things for students and teachers to do on the site include: View and upload photos and videos; listen to and upload podcasts (audio blogs) and music; read and write blogs about the snow snake experience.

For example, during the snow snake prototype phase students and teachers uploaded photos and video of their progress and experience constructing and testing snow snake prototypes. By having the ability to see peer progress at a remote site, students were motivated by new design ideas that in turn promoted continued effort and varied design approaches.

The expert chats were conducted once a week during each week of the snow snake AL program. The expert chats corresponded with the content and activities of that week, therefore enriching the overall experience through a uniform and timely progression of the curriculum sequence. For example, during the first phase of the snow snake curriculum (titled: Background – Shushumeg (Snow Snakes)) the partnering tribal

elder was the expert and discussed his experience and knowledge around snow snakes with an opportunity for students to ask questions through the online environment. Another example was, prior to the engineering design prototype activities, an engineering education professor participated as the expert on the subject of engineering design and prototyping. Students were able to ask questions on prototyping and the reasons for constructing a snow snake prototype prior to the experience of constructing a full scale model. The expert chats were conducted in an Adobe Connect environment. Adobe Connect is a web conferencing product that allows participants in the environment to interact via audio, video and text; along with sharing computer documents of various formats. The chats were moderated by the expert by means of selecting questions from students as they came through the chat program.

Principle support and evidence. The expert chats represent a key element within the online learning environment for promoting positive experiences for students and teachers and fostering the development of science agency. Invariably students and teachers spoke highly of the expert chats associated with the snow snake curriculum. The following interview sequence is a representative example of student sentiment towards the expert chats:

Brant: Can you tell about your experience with snow snakes on the computer?

Coco: No.

Brant: What part of snow snakes on the computer have you liked the best?

Coco: When you had an expert chat, all four of them.

Brant: What have you liked about the expert chats?

Coco: They talk about how to throw them and their design and what tools to use for your snow snake.

From a teacher perspective: “They enjoyed everything about it. They enjoyed the experts that have been brought in to chat.” In an effort to probe deeper into the value of expert chats, another look at the student perspective and the perceived value can be taken. In the following excerpt Zeke shares that by being a part of the snow snake community as defined by the AL environment broadly and the expert chat specifically; his thinking is enriched around snow snake ideas.

Brant: Can you tell me about your experience with snow snakes on the computer?
Zeke: Like some kids really ask good questions and that kind of helps me find out some of the information that I need to know…

Without the new ideas and thoughtful questions from students outside the face-to-face environment, Zeke’s conceptions of snow snakes and the associated dynamics may have remained static to Eagle Soaring School. As it were, Zeke’s conceptions of snow snakes were expanded as a result of the expert chat and the AL environment and therefore fostering the development of science agency.

Supporting Zeke’s sentiments, one of the teachers, Bruce, concurs that there is value in bringing a “community” together within an online environment:

The chats have been very useful; the kids really look forward to the chats. And things like that….[interruption]….But no, like the chats, you know, they’ve been very useful for the kids to see other people’s perspectives and the questions that

others ask that sometimes my kids are thinking about asking but they might not ask. Um, so then they get answered and then someone mentions something and that sparks them to answer. The chats have been useful.

Parker was in agreement with the sentiments of Bruce.

Brant: So you touched upon a variety of aspects of the curriculum, if you had to pick one or two highlights so far, what would they be?

Parker: Well, two highlights, one would be, um, the use of technology with our chats. The kids look forward to interacting and gaining knowledge in that way. It seems kids that I work with learn better with more hands on things. When we do our chats they've had an opportunity to hear audio, see in the text written, so there's all kinds of different ways of learning. They are touching the keyboard, interaction, and their getting a lot out of it. Not one behavior problem usually during our chats.

Feedback from students, teachers and experts who participated in the collaborative activities all commented on how engaging and surprisingly fun participation was. Students enjoyed communicating and sharing with their peers at other sites. Teachers enjoyed seeing how student engagement and motivation was heightened through the collaborative mechanisms. And the experts were pleasantly surprised at how much they enjoyed interacting with students and chatting in a synchronous chat environment.

AL principle #3. The third principle in the AL framework is that an "AL education utilizes the internet for curriculum and learning environment delivery"

(Doering, 2006, p. 207). The internet provides students, teachers, parents, and experts with access to the "heart" of what makes AL such a powerful learning medium, that being the interaction and collaboration with individuals no matter where they are located geographically. Access to the internet and subsequent engagement within the online environment allowed the participating schools to interact and collaborate.

This point in the narrative provides a good entry point into a brief explanation of the dynamics associated with this study. As noted previously, the design of the study is a single case with multiple embedded units. All findings are bound by this case and do not veer, unless clearly noted otherwise. Snow snakes was experienced by more students than just those at Eagle Soaring School. The snow snake project took on a multifaceted tone considering the investment into the development of the curriculum, professional development of teachers, promotional efforts throughout northern Minnesota, and the perceived value in more students participating in snow snake efforts than less. With this being said, the online environment was used by up to five schools and potentially hundreds of students during the course of snow snake activities. In this way the online environment associated with the curriculum represented a common meeting place for student, teachers, experts, and associated community members. Since individuals and entities outside the bounded case were not of primary interest to the study, the associated anecdotal information will not be shared.

The two primary ways in which Eagle Soaring School interacted with school sites geographically distant was through the expert chat mechanism described previously and the culminating event, the snow snake festival that brought the geographically distant

school together at a centralized location to celebrate and compete around the snow snake tradition. Beyond these two synchronous event types, the remaining interactions were asynchronous and occurred exclusively at the project website to be discussed in the following paragraphs.

The online platform known as *Ning* was chosen as the medium to deliver the online portion of the AL curricular experience. Ning is a low cost social networking service that allows users to create their own social networking sites around specific subject matter. Think of it as a type of Facebook with a specific theme and the ability to privatize the audience. The Ning environment provided adequate tools to carry out the various objectives prescribed by the AL framework.

The following are brief synopses of how the internet was used to deliver AL components and how users interacted therein. Firstly, the curriculum and associated pedagogical materials were saved as portable document files (pdf) and uploaded to a blog entry titled “Resources”. Within this entry the curriculum could be accessed in its entirety along with student handouts, data sheets, and assessments that were needed at various points throughout the AL sequence. Secondly, the internet was used for interactive and collaborative experiences that were synched with the curriculum. For example, the expert chat topics were sequenced parallel to the content and progression at specific points during the snow snake curriculum. Blogs and liberal uploading of images and video also enhanced student engagement through monitoring progress at other schools sites. As students saw the progress of their peers at other sites they were motivated by knowing that others were working toward a common goal, that of the Snow Snake Festival, as well

as gaining insight and ideas about snow snake design providing students with material for new things to try with their own snow snake design and construction.

AL principle #4. The fourth principle in the AL framework states that an "AL education enhances the curriculum providing authenticity with media and text from the field in a timely manner" (Doering, 2006, p. 208). For snow snakes the field encompasses the multiple sites participating in activities and the progression through the snow snake design and construction process through to the Snow Snake Festival. The trail reports written by the program coordinator would include progress for the week and an overview of activities conducted. Students from each school site were encouraged to comment on the blog, sharing their experience from the week and any tips or ideas that they came up with from the previous week. Trail reports were posted weekly to keep updates consistent with activities and to continue building the momentum for the culminating snow snake festival and the developing "adventure".

Encouraged from each school site, each week, was the uploading of media (either still images or video) to the Ning site for all to see. By continually updated the media and text within the Ning site, there would almost always be something new for students to see and interact with when they logged on to the site.

Principle support and evidence. According to students, the most valuable media that they had access to were the videos about snow snake traditions both historical and contemporary. At multiple points during snow snake curriculum, select videos were viewed by students as it made sense during the curriculum sequence. Often times these videos provided students with important insight into their current understanding about

snow snakes, shedding light on how to proceed or provide ideas for future snow snake development. One example of a student sharing about the value of media in the form of video to her snow snake thinking is represented in an interview excerpt from Catherine:

> Brant: Can you tell me about your experience with snow snakes on the computer?
>
> Catherine: I learned that they make tracks that go like a hill but then they make it far and they make a skinny part at the end and then you just have plain sticks and throw it.
>
> Brant: So you're talking about the video?
>
> Catherine: Mmhmm

Another example of how media can stimulate future thinking about snow snakes is found in an interview excerpt with Nicolas:

> Brant: What would you do in the future? Like how would you design a snow snake in the future?
>
> Nicolas: I would go out and buy some wood and then get a little saw thing and cut it into a circle and sand paper then paint it. That's what I'd do.
>
> Brant: How do you think you know all that?
>
> Nicolas: Watching that video, cause when he got that one thing then he was doing it the saw thing and put that one thing on top of it, smelted it on it. That's where I got that idea.

When asking a more general question about the overall curriculum, Parker expressed that media and text associated with the AL framework principle as being one of the highlights of the overall curricular experience.

> Brant: So from your perspective, what aspects of the curriculum have been the most powerful in the sense of student engagement and interest?
>
> Parker: Hmm, well, equally powerful are the online, either the trail reports, the photographs that have been put on, and the chats.

AL principle #5. The fifth principle in the AL framework explains that an "AL curriculum provides synched learning opportunities" (Doering, 2006, p. 210). The snow snake AL environment provided three ways in which synched learning opportunities could be experienced. First, building upon the importance of interaction and collaboration within an AL environment, the expert chat mechanism mediated through a virtual environment added to the sense of interaction and collaboration felt by students, teachers, and experts associated with the snow snake AL program. The expert chat topics paralleled points in the snow snake design and construction process.

The second way the snow snake AL environment provided synched learning opportunities was through the synchronization of the STEM content and the snow snake context progression. The goal of the snow snake AL experience was to introduce a traditional game, construct the implements for that game following traditional ways of knowing, and participate in the traditional game following guidelines gleaned from tribal elders and published materials and accounts. While this progression took place within the

context, the STEM content was assisting students in building their knowledge of how the game fundamentally works by incorporating physics content through force and motion concepts that were then applied by propelling snow snakes down an ice track. Another angle was the incorporation of engineering design principals when talking about designing elements of the snow snake and manipulating variables such as the placement of weight so that the snow snake would travel as far and fast as possible down the ice track. Through the context of snow snakes, students were able to more easily engage in the STEM content introduced.

A final synching of the learning opportunities associated with the snow snake AL curriculum can be found when looking at the content/context as it is associated with the media/text solicitations and updates. The snow snake AL project strove to remain consistent with the prescriptions made by Doering (2006), keeping in mind that "the online learning environment where the media opportunities exist must be designed in tandem with the curriculum" (p. 210). Ergo, the activities and experiences students, teachers, and experts had within the snow snake AL environment could be directly linked back to the point in the curriculum and the associated content/context at that point in the progression. For example, when students were learning about the final preparations to be made with their snow snakes, they experienced an expert chat with a tribal elder talking about traditional art, as well as uploading photos and video of their personal progression and experience with their snow snakes at that point for all to see within the virtual environment. Each student could then monitor/enjoy their peers' interpretation of

traditional art as it related to snow snakes, furthering the interaction and collaboration that is so fundamental to the AL framework.

AL principle #6. The sixth principle in the AL framework says that an "AL education has pedagogical guidelines for the curriculum and online learning environment" (Doering, 2006, p. 211). Included within the complete snow snake curriculum document were pedagogical guidelines to assist the instructors in the delivery of each aspect of the curriculum. For example the snow snake curriculum document provided different ways to look at the scope and sequence of content and context related to snow snakes. One of the ways instructors could take a look at the curriculum was through the "Curriculum Overview" feature. Through this mechanism, instructors would have a brief overview of each section of the curriculum and how that piece fit into the overall scheme of things. Instructors could also look specifically at the technology needs and expectations during the snow snake AL program. When looking at the complete curriculum document, including individual lesson plans, instructors would also find specific suggestions for delivery and considerations to make given various logistical dynamics. A teacher could choose to follow the scripted pedagogical guidelines exclusively in their entirety; or, depending on existing curricular expectations unique to their situation, they could pick and choose those components of greatest interest.

Beyond the stand alone curriculum document, the limited number of participating schools allowed for on demand access to support prior to and throughout the delivery of the snow snake AL curriculum for instructors. Before the snow snake AL curriculum was delivered to students, a face-to-face in-service training session was delivered to

participating instructors. During this in-service training, instructors were introduced to the game of snow snakes, the associated curriculum, the AL environment, and logistical details associated with materials and snow snake construction. During this time instructors were encouraged to ask questions and familiarize themselves with materials that they would be expected to deliver to students in the upcoming weeks. Along with the face-to-face in-service training the instructors had direct access to the curriculum developer and technical support staff (same) via phone or email.

AL principle #7. The seventh principle (and final according to the original AL framework) states that an "AL education is adventure-based" (Doering, 2006, p. 211). Dictionary.com defines adventure as "an exciting or very unusual experience." Invariably, upon mentioning the words "snow snakes", it has been my experience that a listener's interest is piqued with a desire to hear more. Contrary to what one may envision when he/she hears the word adventure, that of a large scale expedition or a foray into a mountainous wilderness; this adventure is grounded in the revealing of the individual snow snakes and the mounting anticipation of the culminating activity, the Snow Snake Festival. To support this adventure a variety of mechanisms were in place (many of which were noted previously): collaboration, competition, technology/media, and the Snow Snake Festival. The progression of the snow snake AL curriculum lent itself to building anticipation and consequently motivating students. As students progressed through the design and construction of their snow snake, all the while receiving updates on peer progress through the AL environment, the anticipation towards the Snow Snake Festival increased.

The two additional AL framework pieces that move the original framework of seven principles into the AL 2.0 framework of nine are immensely important to this study. To reiterate, the two additional principles are (a) the identification of an issue and respective location of exploration, and (b) exploration of the issue, environment, local population, culture, and additional relevant factors that provide an authentic narrative for students and teachers to follow (Doering and Miller, 2009). Beginning with the former, an explanation will be given on how AL 2.0 and the snow snake curricular experience worked in unison.

AL principle #8. The culturally-based and historically played game of snow snakes and its affective dormancy during the previous generations represents the "issue" in the "location" of the White Earth reservation, but also in many other parts of the state and region. With the exception of the Iroquois people in New York and to a much lesser extent, Wisconsin, the game of snow snakes and the associated tradition and cultural implications have been relegated to small pockets of individuals that play the game through informal gatherings. It was the expressed desire of White Earth elders to inquire about this game, as explained by Regal, which brought the issue to the forefront and has subsequently become the issue for exploration by students, teachers, experts, and the community as part of the AL framework.

AL principle #9. The AL principle charged with exploring the local issue was manifest in the snow snake curriculum during Phase 1, Parts 1 and 2 (See Appendix C). To begin the snow snake curriculum after the "Alert" podcast and narrative is experienced; students were tasked with gathering local knowledge about snow snakes.

This local knowledge was gathered to paint an accurate picture of the current condition of the snow snake "issue" at White Earth. From this local knowledge, students explored historical academic or anthropological literature about snow snakes that highlighted not only snow snake traditions in Minnesota, or locally, but also gave a broad survey of snow snakes throughout North America (see also Culin, 1975; Parker, 1909; Reagan & Waugh, 1919). With the aforementioned snow snake foundation in place, students, teachers, elders, and the greater White Earth community could then begin to explore and define what snow snakes would mean for their community now and in the future by keeping a close eye on the cultural implications therein.

Curriculum Implementation

This study relied in large part upon the fidelity in which the curriculum was implemented. Having the case study site follow the curriculum as it was authored was paramount to the outcomes secured during the study. Both teachers implementing the curriculum at Eagle Soaring School were asked questions pertaining to the projected implementation prior to the beginning of snow snake activities. Reflections on the actual implementation were secured during successive interviews. From this data, a more accurate picture of student experience can be seen and therefore discussed as impacting the development of science agency in students.

Prior to snow snake curriculum activities it was projected by the two teachers of the study that snow snake curriculum activities would command anywhere from 30-45 minutes, 3-5 days a week. Parker shared that:

> …it looks like every week from here until the festival looks like we are going to be working on it three to five days a week at least. 45 minutes a day for those three to five days. And we are going to give the kids every chance that they need to be successful in the festival.

Given the history of Eagle Soaring School with snow snakes and the teachers associated with the study, it was not surprising to hear this level of commitment to snow snake curriculum efforts.

At the time the snow snake curriculum was prescribed to begin during the second full week in January 2010, the Science Fair had taken on an important role during the school day. The RFTS project had many facets as had been noted previously. Science Fair and snow snakes were both under the auspices of the RFTS program and both were supported by the partnering schools. The science fair activities had an overlap with snow snake curriculum activities of approximately 15 school days which affectively cut into the entirety of phase 1 and part of phase 2. This is of note because it compromised the attention and energy students and teachers were able to give to snow snakes during the early parts of the snow snake curriculum sequence. This sentiment was expressed by both Parker and Bruce. After the science fair activities were completed and focus was placed on snow snakes, Bruce shared this comment when talking about snow snake activities during the midpoint interview:

> I feel like I'm kind of rushed right now just to catch up and get back with the crew. Because we started about two weeks late which I told you we probably would. But, um, yeah it seems to be flowing nicely.

This sentiment was echoed by Parker by saying:

> …one complication that we had here is that it kind of all fell at the same time as our science fair. And we are pushing reading a lot, we are pushing math a lot, but we always try and set up 45 minutes to a half hour at the end of the day to either work on snow snakes and science fair. Well it got to be crunch time you know for about a week with the science fair projects due and we didn't have a lot of time for our snow snakes that week so we fell behind a little bit.

From these comments and the timing by which the science fair event occurred, it could be reasonably deduced that although some effort may have been given to reading the historical literature as part of phase one, part 2; it was more than likely passed over due in part to the science fair overlap. The three main activities during the 3 weeks of overlap with science fair activities were building local snow snake knowledge by students inquiring at home and in their community, the reading of historical snow snake literature, and the beginning of snow snake prototype activities. From the data secured, students did inquire about snow snakes with limited success; the historical literature was "skimmed" or not addressed; and snow snake prototype were given their full attention due, although not necessarily at the prescribed time.

During the final interview the teachers were again asked to reflect on the implementation of the snow snake curriculum. Both teachers confidently expressed that the curriculum was followed to the best of their abilities given the early scheduling complication with the science fair. Recommendations were made by the teachers to possibly start snow snake curricular efforts earlier in the school year during future

iterations to ensure enough time to give proper attention to all curricular components and to more easily negotiate the potential overlap with science fair. Parker reiterated what was shared during the midpoint interview by saying:

> We didn't get to go through the history as much as we could've. We got to the prototypes pretty well and we spent quite a bit of time on the full scale. But I feel like we might have missed out on some of the earlier things, just because of the time factor.

Similarly, Bruce shared that they "skipped a lot of the readings" during the early historical component but that they "actually extended the prototypes longer". The extension of prototype activities was in part due to student engagement and the organic extensions that materialized as a result of activities, e.g. a competition component with further data collection.

Overall the fidelity in which the snow snake curriculum was implemented at Eagle Soaring School was satisfactory to the outcomes of the study. Although some phases of the curriculum and their actual implementation remain somewhat unclear; according to the data, the evidence for their conduction (e.g. artistic rendering) shows that they indeed were. Curricular phases were more than likely modified from the original prescription given the dynamics of the school day, student actions, and teaching style.

Curriculum Extensions

"Curriculum extensions" was a code that was used to identify "any reference to activities that have been integrated beyond the prescribed curriculum." This particular code takes on an important role when considering the development of science agency in

students because of the meaning by which students value the "extension" activities. As the teachers following the prescribed curriculum, there were a variety of situations or opportunities that arose that the teachers took advantage of. For example, during the implementation of the snow snake curriculum during the timeframe of January 11th – March 13th, the winter Olympics were staged in Vancouver, British Columbia February 12th – 28th. The teachers implementing the snow snake curriculum at Eagle Soaring School took advantage of the "teachable moment" and explicitly made connections between the STEM associated with snow snakes as prescribed by the curriculum and the STEM associated with the many Olympic events and the specialized equipment used. When asked to explain some of the highlights of the snow snake curriculum, Bruce talked about the seamless timing and connection between what they were doing with prototypes and the myriad of connections to be made with Olympic events. When these connections were made between the two contexts, snow snakes and the Olympics, students began to make connections with how STEM content played a role. According to Bruce:

> we would start talking about the Olympics and it kind of played a perfect timing role, and we were a little bit behind everybody else because we had some other things we had to do before we started but we talked about the luge, we talked about the skiers, we talked about the ice skaters, you know, what different types of things are they using and then they started to change the design a little bit. Rather than having skis down, they decided to tilt them a little bit so it was like the edge of a ski, or it was like a skate, you know, or it was like luge, less friction, less drag on their prototype and the results have shown that it really does work

> and a, you see the kids realize that, “oh, that’s what friction means”, or, “oh, that’s what it means to place your weight”, you know, where should your center of gravity be or how moving it can really change things. So it’s a, really helped them learn, and speed the process on things that really take a long time usually.

Parker shared similar experiences from his perspective. By using student familiarity with the Olympics, Parker was able to ask questions and dialogue with students in the following way:

> “…the Olympics is going on right now in Canada and what are some of the things that were used in the Olympics like skates or luge or skis or snowboard, and how are they like some of these prototypes?” Well some had the end curved up, some had the concave in the middle, some had wax. Different things like that that kids are starting to pay attention to, friction, “okay, does a figure skate have a lot of friction when it is cutting across the ice?” And they’re really starting to relate that.

The Olympics was a serendipitous and unplanned curricular extension that the teachers responsible for implementing the snow snake curriculum at Eagle Soaring School recognized and subsequently leveraged for the benefit of their students.

The next curriculum extension relates to snow snake prototypes. Snow snake prototypes will be discussed at greater length later on in chapter five. At this time it is necessary to comment on prototypes briefly because of the role they played in teacher driven curriculum extensions. The integration of a competition component into the prototype phase of the curriculum represents an important curricular extension.

Competition is a seemingly natural extension of the prototype testing and engineering redesign iteration, but it was not a part of the original curriculum. According to Parker, "we had a little prototype competition to see what prototype would make it the farthest. We set up a bracket; all of the kids were kind of pretty excited about it." From multiple accounts of students and teachers, the competition aspect heightened student interest and motivation to design a snow snake prototype that would be successful in the competition.

The last curricular extension of note that took place during this study was the explicit integration of culture in the form of ceremony/blessing towards the deeper meaning of snow snakes. The impetus for having a snow snake blessing ceremony was the conversation and subsequent sharing of oral tradition between Regal and another elder that was facile with the traditional story associated with the snake. In the ceremony, the tribal elder that Regal sought out for his deep understanding of the cultural tradition associated with snow snakes, conducted a blessing ceremony that essentially asked the snakes to come out to play. It must be noted that the stories associated with this cultural tradition are sensitive and need to be handled with great care. The timing of the blessing ceremony was important because it needed to be done before the full scale snow snakes were thrown for practice and/or competition. Where other curricular extensions were spearheaded by the teachers responsible for delivering the curriculum, the blessing ceremony was brought to bear by Regal and his deep conviction for proceeding with snow snakes in ways that were respectful and consistent with Ojibwe culture.

Value of the Curriculum

Beyond looking at the actual implementation of the snow snake curriculum as reported by the teachers and as observed; there are other individuals that have attached meaning to the curricular efforts and the resultant outcomes. As noted previously, the snow snake curriculum was developed with the specific intent to highlight a robust and important culturally-based context through not only experiencing activities consistent with the culturally-based context historically but also through accurate and meaningful STEM content. Individuals associated with the snow snake curriculum and in positions of import have attached meaning to snow snake activities associated with this study. One of the codes developed to capture this sentiment was called “Curriculum value” and was defined as “any expression that attaches a value to the snow snake curriculum either as it aligns with current educational objectives at Eagle Soaring School or on standalone merits.” In addition to Parker and Bruce expressing sentiment about the value of the snow snake curriculum as the primary teachers of it; the school administrator, a parent of participating students, and a community elder also associated meaning to the curriculum.

Beginning with the value teachers have placed on the snow snake curriculum, their mindset is on how the snow snake curriculum supports what they are tasked with doing in the classroom. Parker shared that

> they [students] are communicating with each other, working together, working by themselves. Going out and learning about the forest a little bit. Learning about engineering. So it’s perfect, it hits all of the science standards. Just what we’re looking for.

When Bruce was asked about general reflections he had about the snow snake curriculum at the midpoint interview, he expressed the value in which the curriculum was able to make heretofore static, unrelated science content come alive when the context used the content in meaningful, generative ways. This quote from Bruce highlights this sentiment:

> I really like the science being intertwined with the curriculum. It has been a great way to show the kids the difference between, you know, different tools of showing them what friction means, what the motion is, how matter plays a role in things. Because now we have not just the pictures and the definitions and talking about it but we also have, you know, the snakes themselves or the prototypes themselves to show the difference, you know, and it really has helped the kids learn what those mean.

The curriculum has also revealed strengths in motivating students to engage with the curriculum. Parker shared an example of students who were initially resistant to snow snake activities but due to the activities and opportunities associated with the curriculum, these same students changed their tone and became active learners. According to Parker:

> We had one or two kids at the very beginning when we went and harvested the snakes that didn't think that they wanted to partake in that activity at all. Didn't want to do snow snakes. Well as we got into it more and more and we started going and using our technology, and started learning about things that you could learn about at home and bringing it in and all of the sharing that goes on. That same kid now is excited to be in the festival. Excited to work on her snow snake when we get the chance every time.

The competition element should not be lost on the value of the curriculum and its ability to motivate students. Bruce shared that by adding "the competition factor that gave them that extra drive to actually learn more about it. Understand the dynamics of the whole project, which I thought was useful."

Along a similar vein as the teacher's reasons for attaching value to the snow snake curriculum, the administrator looked at the snow snake curriculum with an understandably broader lens. Considering Eagle Soaring School and the value placed on the integration of Ojibwe language and culture, the snow snake curriculum was looked upon favorably by the administration as a result of the curriculums ability to meet these needs. Here the administrator describes how the snow snake curriculum meets the "litmus tests" he requires curricular structures to pass at Eagle Soaring School:

> One of the things that I tried to instill when I came here was every activity we do has to have, has to pass four litmus tests. The first one is that it has to be intentional, so the activity needs to have a desired outcome and in the case of the snow snakes it's learning about culture and then experiencing some of those same activities that their ancestors had experienced. Another one is that it has to be research based and snow snakes is a hands-on student directed activity where they can choose their materials, they can choose their design, they can create their project, there's no rule that says it can't be a certain way. And so in the end they learn some things on Saturday that certain snow snake shapes work better than others, so next year when they make one I'm guessing that they will take that knowledge with them. The third litmus test is that it is based on the standards and

> again, the snow snake project does fit into it. It covers the cultural, historical concept of the people who occupied this part of Minnesota in earlier times. And the fourth litmus test is that it is sequential. It's pretty obvious of the sequential nature because our top three winners were all 6th graders, and because they had experienced or were in a group that had experienced it before, because sometimes we can learn from the people around us. Each year that we do this I think we will see that sequential nature get stronger. And so from an educational standpoint, snow snakes is a, it meets our litmus test for an activity.

Beyond the lens by which the academically minded individuals attach value to the snow snake curriculum, there are individuals such as parents of students participating in snow snake activities and community elders that have a different yet not unrelated motivation for valuing the snow snake curriculum. The parent's valuation of the snow snake curriculum represents a sentiment that, although related to the values placed on the curriculum by teachers and the administrator associated with snow snake efforts, has a markedly different tone when associating value. The parent interviewed for this study had two students who were participating in snow snake curricular activities. This parent and associated students/children also participated in snow snake activities the year before and were quite successful (champion and runner-up). Misty (parent) saw snow snakes as being a valuable school activity as a result of her observations of the engagement with snow snakes versus other school activities and the consequent learning that occurs when students are engaged instead of being off task. The following quote by Misty expresses how she values snow snakes versus more traditional Western academic structures that are

familiar to students and that potentially come with a history of associated classroom management issues:

> I think they had a lot of excitement focused on just the snow snake part. To where the other classes and stuff where it wasn't any different with them or anything but god did they want to be able to just, they couldn't wait for the time to do their snow snake, you know. To where if they'd go to their other classes whatever, act up there, but once it was snow snakes it was focused on gettin' their stick done, and you know, but otherwise no, they didn't have no other difference in classes or nothing, it was just mainly their snow snakes. They just wanted, I think if they had a choice to do it all day I think they would have rather done snow snakes all day than the other classes. But yeah, they enjoyed it and Curt's pretty upset that he's going to 7th grade next year and that, to Mahnomen School you know.

To Misty, time on task and excitement towards the task are both indicators of a valuable curriculum. Misty did not seem to be as concerned as others with the culturally-based context but was more interested in her student's engagement and the avoidance of "acting up" and therefore not learning.

The community elder partnering on the project had yet a slightly different lens by which he valued the snow snake curriculum. A motivation for Regal when discussing the snow snake curriculum and outcomes was for "common knowledge to become common again". The common knowledge Regal spoke of was associated with a deeper understanding of the interconnected nature of the world around us and the interactions

humans have with the environment that are important to sustainability. Historically the Ojibwe people lived so intimately with the natural world that they knew not only content of that world but also the cultural implications for interacting in certain ways. One of Regal's valuations of the snow snake curriculum comes when talking about his desire for students to understand forest ecosystems:

> We are a forest people and a lot of these kids don't know much about the forest. So, um, how do we confer that to them? And I think this ah, Gooniginebeg [snow snakes] is one way that that can happen.

Support for Cultural Relevancy

To provide evidence and support for the cultural relevance of the snow snake curriculum and activities to students at Eagle Soaring School the following interview excerpt with Parker reveals how the curriculum aligns with Ojibwe culture and school objectives from a teachers point of view:

> Brant: From your perspective, what aspects of the curriculum were culturally relevant?
>
> Parker: I would say that the whole curriculum was culturally relevant because we talked about the history of the snow snakes and how it was played in this area years ago. Then we had students go back and talk to their elders about what they used to do in the winter for pastime, or if they had ever heard of the snow snake game. And then from there it went into them actually learning to play the game themselves and bringing back that history, using the Ojibwe language and parts of

> the snow snakes, and, you know, the shushumeg or a you know the different words that were used were culturally relevant so, basically the whole works had cultural relevance and history and science. Really integrated on most every class at school too, your language arts, your vocabulary, and your science and your culture and your history.

As noted in the "limitations" section of the previous chapter, although the curriculum and activities are culturally relevant for this case study, the cultural relevance would cease outside of a completely Ojibwe student population.

In this chapter a journey was taken from large to small, presenting contexts that will be important to consider in the following chapters. Beginning with the overarching bounded case and the associated figured world, a big picture lens was placed on the contexts for this study. Delving deeper, considerations were given to the types of science experiences students had at Eagle Soaring School before experiencing the curriculum implemented for this study along with a grounding in the context of snow snakes, both of which set the stage for an in-depth look at the culturally-based and integrated STEM curriculum. The curriculum was then explained in part through the lens of the Adventure Learning framework by which the curriculum was developed. The chapter wrapped up with an explanation of curriculum implementation, enacted extensions, and value placed therein. Now that the stage has been set, an earnest look can be taken of the findings for this study that are associated with the research questions.

CHAPTER FIVE: FINDINGS

Impacts of Curriculum Experience

Now that the stage has been set, it is possible to look at specific outcomes and impacts of the culturally-based STEM curriculum. The outcomes and impacts can be put into three overarching categories with each category having various subcategories. The three categories are Science and STEM learning, Agency, and Community Impact. It is through the proceeding explanation and evidence within categories that the research questions associated with this study will be answered with further discussion to follow in chapter six.

Science and STEM learning

Science Content

As a result of the explicit scientific experiences in the snow snake curriculum, students expressed various associations between science and snow snakes. Given that the curriculum was an explicit integration of STEM content with a culturally-based context and that science agency was the outcome of interest; "Science content" was an important code to look at for a number of reasons. The code "Science content" was defined as "any reflection of science content knowledge resultant of either the prescribed curriculum or curriculum extensions." An example of a student expressing scientific content associated with snow snakes can be found in the following interview excerpt:

> Brant: Can you tell me two things you have learned about science through snow snakes?
>
> Daisy: How to tell about the stick for friction and how to throw it good and seeing

the level point if you drop it, you have to see which weight does better and if it's not on the right point that stays there it won't go that good…

Brant: So how did you learn about friction and the balance point?

Daisy: Throwing them.

This excerpt is an example of science content gleaned as a result of experiencing the snow snake curriculum. The following is an example of a deeper understanding of scientific processes that can be attributed to experiencing the snow snake curriculum:

Brant: Can you tell me two things you learned about science through snow snakes?

Christopher: Um….The testing of it…

Brant: Can you talk about that a little bit? What do you mean by testing?

Christopher: Testing how to throw in the gym. How smooth it will go, how good it will go, and if it will work in the contest.

Brant: How is that science?

Christopher: Like testing a new experiment you got and just found out. That's all I know.

In another excerpt a student exhibits clear and accurate use of scientific language and dialogue.

Brant: Can you tell me a little bit about how you might use the science learned through snow snakes in your life?

Nicolas: Mm….I used hypothesis on Zekes cause his didn't really go that far.

Brant: What was your hypothesis?

Nicolas: That it wouldn't really go far. And I guessed it right, it didn't go that far. But in the gym it went pretty far, but on the soft snow it just dug into the ground.

Throughout the student data there were multiple instances of students expressing scientific understanding for both content and process. Common scientific terminology and phrases used associated with content included: friction, balance point, testing, power, mass, aerodynamics, hypothesis, and guessing. When students were asked about the science associated with snow snakes, often times they would refer to experiences within the prototype phase of the curriculum. Many of these references to science related to materials and the associated distribution or use of materials. For example students often talked about weight and the placement of weight to elicit specific movements in the snow snake prototype. Other times students talked about friction reducing materials such as wax or oils and their ability or lack thereof to increase the performance of either their snow snake prototype or their full size version.

From a teacher perspective the integration of science content into the snow snake curriculum was a welcomed and effective component. The sentiment expressed by Parker could be echoed by countless science teachers tasked with teaching content that does not directly apply to the lives of students. With snow snakes and the infusion of science content, students were able to attach meaning, and ultimately understanding, to the science involved.

Brant: Did you see student feelings and/or beliefs toward science changing as a result of snow snake curriculum activities?

Parker: Well, I saw their thoughts about science change as far as they were; they knew more about different things, and processes. A lot of it has to do with the scientific process, you start at one point, you test objects out, you learn about variables. We talked about the table and the ice track and why we used the table, and ah, make a smaller model so it's not as expensive, come up with a full scale model. That's real life science. Real life type ideas and I think that that did help the students engage in science even more because it is something that they can apply themselves to now that they are in the competition. If it's something out of the text book and they just know that some business in Atlanta does it then they're not so interested. When it's something that they create and something that they're using the variables and they're going through the scientific process, I thought that it was enjoyed more by the students and I think that they learned more from it.

STEM Content

As noted in chapter three, interviews were conducted at three different points along the snow snake curriculum sequence. The first interview was conducted just before formally beginning snow snake curriculum activities, the second interview was conducted at approximately the midway point of the curriculum; and the final interviews were conducted the week following the Snow Snake Festival. At the midpoint and final interviews, students were asked what they have learned about STEM while working with snow snakes or things they "know" about STEM through snow snakes (See Appendix A

for interview protocols). Instead of using “STEM” as an acronym during the interview questions, the individual content areas (e.g. technology) were expressed and in the case of the final interview were their own question. For example: “Can you tell me two things you know about technology through snow snakes?” These questions generally had “probes” that would be entertained depending on the response of the student. For example, the probe for the aforementioned question was: “How did you learn these two things? Can you tell me about how you might use technology in your life?”

The intent of the STEM questions was to gain a sense of how STEM as an integrated construct was evidenced in the snow snake curriculum and actually materialized in student understanding. Another interest was to see how STEM content as gleaned from the snow snake curriculum was transferred to other contexts in students’ lives. By asking questions about STEM it was hoped that further evidence for science agency could be secured.

The code “STEM content” was used for data that fit this description: “Any explanation of STEM as an integrated construct. Sentiment aligning with STEM as intentioned in the snow snake curriculum.” Upon further analysis, other aspects of STEM were recognized and provide interesting insight into the type of experiences student’s associate with STEM meaning through the snow snake curriculum. The “STEM content” code was used not only for STEM references as a unified and integrated construct but also for individual content references (e.g. engineering). The following interview excerpt highlights an expression of STEM content as it relates to snow snakes:

Brant: What have you learned about engineering while working with snow snakes?

Catherine: You have to get the right tools and then you have to be careful with them, then you have to try and make it how you think it will go faster.

Brant: So figuring out how to make it go faster you would say is engineering?

Catherine: Mm, no, I mean, [mumbling]. Engineering is where you get a bunch of tools and you try to make your snow snakes, um, a little lighter or a little heavier because you can put lead in it or you can cut like designs in it or something, yeah. That's what I am going to do with mine.

Most students when asked about singular content areas were able to articulate a response either accurate or otherwise. Sometimes the responses did not evidence STEM content learned through the snow snake curriculum and were stated as such. Very few students were able to articulate STEM as a fully integrated construct. The following interview excerpt depicts the only student response that shows facility with multiple STEM content areas and how they interact:

Brant: So what is STEM?

Nicolas: Mm….engineering is where you help create something, or something. And math is where you figure out problems and solving them. And technology is the tools that you make it with.

Brant: Are those things related?

Nicolas: Yeah, cause the engineer uses the technology to craft it and figure out problems how to make it better.

It should be noted that most students were not asked the question “what is STEM” because of the problematic nature STEM as an acronym presents. For example, “STEM” to the uninitiated could just as easily be a part of a plant. Because of this, the question was avoided unless the student exhibited facility with STEM content when the disciplines were in isolation.

Other students showed a depth of understanding with STEM, in this case engineering, that was accurate conceptually but did not have the language to articulate understanding as it would be represented in the field of engineering. The following interview excerpt highlights this:

Brant: Can you tell me two things you know about engineering through snow snakes?

Coco: The paintings.

Brant: The paintings?

Coco: Mmhmm

Brant: What do you mean?

Coco: Like you can engineer your snow snake to look like you want it on your snow snake from a piece of paper.

Brant: Which is a painting?

Coco: Mmhmm

Brant: How does that work?

Coco: I don't know, I just thought of it in my head.

Brant: So say it again, let me try and get this straight.

Coco: Like if you want to paint you can engineer on a sheet of paper and you can draw what you want it to look like and you can draw what you want it to….and you can paint it on the snow snake to look like it was on the sheet of paper.

Brant: So what purpose does the painting or sheet of paper have?

Coco: The engineering.

Beyond these few specific examples of students articulating STEM understanding, there were some common themes shared by many of the students around what STEM is and how it works. These common themes can be parsed into individual STEM disciplines, excluding science, given that science commanded its own section and attention previously.

Beginning with "technology", when asked about technology as it related to snow snakes student shared responses that could be categorized as actions and artifacts. Technological actions offered by students included "carving" and "shaping" the snow snake. These actions were made possible by artifacts of technology as expressed by students, not necessarily shared by the same student. Technology artifacts included

references to “equipment” such as a “sander”, as representing the connection between technology and snow snakes. Interestingly, students did not associate “technology” with educational technology as may have been expected. When asked about interactions on the computer the response was much different than when students were asked about the relationship between “technology” and snow snakes.

The next STEM discipline students commented on was “engineering”. Within engineering there were some common answers that students expounded upon when asked about the manifestation of engineering within the snow snake curriculum. The most frequent answer offered, dealt with “design”. Engineering was “design” for students for a variety, yet similar reasons. Students talked about using design to “create something unique” through “whittling” making their snow snake “round” or “pointy”; both of which would connote an aesthetic appeal. Students also talked about using design to their advantage to make a more durable snow snake that would withstand use and keep from breaking as well as design for success, allowing the snow snake to go “faster” down the ice track. Students used phrases such as “fixing it” or “making it” when referring to engineering as it related to snow snakes.

There was also confusion between engineering and other STEM disciplines. Similar to what some students defined as technology as related to snow snakes; other students explained very similar elements as being engineering. For example, two different students talked about “carving” as an activity that had associative meaning. One student thought carving was technology and another thought carving was engineering. Other examples include students talking about tools such as saws, chisels, and pocket

knives as being engineering, and other students defined “equipment” as relating to technology.

The last STEM discipline is “mathematics”. When students talked about mathematics in response to the question asking: “Can you tell me two things you know about math through snow snakes?”; student responses invariably related to measurement. Measurement was used when figuring out the distance in throwing a snow snake. It was also used for snow snake length, width and weight. Students did not confuse mathematics with science, technology, and/or engineering. Students had clear conceptions of what mathematics was, albeit at varying levels of depth.

From the data coded to both STEM content and science content it can be seen that students often confused science with engineering. For example, prototypes, which will be discussed in the following section was included in the snow snake curriculum as an engineering design iteration that would complement the science students were learning and vice versa. When asked about the science they learned through snow snakes, some students responded with an explanation of prototypes. Although this is not entirely inaccurate since prototypes were used as a mechanism to not only teach engineering but also science, it is reasonable to deduce that the close relationship between the two in the curriculum, and the loose use of language around the activities, led students to these ends.

Prototypes

“Prototype” was a code in and of itself because of the frequency by which prototypes were discussed and the important role this portion of the curriculum played in the development of STEM content knowledge but also science agency. The “Prototype”

code was defined as “Any discussion around snow snake prototype impacts.” The following excerpts are examples of how students discussed prototypes during interview questioning:

> Brant: Now think about classroom activities, computer activities, outside activities that you’ve done with snow snakes.
>
> Zeke: We’ve been carving them in class and watching videos of them. We’ve been watching videos on the computer about them. And we made prototypes and tested them downstairs.
>
> Brant: Can you tell me about that prototype activity?
>
> Zeke: We make prototypes and so we go down stairs and test them. Cause there is a table, you just take…. that has four legs and fold up one side and measure the length it went. The first day they measure how far it went then yesterday they did a race against them.

And

> Brant: Were you more interested in snow snake activities compared to other school activities?
>
> Coco: Mmhmm
>
> Brant: How come you think?
>
> Coco: Cause I like prototypes.

And

Brant: Anything else that was helpful from the prototypes?

Zeke: Like you kind of learn where the weight is supposed to go. Cause it was supposed to go on the front or if you wanted it in back you're supposed to have some weight in the front too.

The primary reason for authoring the snow snake curriculum with a prototype design iteration was to give students a tangible experience with prototypes and show how prototypes can be valuable when thinking about and designing a full scale or production model. Explicit attention was given to defining what a prototype was and the experience of using simple yet functionally similar materials to test multiple variables and have the subsequent data analysis inform future actions. The intent of the snow snake curriculum was evidenced in excerpts from student interviews. The following sequence highlights a student's thinking around the value of the prototype activity for informing full scale snow snake design and construction:

Brant: Why are you doing the prototypes?

Zeke: To see what shape or what shape or like what weight will do better.

Brant: And then what do you do with that information?

Zeke: You try and make it, kind of try and make your snow snake look like that. Or try and get it similar like that.

Brant: So you're talking about your actual snow snake, the full scale?

Zeke: Yeah.

Possibly more illuminating about the value of prototypes were the teacher responses. In the following excerpt Parker talks about how students were interested in continuing snow snake prototype activities as a result of initial observations and data collected. Through these experiences students were able to try multiple variables with the outcomes motivating further testing:

> Parker: One big highlight for me was when we were, went through, did our prototypes, collected data, students started to see what worked, what did not work, the highlight of that whole part was when we were done collecting the first round of data. We allowed the students to make a….well, one more day to make any repairs or if they wanted to try a different kind of model with the prototype that they were able to do that, and how excited that they all were to make changes after they learned, after the first round of testing, what designs worked better. Everyone was very excited about that, so that was a highlight.

One of the more interesting and exciting findings from the data is evidenced in the following interview excerpt with Bruce. In it he talks about the emergence of students that typically don't achieve in an academic setting but found tangible success through aspects of the snow snake curriculum. This success then seemingly motivated further inquiry into actions that would continue the success.

> Brant: So you've had some, you've observed some of those instances where I guess you'd call them "aha moments" where students are making those connections?
>
> Bruce: Yep [laughter], in fact even our kids that we consider kind of lower level,

> you know, they're the ones that have actually excelled the most with the hands on prototypes. They're the ones that are willing to take more of a chance. They don't second guess, you know, kind of what you're telling them rather than putting it this way "what if you tried doing this?" Then they'll ask you quick, "what is that going to do?" And once you tell them it's like, oh yeah, I see that, I see the connection. They see the connections faster. When you can compare it to, you know, did you watch the luge last night, yeah, well what if you made it look like that? Well then it was like, boom, a light bulb went off and it made sense to them. It was a good moment for some of them.

This excerpt also represents aspects of agency, or more accurately the types of experiences that promote agency in students. Student agency attributable to the snow snake curriculum and activities will be explored in depth in the following section.

Agency

Science agency represents the outcome of primary interest to this study. This study is looking at the development of science agency in students as a result of experiencing the snow snake curriculum and associated activities. As noted previously, science agency has been defined as an expressed behavior that illuminates positive dispositions towards STEM as an integrated construct for the purposes of taking action in a student's individual life. The data revealed a number of interesting representations of agency that elicited multiple naturalistic codes and consequent sub-codes. This section will progress through the agentic data by first discussing data categorized as representing "potential agency" in students. Potential agency will be followed by depictions of science

agency and the multiple forms or representations therein. Lastly a close look will be taken of one student in particular that was of special interest due to her previous experience as the snow snake champion during the pilot iteration's first annual snow snake festival competition.

Potential agency

As analysis progressed through student interviews it became clear that representations of agency were highly nuanced. Somewhat rare were the interview excerpts that epitomized science agency in students from an initial reading. Since agency is closely associated with a student's ever changing and developing identity, it is reasonable to deduce that the identification of science agency would also be somewhat elusive. Because of this variance in the progressions of agency and the nuanced representations in students, multiple descriptive codes were used to gain a sense of science agency. "Potential agency" was a code used to identify interview data that had ingredients for the development of science agency in students, yet could not be clearly identified as a representation of science agency. The description used which guided the coding of potential agency was "any expression that includes reference to STEM content being used with snow snakes but does not recognize STEM as an integral tool in snow snake success. Another indicator of potential agency is excerpts that have agentic qualities but do not have enough information to fully portray agency as evidenced in students or as observed by teachers." The following are examples of potential agency from student interviews:

Brant: Was making prototypes helpful to your thinking about how a snow snake travels and designing your full size snow snake?

Coco: Yes, cause if you use wax it will probably go that far on the prototype but if you use it on a real snow snake it will go far.

Words like "probably" or “maybe” are representative of potential agency. They highlight a student’s thinking and hypotheses about how science can be used for snow snake success. Predictions on how an adjustment derived from scientific understanding could be used for snow snake gain are yet another representation of potential agency.

The next excerpt depicts potential agency because although the student is making a connection between snow snakes and using science, the explanation is tenuous and does not command the depth of understanding that would denote science agency as defined for this study.

Brant: Do you think you could use science to make a better snow snake?

Catherine: Yeah

Brant: How?

Catherine: Um, like I said again, you can put weight on it, and not weight on it.

This next example of potential agency shows the student having very distinct ideas about what did and did not work from their personal experiences with snow snake activities. Along with these definite ideas there is also uncertainty evidenced by the use of “maybe” and a tone of non-commitment.

Brant: So how did your full size snow snake work?

Zeke: Not very good

Brant: Why do you think that?

Zeke: Because the snow was soft and really melting and the track was getting worn down.

Brant: And what did you call those things that you put on?

Zeke: Skis

Brant: You put skis on your snow snake.

Zeke: Some little ones in the middle.

Brant: How would you do it different if you had to do it over?

Zeke: Mm, I don't know, maybe make my snow snake a little smaller and a little lighter. So….So like if it was like it was on Saturday [Snow Snake Festival] it would probably go better because those really light ones went farther than the heavier ones because the heavier ones would just sink in the snow it seemed like.

This excerpt shows that although the student can articulate experience, he does not display ownership around the concepts associated with science that could be used for future snow snake success.

Building from the previously discussed depictions of potential agency, there are also behaviors and dispositions inherent in certain students that promote the development

of science agency. “Disposition towards agency” was a code developed because of the tone and specificity of language used by one student in particular. The description guiding this particular code read as follows: “Any sentiment that leads me to believe that this particular student has an inherent disposition towards developing agency regardless of what kind of agency it is. This could be coupled with a competitive nature and the will/drive to succeed.” This interview excerpt with Daisy epitomizes a disposition lending itself to the development of science agency:

> Brant: Tell me about your experience at the Snow Snake Festival.
>
> Daisy: It was fun and I didn’t know what snow snakes were until then. And…
>
> Brant: Until the Snow Snake Festival?
>
> Daisy: No until like I started, and the festival was fun seeing how different people made there’s and designed it. And seeing how they threw it. And just learning more from, getting some knowledge on looking at other peoples’ snow snakes.
>
> Brant: What was the best part of the festival for you?
>
> Daisy: Competing. And seeing how other peoples was different from mine.

Daisy is a motivated student who carefully thinks about the experiences she is having. Although Daisy came into snow snake activities approximately half way through due to a transfer from another school, she was able to come up to speed with the other students and excel in her snow snake design as well as competing during the snow snake festival. From the data in the "Disposition towards agency" code it is apparent that Daisy enjoys learning and experiencing new things which is a disposition that eliminates barriers to the development of science agency.

Another example of a student displaying a disposition towards agency is found in the following interview excerpt:

Brant: Do you feel like you're pretty confident in your understanding of aerodynamics and friction?

Nicolas: Kind of….I need to learn more about it.

This student had expressed specific and accurate understandings of aerodynamics and friction as it related to snow snakes. By using the phrase "kind of…" this student displays a tenuous confidence in his understanding of these scientific concepts. He then goes on to admit that he needs to learn more about those topics. This tenuous confidence and willingness to learn more represents important dispositions that could later lead to science agency.

Potential agency could also be used as a clue for where to inquire about science agency being developed. For example, a teacher sharing an observation they have made of students using their experiences around STEM for proposed application to either snow snake prototypes or the full scale models. The following excerpt shows students making observations and then being proactive to do something that will provide a greater potential for success. Taking action as exhibited in the last part of this teacher interview excerpt shows potential agency in students.

Brant: Could you talk a little bit more about that, you saw students that made the connection at the festival with, I guess, the underlying reasoning for the prototypes?

Bruce: They came back, because we had done a lot of different prototypes and

> some had done the ski style with prototypes. The flat bottom, and they were successful but they never really put together that we could do that with a round object. So they came back after they saw, you know, I think it was some of the Fond du Lac students had some of those flatter, you know, even some had ski shapes, but some had the more natural looking snake style, plus had a flat bottom, like well, this is how they did it, they went and talked to them first and then came back to me and asked if we could get the tools to do that.

Similarly, when students showed a resolve and commitment to snow snakes, a conclusion to be drawn is that potential agency is displayed. This is evidenced in the following interview excerpt. Bruce is talking about students' reaction to their performance at the snow snake festival.

> What I liked too, they weren't mad that it didn't work out the way they thought it was. They were more of, "this is what I'm going to do next year" you know, they were looking forward to what's going to happen in the future rather than being upset about it. You know, so, I thought that was, you know, good because at that age you never know if they're going to get upset or if they are going to be like "oh, we didn't do this because of this", well, they didn't use excuses it was more of a this is what I'm going to do to make it better.

This excerpt is considered a display of potential agency because it shows student commitment and investment into the premise of snow snakes with an emerging knowledge base that will support future actions.

Another example of potential agency is shown when students take the knowledge

afforded from experience and apply it to a context which they are interested in. Bruce briefly explains what this looks like in students:

> And some of them are getting the ideas of, what if I put grooves in it or what if I did this, and they're starting to take some of that prototype idea and adding to applying it to their snow snake itself.

Potential agency and behavior that could be categorized as clearly agentic have subtle yet important differences. Potential agency displays a tenuous command of the science related to snow snakes and how that content knowledge can be used for snow snake development. Potential agency depictions use non-committal language that denotes a tenuous understanding of STEM content. Agentic behavior on the other hand has more distinct qualities and specific demonstrations by students that provide evidence for agency. The following section digs into these representations and further defines the nuanced nature of agency as it relates to this study.

What does science agency look like?

When coding data to "agency" the associated description for the coding decision read: "Any sentiment that displays clear agentic qualities." After all data was coded, data coded as "agency" was given a closer look to tease out its nuanced nature. It was found that agency was expressed around:

- Types of wood - development of "theories" around the type of wood that is most desirable for a snow snake.
- Using materials - students exploring the use of different materials that will give them a better chance of snow snake success.

- Physical actions - making the connection between throwing a snow snake and throwing a spear when spear fishing in the wintertime.
- Science content - Aerodynamics and friction
- Technology - using the snow snake experiences as a corollary to actions a builder may make.

For example one student, Jerome, attributed his success in developing a prototype and testing the prototype to his use of materials such as wax and weight in his design. Nicolas, another student expressed agency through the mobilization of knowledge for future gain not only for himself but for others; in this case crafting a snow snake that will perform better in a future competition: “Yeah, next year I’m going to tell people to make small and light ones, medium sized ones because they went long, longer this year.” Agency was evidenced here by projections on future activities and decisions. Also noteworthy was Nicolas's ownership by saying "I'm going to tell people..." Agency can be expressed through both an extension of the science content learned through the snow snake curriculum to unrelated contexts; as well as expressions of knowledge and ownership around the science of snow snakes. This expression of knowledge is usually couched within expressions of plans for future snow snake designs. In working with the agency data, three sub-codes emerged as specific ways in which science agency was evidenced in students. These sub-codes are: Connecting snow snake experiences to outside contexts, emergent leaders, and facility with science. Further explanation of these sub-codes and illustrating examples follow.

Connecting snow snake experiences to outside contexts. The sub-code

“Connecting snow snake experiences to outside contexts” was guided by the code description of: “Any expression where a student makes a connection or extension from what was done at any point during the snow snake curriculum to a context clearly outside of snow snake activities.” Harkening back to the definition of science agency for this study, that of an expressed behavior that illuminates positive dispositions toward STEM for the purposes of taking action in a student’s individual life; by student’s connecting the snow snake experience and the STEM content therein to heretofore unrelated contexts the dispositions are clearly not negative and agency is being expressed by calling upon prior knowledge. Three examples will be shared and discussed that illuminate the data coded to “Connecting snow snake experience to outside contexts”. Each example will be progressively stronger in highlighting the representation of science agency in that particular student. The first example shows how a student connects the design and performance of skis to his thinking around snow snake design and construction. Also in this interview excerpt is an expressed connection between the properties of a material, in this case wax, and the connection between prior knowledge of wax on a floor surface and how that may benefit snow snake performance.

Brant: But why did yours go farther than everybody else’s?

Jerome: Because, I don’t know, I had wax on it and had more, had weight on it.

Brant: Interesting, can you talk about your design a little bit?

Jerome: I put wax on the bottom of it. I put wax on the bottom and then there’s, it’s kind of like a triangle, but I was trying to make it so that it would be a circle but it wasn’t. Then I got my bottom wet before I put the wax on and I made it so

that thing would point up like a ski. And then I was put it on the bottom and put some wax on there and then, some clay to hold it together.

Brant: Why wax?

Jerome: I don't know, I think it goes faster.

Brant: So you think wax will make it go faster but what has your experience been that makes you think wax will work to do that? Have you used wax in other places that make things go faster?

Jerome: No. When you wax the floor it's slippery.

Brant: Okay, that's interesting. You talked about your design where you bent the tip up. How did you get that idea?

Jerome: Um, I don't know. I got it cause, um, I don't know, so it will look like a ski, and skis are fast.

Notice how Jerome makes connections with what he knows about skis and their performance and properties of wax as experienced on a floor surface. Both outside contexts were derived from prior experience and called upon for snow snake use. This is an example of agency because this student is comfortable with snow snakes to the extent of thinking beyond snow snakes and the associated content to contexts that could be called upon to further his chances of success. In this case, skis and wax.

The next interview excerpt from a different student, Christopher, shows the connection between snow snakes and spearing, or spear-fishing. Both contexts are culturally-based, snow snakes as a historically played traditional wintertime game and spearing as a historical and traditionally practiced act of sustenance during the wintertime

in the region where the curriculum was delivered and the study conducted.

Brant: Are there snow snake activities that you feel were useful to you?

Christopher: The throwing.

Brant: The throwing? Why was that useful?

Christopher: It's like throwing a spear but underhand. So if you ever go spearing its useful.

Brant: Do you ever go spearing?

Christopher: Yeah, I do with my uncle sometimes.

Brant: Tell me about that.

Christopher: It's fun. You just get to go out there, chill, wait for fish to go by, and you just throw a spear at them and it's some fun. Joke around with your uncles, laugh.

The following interview excerpt with a different student, in this case Nicolas, also discusses spearing and in addition extends his understanding of science through snow snakes to a more contemporary context, that of riding a bike. To reiterate the background information shared in an earlier section, when asked about what he learned about science through snow snakes Nicolas discussed aerodynamics and friction and related it to his experience with the snow snake prototypes. What follows is where the aforementioned was probed for extension.

Brant: So this whole idea of aerodynamics and friction can you see how that, or would that apply to your life beyond snow snakes?

Nicolas: No….a little bit of aerodynamics cause I ride bike in the summer and I hit jumps.

Brant: So how does aerodynamics work there?

Nicolas: When you hit the jump you could move and stuff and it would be weird once you hit the ground. And how far you go, if you keep it straight and the handlebars could mess up the aerodynamics and go a little bit slower in the air. How much it would fly through the wind.

Brant: Is there anything else in your life where you could use aerodynamics or friction or your knowledge of those two things in your life?

Nicolas: In spearing, spearing fish. You have one that has a fork, a fork spear and a straight spear.

Brant: Hmm, do you spear?

Nicolas: Yeah, I spear with my uncle.

Brant: So how does aerodynamics or friction work with spearing?

Nicolas: When you spear it could be accurate or unaccurate with aerodynamics. But once right it'd go straight if the pitch fork one it would kind of go off to the side.

Both Christopher and Nicolas made the connection between snow snakes and spearing. This connection is reasonable given the shape and throwing motion of both, but the connection should not be discounted as coincidence. Both Christopher and Nicolas called upon prior knowledge when considering their comfortableness with snow snakes. Without a thorough understanding of snow snakes and the associated science, the ability to make the connection back and forth between snow snakes and spearing would not be possible. Nicolas was able to make a more explicit connection between the science of snow snakes to outside contexts. It is interesting to note that Nicolas displayed a depth of science agency by not only making a connection to the traditionally practiced act of spearing fish, he also made the connection to a contemporary pastime rife with physical science, that of riding a bike. It is unclear from Nicolas's interview if the type of bike Nicolas was referring to was a motor bike or a bicycle. Regardless, Nicolas represents a student that has exhibited science agency through connecting snow snake experiences to outside contexts.

Emergent leaders. The sub-code "Emergent leaders" was guided by the code description of: "Any expression that depicts an unlikely student emerging as an authority and or leader around an aspect of snow snake activities." The data coded to "Emergent leaders" was exclusively from the perspective of the teachers associated with this study and their observations around students emerging in capacities out of the ordinary to their typical modus operandi. The prototype design iteration was the experience that provided the most powerful representations of students emerging as leaders. This first excerpt

comes from Bruce and highlights the role reversals that occurred through snow snakes and the perceived student impact.

> With the prototypes we have seen some of that too with, and like I said, even some of our kids that are usually, you know, not high achievers, are the ones teaching the high achievers, “well this is what I did and this is why it worked”, you know, so, it’s kind of changed roles in the classroom with these, which is really good because it gives those kids a chance to know what it feels like to be, you know, the one looked at, you know, looked up to. So it’s helped with some self confidence.

This observation by Bruce aligns with observations made by Basu, Barton, Clairmont, and Locke (2009) when discussing the emergence of critical science agency in a student enrolled in a high school physics course. Basu et. al describe a student that had traditionally underperformed academically and was also a classroom management issue. Through physics, or in the case of this study, snow snakes, these students were able to emerge as knowledge bearers and therefore were looked upon by classmates differently and in turn, looked at themselves differently.

The next excerpt, again from Bruce, delves deeper into the impacts snow snake curricular experiences have on students.

> Brant: From your perspective, what aspects of the curriculum have been the most powerful in the sense of student engagement and interest?
>
> Bruce: I would have to say allowing, you know, everybody to be equal to start with and just seeing how you have certain kids become leaders who probably

seldom or have never had that opportunity to, you know, kind of be, I don't want to say the smart kid in class, but the top dog for a while. You know, give them that self confidence, building up their self esteem a little bit, you know, just knowing that, "hey I did this and it's the best one". You know when we did the first runs of the prototypes and one of our kids that won it, I mean; you would have thought that he just won a gold medal at the Olympics. You know, he was jumping, yelling…

Brant: For the prototype?

Bruce: Yeah, I mean he was just so excited, and it kind of gave me goose bumps and everything, he was just, just to see a kid that usually kind of mopes around and, you know, not real, you know, motivated all the time. But this really motivated him and it's something that he strives at and it's just, you know it was great to see something like that happen. We've had a couple others too of course but that particular story is just, real touching to see kids like that.

Implications from this excerpt appear to go beyond a student emerging as a leader. The outcomes of increased self-esteem, self-confidence, success, motivation and the like as expressed by Bruce are both pre-cursors to agency and representations of agency.

When a student experiences success, in this case through snow snake prototypes, a natural outcome is an increase in self-esteem, self-confidence, and motivation for the subject matter or activity in question. It is reasonable to conclude that in order for a student to develop agency they would have to feel good about themselves and their abilities associated with a task, and be motivated to engage in the task. With these actions

taking place a student's identity begins to form around their performance on the particular task. Agency is then not far off.

The final excerpt associated with the sub-code "Emergent leader" is from Parker. In the following excerpt Parker discusses his perspective on students emerging in capacities that are atypical to their usual academic performance. The sentiment shared by Parker corroborates those expressed by Bruce previously:

> …all of the kids were kind of pretty excited about it. Especially some of the kids that may not necessarily do well in other parts of the, you know, academic, that really struggle with math or reading. Everyone here is just so involved that the kids that had the farthest prototype was very excited, huge smile on his face. But then he's also one of the kids that may struggle a little bit in other academic areas and that just makes it a little reward because there's a lot of different ways to reach kids and everybody's good at certain things and it's nice to have this extra activity in the science curriculum where we can bring that out in students.

Similar to the evidence for critical science agency as expressed by Basu et.al (2009), these excerpts depicted emergent leadership around snow snake activities and denotes an important ingredient in developing and maintaining agency, in this case science agency. Without the structures that positively affect identity development such as self-esteem and self-confidence towards a topic, agency would not be possible, or remain at low levels with little action associated with the agency.

Facility with science. The next and final sub-code identified as evidence of science agency is "Facility with science". This code was guided by the description of:

"Any expression by a student that exhibits the use of science for snow snake success, either currently or in the future." The two excerpts following are observations or recollections from the participating teachers. In the first excerpt Bruce talks about a student's explanation of why their snow snake did not travel as hoped, attributing the poor performance to an issue of friction.

> …she was one of them that came back too and said, well because of the design of hers not being a typically straight snow snake it actually worked against her because now it dug in and caused more friction rather than on ice it was less friction because it had just points on it. You know, so that was something that she pointed out, which I knew of course, but with her to point it out I thought was pretty impressive that she knew that.

Similarly in the next excerpt from Parker, it is recollected that a student came to an understanding of why their snow snake did not perform well attributing the poor performance in this case to the scientific concept of "balance point".

> Sometimes when it didn't work out the best for them they were disappointed. You could see that. But, they knew by watching their classmates what happened with their engineering. They could tell you right away, "Well, my balance point was a little bit off".

Reflecting again on the operational definition for science agency, by students expressing a causal relationship between science and snow snake performance outcomes, they are in essence defining actions to be taken in the future. These future actions to reduce friction

or calibrate the balance point are actions pursued by students that would not be possible with an apathetic or negative disposition towards STEM content.

Further examples. There were a couple representations of science agency that were noteworthy, but because of their unique nature were not appropriate for the aforementioned categories. The following excerpt is an example where a student not only shows a facility with science content but also makes a connection to a context outside of snow snakes. Although every effort was made to categorize agentic data into its own sub-code, this excerpt and the intermingling of two of the three agentic sub-codes could not be parsed apart. Thus, the following excerpt represents an important display of science agency in this particular student.

Brant: What have you learned about science while working with snow snakes?

Christopher: I learned that you use science mostly every other day. Like let's say if you're throwing a dog ball you need just the right speed so they don't catch it and if they don't get hurt. The um height of the ball, the weight of it. And if it is light and if it's brand new it's like rubber so if you throw it actually like barely even it will go fast so…..

Brant: And what about that is science?

Christopher: Um, just mostly figuring out all the power, the mass of it, the width, the weight, everything about it.

Within this excerpt Christopher displayed a facility with science through proper use of scientific terminology by making a connection to a context outside of snow snakes.

The question asked about science through snow snakes and Christopher made the seamless and accurate connection to a context that was familiar to him. It could be reasoned that Christopher's understanding of the physical science principles associated with throwing a ball to a dog was derived in part from learning about the physical science principles associated with throwing a snow snake.

Science agency proved to be nuanced and complex as represented in the previous sections. There was one student in particular that experienced an evolution of agency towards snow snakes and science. The following section delves into agentic representations associated with Catherine Blue, first annual snow snake festival champion.

Catherine Blue: Assumptions and Evidence for Agency

Since agency is so closely associated with identity, and identity is closely related to the experiences an individual has, for good or bad, there was one student in particular that was of interest because of her prior experience with snow snakes. Catherine Blue, although a grade younger than the rest of the students (embedded units) of this study, was included in the study for a variety of reasons. The first and primary reason was that because Catherine won the first annual snow snake festival competition it was hypothesized that she was the one student that had agency around snow snakes because of her previous success. The second reason for including Catherine was that because of the aforementioned success, the bound case of Eagle Soaring School, the findings from this study, and in some ways, the overall success of snow snakes during the second year can be attributed in part to that one event. More will be discussed about the importance of

this student's actions and success later in this section. What is interesting is that this unassuming student became the face of snow snakes and in many ways reluctantly carried the burden of snow snake champion.

The development of agency takes time. There were a number of codes that revolved around agency yet were unique to the experience and history of Catherine Blue winning the first annual Snow Snake Festival competition. The reason for highlighting this individual student is that the data associated with Catherine and her experiences shed light on the evolution of agency in a student. The remaining codes associated with agency in some fashion are: "Snow snake agency", "agency recognized by others", "agency protection", and "loss of agency". Each code will be woven into the ensuing narrative of this section to paint a picture of how agency was identified during this study in Catherine Blue.

Snow snake agency. The first annual snow snake festival was a special event. Special in the sense that everything came together at the right time. The conditions were perfect on North Twin Lake. The week prior had seen snow and cold temperatures. On the day of the event the sun shone brightly and the temperature hovered around freezing. A modest showing of students (20) from three schools made up the competition field. A handful of parents were in attendance but it was mostly teachers and festival organizers. There appeared to be only one complete family unit in attendance to support their respective competitors. Complete in the sense that there was a mother and father in attendance along with siblings and even an uncle, Uncle Travis. As the competition progressed the excitement increased. Head to head competition between students was

eagerly viewed by most, the exception being the students drawn by the unmistakable force of the “king of the mountain” snow hill.

Uncle Travis had taken Catherine aside early in the competition to discuss and demonstrate technique (see Figure 5.1). It was not about throwing the snow snake with brute force, the champion today would have to master technique and read the conditions of the track. The way the tournament was set up pitted the female champion against the male champion to see who would be crowned overall champion for the first annual snow snake festival. The school of the overall champion would be the proud recipient of the traveling snow snake trophy. The traveling snow snake trophy would be competed for each year and would become a point of pride for the school in possession of the trophy.

Figure 5.1
Snow snake instruction

The overall championship round saw a brother and sister matchup. Catherine and Christopher had won their respective divisions. Now they would face each other for the overall championship, their family fully in attendance eagerly looking on. The competition was best of five. To win, either Catherine or Christopher would have to have the farthest throw three times. Back and forth they threw and back and forth they won. But it was Catherine that prevailed as champion. Watching the parents of the two competitors gave one the sense that this type of event and the opportunity to support a child in a competitive endeavor was a sorely absent experience on the reservation. The emotion in the voices and on the faces of the parents was clear. They were proud of the success of their children; especially proud of their champion (see Figure 5.2). Everyone agreed that the day was a success and a great experience for all involved. A free lunch was consumed, awards were given, and everyone headed home for the rest of their Saturday afternoon.

Fast forward from this point approximately nine months. The figured world of Eagle Soaring School had evolved around the traveling snow snake trophy and a champion in their midst. Of any school, Eagle Soaring School was excited and in earnest preparation for the second annual snow snake festival competition. Nine months had seemingly been plenty of time for the experience of winning the first annual snow snake festival competition to infiltrate Catherine's identity and subsequent agency around snow snakes. When talking to Catherine's mother she shared that "[Catherine] thinks she's got more skill than any of them anyways. Because she won last year." And, "Catherine's

always saying, ‘well I’m the grand champion’ and Christopher is always [saying] ‘not this year’”.

Figure 5.2
Snow snake pride

Coming into the second iteration of the snow snake curriculum and activities, Catherine, of any student, had agency, in this case snow snake agency around her ability to be successful in a snow snake competition. Snow snake agency was coded to the description of “Any expression of agency that is specific to snow snakes and does not necessarily include science.” From the aforementioned quotes from the midpoint parent interview it is clear to see that Catherine was exhibiting snow snake agency, however tenuous this agency turned out to be.

Agency recognized by others. Partly attributable to the figured world that had developed at Eagle Soaring School and the fact that there was a champion with

knowledge in their midst, Catherine became a valuable resource for her peers and teachers. The code “Agency recognized by others” was used keeping in mind the description of: “Any expression of a student seeking the knowledge of another student because they have recognized the other student’s expertise around snow snakes. Also, teachers seeking the knowledge of a student.” The only data coded to this category was in reference to Catherine. The following interview excerpt with Bruce clearly represents how peers and teachers recognized and sought Catherine’s knowledge; a knowledge that is an artifact of the agency Catherine commanded as recognized by others.

> Brant: Have you observed any students emerging as authorities on snow snakes?
> Bruce: Um, well, as you probably know too, Catherine definitely is kind of our guru in the room being last year’s title winner. And she’s already talking this year. But yeah, she’s kind of been our go to, she’s shared some pointers but she’s kind of keeping some of them to herself yet. Um, how she threw it, you know, how do you stand, do you get a running start, you know, all those different things she has shared with the group. So she’s really been, not only useful to the kids but useful to me too because she has more experience so. So she’s kind of been our leadership role, with doing that. We do have a couple others that are trying to be the leaders but aren’t real sure so they kind of run it by Catherine first, you know, to see “do you think this will work”, you know, so it’s really cool, they’ll actually go to Catherine before they’ll come to me [laughter]. I’d definitely say that Catherine has kind of been…

Agency in this case was perpetuated by those who sought Catherine's knowledge. Although there was legitimacy to Catherine's agentic behavior, the depth of agency as associate with her identity as snow snake champion was thin. Catherine's facility with snow snakes was attributable to technique and maybe a little bit of luck. Becoming champion thrust Catherine into a role that she reluctantly accepted, but was cognizant of it not being permanent.

Agency protection. Knowing that there would be a second annual Snow Snake Festival and that the pressure would be on, both self induced and community induced, Catherine began to take steps to replicate her previous performance. Catherine's mother shares one of the strategies Catherine implemented to better her chances of success.

> Yeah and she chose, and they went out and they got different sticks too, and why she didn't use the one she chose out there this year I don't know. If it was, if it didn't weigh close to the same as last year or what exactly why she didn't use the one she chose in the woods this year but she ended up using the same one. Maybe she thinks it's luckier. I don't know.

This excerpt is evidence of agency in Catherine. What Catherine is doing is reverting back to what made her successful initially with hopes of the same outcomes in the future. This is an example of a student protecting their snow snake agency. To this point the agency Catherine has displayed could be categorized as snow snake agency. For this study the research questions are looking for evidence of science agency. Although snow snake agency and science agency are akin to one another, for Catherine snow snake agency was contingent upon performance. This performance contingency effected

Catherine's science agency.

Loss of agency. The second annual Snow Snake Festival doubled in the number of students and participating schools. The second annual event was much different than the first on many accounts; weather, participants, spectators and location to name a few. The important aspect of the second annual festival to consider for this point in the discussion is this: Catherine did not win. By Catherine not winning, her agency towards snow snakes and science, as well as her identity, shifted. The code "Loss of agency" was guided by the description of: "Specific to Catherine, after having developed agency around snow snakes as a result of past success, a lack of success resulted in a loss of agency".

Brant: Do you feel like you are good at science?

Catherine: No

Brant: How come?

Catherine: Cause I didn't really figure out what would work the best because I didn't really work on it but I did my best whenever I could.

The excerpt from Catherine is very interesting. After looking at her initial and midpoint interviews compared to what she shared in the final interview (above), the progression is fascinating. In the initial interview Catherine identified science as her favorite subject in school but also said that she wasn't good at science because she was a beginner. She shared that she was willing to work hard at science if it meant a chance to go to college and live a good life. At the midpoint interview Catherine shared that she was good at science. This sentiment was derived in part from her experience with the local science

fair and enjoying the work she did with that project evidenced by her saying "me and friends we did a science experiment and then I just after the whole thing was done I just wanted to do more and more and more." Where things get even more interesting is in the final interview where Catherine does not hesitate to say that she is not good at science. In reference to the snow snake festival experience she explains that she is not good at science "Cause I didn't really figure out what would work the best because I didn't really work on it but I did my best whenever I could." This shows that Catherine, although negative about science has associated snow snake success with science. In other words science and a facility with science hold the key to understanding how to be successful with snow snakes.

Community Impact

A final impact to be discussed is the impact of the snow snake curriculum experience on the community. The code "community impact" encompassed the early analysis of data that fell into the category of: "Any reference that has implications beyond Eagle Soaring School involving individuals other than students and staff directly or referencing the future." Understandably, this code revealed many facets after initial coding. Further analysis elicited the following sub-codes: "Connecting people", "Family involvement and impact", "Opportunity for competition and sportsmanship", "Restoration of tradition", "Secondary ownership", and "Set in motion" The most referenced sub-code was "Family involvement and impact". This sub-code will begin the discussion around the community impact of the snow snake curriculum and activities. The remaining sub-codes will follow.

Family Involvement and Impact

The sub-code "Family involvement and impact" was used for "any excerpt displaying the impact of snow snakes on family members." Again, this sub-code being the most referenced sub-code for "community impact" elicited further categorization due to the nuances therein. Family involvement can be discussed in terms of "spectating", "interest", and "action". Also of note were the proclamations of commitment to action by Catherine and Christopher's mother that go beyond school activities.

Spectating. Beginning with "spectating", traditionally there have not been many activities or events for parents and/or family members to attend and watch their child or relative perform at Eagle Soaring School. Snow snakes and the associated festival competition provided a spectating opportunity that represented an important need being met as part of Eagle Soaring School's mission, that of family involvement. The following interview excerpt with one of the administrators at Eagle Soaring School highlights this.

> Dean: …I don't know if you noticed on Saturday but there were a number of parents form Eagle Soaring there also.
>
> Brant: I know I saw Misty but I wasn't familiar with some of the others. But there were?
>
> Dean: Chris was there and she had Zeke and Missy. Kenton was there and he had grandkids that were participating. There were a couple of others and so it meets that component also of family involvement and sense of pride with family. Misty was out trying to coach her kids on how to throw the snake; I thought that was kind of interesting.

From a parent and family perspective, Ronald, father of Catherine and Christopher describes his thoughts around the first annual Snow Snake Festival.

> Ronald: I knew nothing about snow snakes, them kids had mentioned it once in a while, we're going to go work on our snake, so what the hell's a snow snake, they wouldn't say nothing. Then the morning of the event I wasn't even going to go. I said, what's this all about, you know, so we went. She was going for sure [mother], so let's go. So we got ready and went down there and I had a good time.
>
> Brant: Nice [laughter]
>
> Ronald: You know my uncle showed up with his kids and they're tossing them around a little bit trying to practice what they could, you know. They just had a blast. Yeah, I enjoyed it.
>
> Brant: Yeah, so did I.
>
> Ronald: Enjoyed the meal afterwards.

Although there was reluctance at first to attending the first annual snow snake festival, once there, Ronald thoroughly enjoyed himself.

Interest. From spectating to "interest"; the difference between the two is that the former stands primarily as support of family and giving credence to the legitimacy of the event merely by attendance at the event. The latter takes this a step further to expressing interest either through inquiry into future snow snake activity prospects to supporting snow snake efforts in some way. The two interview excerpts that follow (one from an

interview with Misty, the mother of Catherine and Christopher, and one from Parker) demonstrated expressions of interest around snow snakes that are rooted in the community. The first from Misty:

> Brant: Have any other family members been involved, because I know Uncle Travis has come up as kind of helping with technique last year at the festival and possibly having some materials that would help this year. Any other family members been involved or have expressed interest in snow snakes?
>
> Misty: Their uncle has asked them about it. Their uncle, my brother Erving has asked them about how they are doing it, asked them where they went to get the snow snake, or what kind of wood it was, you know. So he was asking questions on if there's a particular kind of wood that they have to have, or if it could just be any kind of wood or any kind of type of tree, or, so, their uncle is the one that has questions on how they're going about it. Or whether they should choose a, if he was to try and do one should it be bigger or should it be smaller, or heavier or light, you know. Because that dried wood is a lot lighter to where the solid like the oak and stuff like that is. To me their uncle would love it if he could have went out with them to get the wood, you know, and I think he would probably be more, he would be interested in even making one himself, you know, I could see. Because he's more, um, with these kids, with his other nieces and nephews, he's more of the person to take them all out sledding and stuff right now. He likes doing everything with them and knowing. Like they're doing snow snakes, he'd like to know how to do snow snakes. That way if he had his own and could make

> it his own then he'd be able to bring them all to the ice and make the trail for them and everything like that. So Erving, their uncle, is very ambitious with these kids. So I know Erving would, he has a lot of questions about it.

Uncle Erving and Uncle Travis have no connection to snow snake curriculum and activities other than through the family of which Catherine and Christopher are the children involved with snow snakes. From past actions of Terry in assisting Catherine at the first annual snow snake festival with her technique and providing technical assistance such as the application of bear grease; to the expressed interest of Julius as just seen; snow snakes has gone beyond what takes place in the classrooms at Eagle Soaring School to the greater White Earth community.

The next brief excerpt with teacher Parker displays the types of interactions he is having with parents that denote interest around snow snakes: "Even at conference time or whenever I run into their parents or families they still talk about snow snakes. It had a positive effect for everybody." This excerpt was in reference to the first annual snow snake festival and the impact it had on Eagle Soaring School and the interest it still held with parents. Now after the successful second annual snow snake festival and the associated curricular events; it can be reasonable concluded that parent and extended family interest has been maintained, if not increased as evidenced in the aforementioned data.

Action. "Action" represents a third representation of family involvement and impact. "Action" extends "Spectating" and "Interest" into yet another realm of impact as

represented by the verbalized intention to act at some level around supporting the snow snake efforts of students. The two excerpts highlighting this section deal with the passing along of traditional knowledge or knowledge from experience that may be useful to snow snake efforts. This first excerpt is from Ronald:

> Ronald: I had mentioned to Curt, my uncle uses a lot of bear grease on his rice knockers and such you know. I mentioned to Christopher to try and get some from his uncle and have his uncle help salt it down with that bear grease you know.
>
> Brant: Absolutely.
>
> Ronald: I mean kids use wax, why not use a little bear grease or something.

In this second excerpt Parker relays interactions he has had with students and his estimation of their value. Here Parker is sharing a comment heard from a student in reference to a home interaction:

> …"I talked to my Dad about it and the wax will work better," so they are having a lot of communication at home. You know and people are finding more and more out about the engineering of the snow snake and their parents are putting input in. It's very cool.

The epitome of "Action" represented in the data coded to "family involvement and impact" can be found in data relating to parental commitment to action beyond school activities. After an interview session where Catherine and Christopher's family invited me into their home, I reflected upon the significance of the conversation I had

with Misty. The emotion and passion Misty exhibited around our conversation about snow snake was noteworthy. She was clearly excited about the future of snow snakes, how that may impact her children, and her willingness to be involved and promote snow snakes in whatever way she can. The following is an excerpt from my field journal as I wrote some notes in the car on the side of the road shortly after the interview:

> At the end of my time at Catherine's house, Misty, Catherine's mother began talking about making her own snow snake, creating a snow snake track behind the house and setting up a wood shop of sorts in the basement for her kids and friends to work on and craft snow snakes. She was passionate as she talked. As if her talk escalated her excitement. It was beautiful and inspiring. I fear that the enthusiasm will wane over time. Maybe not. Snow snakes has transcended school walls, my hope for this whole business.

From interview excerpts with Misty it is clear that she is willing to lend a hand and even participate if the opportunity presented itself. Considering her oldest son Christopher is graduating to a different school in the following year, Misty showed her commitment to action by saying "if I have to bring Christopher somewhere, you know, in the afternoon or afterschool for a couple hours or something I would, you know, and I'll bus the other boys, you know. Or haul the other boys." Later on Misty expressed her personal desire to have the experience of crafting and throwing a snow snake alongside her children:

> Misty: I would like to check out the video [from the Smithsonian] and everything because if there's a way that from that video that I could get the thing and

experience it myself to where if I would've known that I could go out and pick a snow snake, go to their school, you know, weekly and do my own, then I definitely would have been there to make my own. To where my brother and we would have had, I bet you if they would have offered to have family members coming in I bet you that school would be full of family members to where it's more family instead of just kids. I would, I'd make me a snow snake, and I'd take my kids out there, and I'd whizz it further than them [laughter]. I'd be champion [laughter]….Because like I said I would like to be able to make my own and experience it with them and have my own snow snake to say, you know, it's not just my kids doing it, it's me also, you know, or my brother. Yeah, I would like to get everything behind it to be able to make my own. As of right now the kids would probably show me how to carve it and everything to where I wouldn't even know where to begin. If it has to be a certain log or a certain type of wood or not you know.

Brant: Sure

Misty: That's one thing is to be able to watch the video and try to experience it myself also besides you know, just the kids experiencing it. Because I would participate.

Misty's tone denotes a desire to have had this type of experience in school when she was the age her children currently are. Now, in a way, she can live out this experience vicariously through her children by having at least some snow snake curriculum

experiences alongside them.

One last representation of the impact snow snakes has had on student's families can be found in the following excerpt from Misty.

> …I am going to pray next year, you know, that some snow stays anyways so we can, you know, participate. I am going to do me some praying….Every year that it happens it's just going to do nothing but get better and more, you know, so…

By Misty expressing her intention to pray she is recognizing the importance of this event and associated prior activities to her children's lives. When the event occurs she sees it as a positive part of her children's lives, as well as the lives of her family, both primary and extended. She believes in snow snakes and feels like it is an important part of her family culture as well as the cultural fabric of White Earth and other tribal communities.

Additional Community Impact Findings

The next suite of sub-codes associated with community impact is minor in their extent but valuable in further painting the picture of the scope by which the snow snake curriculum and activities has impacted the community. Sub-codes include "Connecting people", "Opportunity for competition and sportsmanship", and "Secondary ownership".

Connecting people. Beginning with "Connecting people", this sub-code was guided by the description of "Any expression that talks about snow snakes as an activity that connects people. Connections between students from different communities and/or individuals that did not have a specific reason to reach out to one another therefore connecting as a result of being associated with snow snakes." An example of this sub-code can be found in the following interview excerpt with Misty.

Brant: So it makes me think like, you know, back to snow snakes because that's on my mind. Snow snakes is something that could bring those communities together and it really did. It brought Maple Hollow and White Earth, and Eagle Soaring and Rice. Those four communities were represented. And then we had Fond du Lac but I can see how people may be like, well, I don't want to compete or I don't want to interact with someone from that community so then they are negative towards snow snakes but. I don't know it's…

Misty: Yeah, I could see that happening, you know, but like I said if your parents are teaching you that whether you're from White Earth, Round Lake, Eagle Soaring, Rice, wherever you are we're still all the same person inside. You still wouldn't want to be put down. You still wouldn't want to be placed in a different category, you know, so my kids ain't like that, um, I try to teach the nieces and nephews and cousins and you know, everybody, I tell them, you know, it don't have to be this way, we could grow out of it, you know. So I think snow snakes for that could help these kids you know, coming up, our younger generation. I think that they could make them work together to say 'well hey you're doing this too and I'm doing it, we do have something in common, we both like this snow snakes.' So I think maybe, you know, maybe it can change some of them kids to where these kids are saying, 'oh I went to snow snakes last night and god I was, these kids from Eagle Soaring, they were a little better than I, or, you know, maybe they were a little worse than I was, you know, but god we played together and it was fun.' So I think in a way it could.

Brant: And it brings up an interesting point. I heard some things about [the Snow Snake Festival] where they made friends, you know, from other places, and they learned from one another, and so I think you're really on to something. I think that could be one of the outcomes.

Misty: And like I said, it's getting, to me snow snakes is gonna do nothing but get larger, you know, I mean like last year 20 kids, this year 40 kids, what's next year going to bring us, 60 kids, you know, and is it just going to keep on getting bigger and bigger. And we're going to have all these kids from different parts of this Reservation competing with each other, you know, so I think that it can, it might be able to change at least our younger kids' thinking, you know, to where, I mean adults are grown and stubborn and they ain't going to listen to their kids saying, 'oh I was with someone in Eagle Soaring and god, you know, they ain't bad,' you know, so I don't think it's the parents are gonna listen but I think we can change something with the way these kids think and so, I think that it's good. I think it's a good idea that we do have different kids coming from all over.

From this excerpt it would appear that snow snakes, in part as a result of snow snake curriculum activities, including the festival, may have the potential to connect people in ways heretofore unanticipated through a culturally-based STEM curriculum. Although what Misty proposes seems idealistic, the fact remains that snow snakes, much like other sports/competitions (e.g. the Olympics) has the ability to unite people groups that traditionally have had a contentious relationship. In the case of snow snakes and this

study the contention is between “clans” within reservation communities that have traditionally quarreled or have avoided one another.

Opportunity for competition and sportsmanship. One of the things sorely lacking on the reservation, especially at the case study site of Eagle Soaring School are opportunities for competition and sportsmanship for students. The data coded to “Opportunity for competition and sportsmanship”, guided by its descriptive title, illuminates this need at Eagle Soaring School. Parker shares a reflection in the following excerpt highlighting how snow snakes meet this need.

> …and then it was kind of fun to see the students supporting each other; their team. We don’t see that very often where they have a chance for that. Where they were cheering each other on and just kind of like the video from the Smithsonian where they were cheering their team on and showing the good sportsmanship. It was kind of fun to watch. So that was a highlight for me from the festival that I noticed.

Snow snakes is seasonal and commands only a small part of the academic year. That being said, the experiences and memories associated with snow snakes are lasting and play into the figured world established at Eagle Soaring School.

Secondary ownership. “Secondary ownership” was coded on two occasions. The sub-code was guided by the description of: “Any expression of ownership of snow snakes by an individual not directly involved with curriculum and activities.” The first occasion shared from an excerpt of my field journal recollects a lunch conversation that I serendipitously overheard while taking a break from research tasks.

> While sitting at lunch the speech pathologist that splits time between Maple Hollow and Eagle Soaring comes over to talk to Bruce the 5th grade teacher. They got to talking about snow snakes and the speech pathologist goes into what she knows about activities at PP. It was very interesting to hear her talking as an authority on the subject of my efforts. She was talking about how they were planning to integrate the curriculum into mathematics and language arts. Her air was that of ownership even though she was just a peripheral observer.

The next representation of "secondary ownership" comes from the final interview with Misty. In it she talks about her desire to take snow snakes to Catherine and Christopher's extended family.

> Brant: Anything else you would like to discuss about snow snakes?
>
> Misty: No, um, I would like to, if you do make copies of that movie I would like a copy of that. I would like to show their uncles and them on how, like how other tribes do it. I was trying to explain to Ron on showing him, like I saw this, you know, and they made their stick and it was different and they had like a steel tip on the tip of it so it was kind of different, you know, so he calls me a rambler, is what he calls me.

The ownership that Misty displays around snow snakes is subtle. By synthesizing her experience at the Snow Snake Festival, including the watching of the snow snake video from the Smithsonian, Misty is attempting to recreate the experience for Ronald, Catherine and Christopher's father, as well as her brother and brother-in-law. The

significance here is that in order for snow snakes to continue on beyond what will be done in the academic setting, it is necessary to have a champion that will perpetuate the tradition and associated cultural understanding. One champion is essential, multiple champions are even better.

The final suite of sub-codes associated with community impact speaks to the deeper meaning of snow snakes and the resultant impact on the traditions and cultural living that once was. The two sub-codes to be discussed to round out the findings are "Restoration of tradition", and "Set in motion"

Restoration of tradition. "Restoration of tradition" was coded to data meeting the description of: "Any expression that denotes something that was lost now being found or restored; or the rejuvenation of an important aspect of traditional cultural living." During the midpoint teacher interview teacher Parker discussed the response to one of the curricular components. This particular activity had students ask their families and community elders about the game of snow snakes as it applies to their life and the place that they live.

> …yep, and kind of like what I said before, everyone had a response or most kids, probably 90% of the kids had a response. And of those 90% maybe only one or two said that their parents even knew something about the game of snow snakes. That's why, you know, when they go home I look back and think maybe snow snakes is something that has been lost through the generations because they have been asking one, two, maybe three generations back was the furthest we got. You know great grandma or great grandma I guess. And with that, it's kind of nice that

> we are bringing something back from the culture and heritage that they didn't know about and maybe….It's just such a fun game. Hopefully the kids will be able to tell their kids one day what those are, the game.

It is clear from Parker's reflection that the game of snow snakes and the associated cultural artifacts and practices have effectively become dormant according to the information students secured. Now there is hope that the students involved in snow snakes will be keepers and practitioners of the cultural aspects of snow snakes by not only playing the game but also by supporting others by sharing their knowledge.

Bruce shares a reflection coded to "restoration of tradition" that highlights the excitement students are taking home with them to promote the game of snow snakes within their families.

> …she was saying 'next year I'm going to bring him [father] and he's going to help me do this,' and I said 'well that would be great.' I said, 'you could start right now if you want to you know' [laughter]. It sounded like there was some experience, like personal first hand with that one, the other ones were more stories that were kind of passed down, you know, and had heard of it and things like that. But I know that we have a couple kids now that are already talking about, um, 'I've already talked to my uncle and I'm going to keep my snow snake and they're going to build one and my cousins are going to build one and we're going to have our own competition at home.' So they're going to start like a family tradition up again, so. If anything it's brought some families closer and given them another activity that's been a long traditional game.

Set in motion. And finally, the sub-code "Set in motion" was guided by the description of: "Any expression that denotes the beginning of something that has important implications for the community." When talking to tribal elder Regal about his reflections on snow snakes and the implications that he saw, he shared the following thoughts:

> Well, we introduced a whole other generation of kids to, because every kid that did will talk to five kids that didn't. You know, and the story will start taking on a life of its own. And it should! It should, wherever it goes [laughter] more power to them. You know the Tara's and the Steve's and the Greg's and just all, all of them, you know they're going to look back on it, yep, we did that.

It is difficult to gauge the extent to which the snow snake curriculum and activities have impacted the community. From the data shared in the previous sections there is evidence for the beginning of a profound impact on the community as a result of snow snake curricular activities and the resonance by which they have been received with those involved in the community, parents, elders, extended family members and educators, to name just a few.

In this chapter the major findings were introduced and explained through three overarching categories: Science and STEM learning, agency, and community impact. Within each category the codes, sub-codes, and associated data were presented and analyzed. The following chapter will revisit the study's purpose through an explicit answering of associated research questions. Literature presented in chapter two will then be called upon to situate the overarching findings of the study within the existing

literature base. Implications, suggestions for future research, and study conclusions will conclude the final chapter.

CHAPTER SIX: DISCUSSION AND IMPLICATIONS

In this chapter the purpose of the study will be reviewed along with a brief overview of the means by which data was collected and analyzed. A restating of research questions with an accompanying discussion will follow. The purpose of research question restatement and discussion will be to explicitly make connections between the data introduced in the findings and how the findings adequately address research questions. Appropriate connections to the existing literature will be made that further situate the findings into the greater body of literature that informed this study. The chapter will conclude with implications for relevant audiences and suggestions for future research.

Review of Study Purpose

The purpose of this study was to understand the experiences of Ojibwe upper elementary school students with a culturally-based and integrated STEM curriculum and its impact on students' science agency. To explore the purpose of the study, a culturally-based and integrated STEM curriculum was developed using the Adventure Learning (AL) framework (Doering, 2006, 2007; Doering & Veletsianos, 2008). The culturally-based game of snow snakes was used as the context by which to deliver the integrated STEM content. STEM for the purposes of this curriculum explicitly applied mathematics (scaling and data), and science (force and motion) to an engineering prototype iteration that used available materials and tools (technology) for success.

As noted extensively in earlier chapters, the issue being address through this study relates to the achievement struggles of American Indian youth given the predominantly Western education system that guides their learning (Baker, 2003; McKinley, 2007).

Along with academic achievement struggles, opportunities to learn are often limited among reservation communities in part due to a lack of resources in reservation schools and the need for curricular innovations that connect content knowledge to students' experiences and identities. Assuredly the factors contributing to the historical struggles of American Indian youth are myriad and complex (U.S. Commission on Civil Rights, 2003). This study sought to look beyond standardized test scores to a more foundationally indicative paradigm that could affect change, that being student science agency.

Agency was used as the operational term of interest for a variety of reasons. Foremost was the fact that there is a void in the literature concerning science agency and American Indian youth. Agency emerged as a fruitful avenue for inquiry given the hypothesized outcomes related to experiencing the culturally-based STEM curriculum. The foundations related to agency are closely associated with efficacy and identity development (Bandura 2001). By combining snow snakes, which resonates with the culture of the students experiencing the curriculum, they more easily engage with STEM content, and therefore have the potential to develop agentic dispositions around science.

A case study research design was used for this study. A case study was chosen because according to Yin (2003) a case study investigates a phenomenon (e.g. science agency) which occurs within authentic contexts (e.g. snow snakes, AL, and Eagle Soaring School), especially when the boundaries between phenomenon and context are unclear. The research project was designed to gain insight into how students experienced the coupling of snow snakes with STEM content. From this research lens it was hypothesized

that by gaining access into a student's lived experience, insight into a student's science agency could be seen.

Data was analyzed using agency as the theoretical framework. Naturalistic codes were developed and then analyzed using NVivo qualitative data analysis software. With the help of NVivo, the naturalistic codes were reduced from overarching themes to capture the essence of the phenomenon in question from substantial raw data sources. As discussed in depth in chapter two, agency calls upon the critical theory (e.g. Pruyn, 1999), personality development (e.g. Little, Snyder, & Wehmeyer, 2006), and social cognitive theory (Bandura, 2001) literature and is closely associated with identity development. For this study agency was first operationalized devoid of content implications (e.g. science). Once this foundation was laid, science was incorporated and operationalized as it directly related to this study. Therefore, the operational definition for science agency was: An expressed behavior that illuminates positive dispositions towards STEM for the purposes of taking action in a student's individual life.

Discussion of Major Findings

The overarching research question for this study was: How does a culturally-based and integrated STEM curriculum impact a student's science agency? Before delving into a discussion around the evidence supporting answers to the overarching question, the three sub-questions will be discussed. Once the three sub-questions are discussed through study findings the overarching question will be revisited, effectively tying the study together.

Sub-question #1

The first sub-question was: What does science agency look like for 6th grade students? From the data, three representations emerged as depicting science agency, they are: connecting snow snake experiences to outside contexts; emergent leaders; and facility with science. Each representation will be discussed to highlight the tangible outcomes associated with science agency actions.

When a student makes explicit connections to contexts outside the snow snake experience they are displaying the ability to think beyond a surface level understanding of STEM content through these connections. As noted by Turner and Font (2003), a rigorous understanding of content will position students to act in transformational ways. Transformation then denotes the ability to move beyond the context associated with the content. The operationalized definition for science agency for this study states: An expressed behavior that illuminates positive dispositions toward STEM for the purposes of taking action in a student's individual life. Although making a connection to an outside context does not denote action per se, the expressed behavior of making the connection shows that students are thinking beyond snow snakes in ways that could indeed be mobilized into action given the right circumstances. For example, in the findings students talked about connections between snow snakes and the traditional act of spearing fish, riding a bicycle, and the use of wax on a flooring surfaces. The connections were associated with the physical science properties of snow snakes and spears and how their respective performance can be explained through science. In this example students did

not take action but the types of thoughts they were having make agentive action possible when the opportunity presents itself.

The next representation that denotes science agency development in students is when students emerge in leadership roles. Both in Barton and Tan (2010) and Basu, Barton, Clairmont, and Locke (2009) students emerged as leaders through their intentionality and achievement on tasks and how they were perceived by others as a result of authoring their own spaces within the informal and formal science education environment respectively. For example, in this study there was one student in particular that emerged as a leader in the snow snake prototype activities. As noted by the teachers associated with this case study, this particular student had heretofore struggled academically. Through the snow snake prototype activities this student commanded a level of facility with the STEM content that allowed him to emerge as an authority because of the performance of his snow snake prototype during testing. This consistent success set him apart from his classmates as an individual that had an understanding of the underlying STEM content that allowed him to take action in his life to be successful at a task. This success was recognized by his peers, and consequently he emerged as a leader that was consulted for the knowledge he possessed. When a student emerges as a leader it can be reasonably deduced that the student has expressed behavior that shows he or she is positively inclined toward STEM content and is able to mobilize this content knowledge for personal or group gain.

An obvious necessity of developing science agency is a student's facility with science. Facility with science is more than just expressing an understanding of content.

Facility with science is the ability to mobilize this understanding in agentive ways, in other words, taking scientific knowledge that a student is facile with and using it to take action for personal or group gain. This notion of facility with science is supported by Turner (2003) when noting that students need to have an understanding of the content in order to act upon that understanding. Facility with science was represented in students when explicit connections were made between science content and the outcomes associated with either snow snake prototypes or full scale snow snake activities. For example, when a student's snow snake prototype performed poorly during testing they were able to address the reason for the poor performance through scientific discourse. The scientific discourse associated with the poor performance would then provide avenues to explore in redesign efforts to enhance future performance.

A facility with science therefore provided the requisite expertise to take action for personal or group benefit. Without an expressed facility with science a student may display a non-committal or apathetic attitude towards future actions that could enhance snow snake performance. A non-committal or apathetic attitude would confound a student's ability to take calculated scientific action that would increase their chances of success. Thus, a facility with science is a representation in 6^{th} grade students that denotes the development of science agency.

Sub-question #2

The second sub-question was: What key experiences are involved in the development of science agency through a culturally-based STEM curriculum context? To answer this question a look must be taken at the impacts on students understanding of

STEM content and science in particular. As noted previously, “STEM agency” was not pursued because of the problematic nature of the acronym regarding student understanding. STEM education as it has been discussed in the literature has not found solid footing within K-12 discourse (Sanders, 2009). Therefore to use it with students without the historical background that a subject such as science commands would confound the goals and objectives of this study. This being said, there are some important findings related to STEM and science in particular that represent key experiences for the development of science agency in students.

First considering science content, the snow snake curriculum focused on physical science principles. Primarily through the engineering design iteration where students designed, constructed, tested, and redesigned snow snake prototypes, a number of physical science principles were learned and highlighted in student interview data. As a result of this experience students commented on their understanding of both scientific content and processes. Concerning scientific content students discussed: Friction, balance point, power, mass, and aerodynamics. For scientific processes students discussed: Testing, hypotheses, guessing, and experimenting. Teachers also had things to say about the value of the science as it related to the snow snake context. Most notable were sentiments relating to the ability of the snow snake context to provide authentic meaning to the science learned.

When talking about science agency it is a reasonable assumption to make that the science content learned and the experiences securing that content understanding are very important (Barton and Tan, 2010; Basu et al., 2009). To develop science agency the

science content must be meaningful to the goals and objectives of the curricular experience as intended through the design of the curriculum. The science content learned as expressed in the findings and reviewed in this chapter highlight those principles and processes that were meaningful to students and should be considered when developing culturally-based and integrated STEM education curricula for science agency development.

STEM content understanding was solicited through questions associated with the individual disciplines. Only when a student displayed a facility with those disciplines individually did interview probes inquiry about "STEM" understanding. Considering responses to engineering, student understanding related to design most notably. Students recognized that through engineering they could design a snow snake prototype or full scale model that had characteristics that would promote success in competition. Technology without exception related to understandings associated with tools that could be used to carry out engineering design concepts. Technology as expressed by students did not relate to educational technology in the form of computer mediated curricular experiences. And lastly, mathematical understanding was expressed as being involved with measurement activities. Through the use of data as secured through prototype activities, students made informed decisions on their prototype redesign.

Prototype activities and the associated data provided the most compelling support for STEM integration and represent the types of experiences that should be explored to support the development of science agency in students. The prototype activities were consistent with Sanders' (2009) prescription for "problem-based learning that

purposefully situates scientific inquiry and the application of mathematics in the context of technological designing/problem solving" (p. 21). The prototype portion of the snow snake curriculum was referenced frequently in the data by students and teachers. It was within the prototype design iteration that students were able to tangibly interact with STEM principles and make connections therein.

Learning STEM content through an integrated STEM education philosophy proved to be important for the development of science agency. Prototypes being the most notable experience due to the inherently engaging process by which prototypes are designed and tested. The hands-on experiences associated with the prototype portion of the curriculum coupled with the explicit use of STEM disciplines made for meaningful learning experiences for students. Without these experiences and the ability to apply STEM content in ways that are relevant to the learning objectives prescribed in the curriculum, it is reasonable to assume there would be a greater disconnect between content and the application of the content learned.

A final experience that promoted the development of science agency in students was the expert chat sessions. With the expert chats students were able to interact in meaningful ways with an expert on a topic that was relevant to specific points in the curriculum sequence (Doering, 2006, 2007). Experts brought contexts and content to life by sharing information that students could consider and apply in curricular activities. Students commented on having their conceptions on a topic shift as a result of hearing an expert explain an answer to a question that was posed by a student from a school site other than their own. The experience of an expert chat proved important because they

incorporated perspectives that were outside of the resources available within the figured world of Eagle Soaring School. The synched nature of expert chats also increased engagement and subsequently, the intentionality of students towards the curricular topic at hand.

Sub-question #3

The third and final sub-question was: Are there impacts on the community associated with the implementation of a culturally-based STEM curriculum? The data revealed a number of community impacts that were discussed within the study findings (chapter 5), they were: Connecting people; family involvement and impact; opportunity for competition and sportsmanship; restoration of tradition; secondary ownership; and set in motion. Although each community impact represents an important aspect of how the culturally-based STEM curriculum influenced the community, for the purposes of the discussion around the third sub-question, "family involvement and impact", and "restoration of tradition" will be highlighted.

When considering the impacts on the community of a culturally-based STEM curriculum, the involvement of students' families emerged as an important outcome. Throughout the literature on culturally-based curricular initiatives there are consistent references to the incorporation of community, with families being an integral part of communities (Castagno & Brayboy, 2008; Demmert & Towner, 2003; Morrison, Robbins & Rose, 2008). Family involvement could be categorized in three ways: Spectating, interest, and action. Each one is noteworthy because they show the different ways in

which families of students participating in snow snake curriculum activities were mobilized to act on behalf of their students.

Spectating, interest, and action represent a continuum of involvement that is important to consider when developing culturally-based STEM curricula. Spectating was relevant to snow snakes because of the snow snake festival event. Family members that were in attendance to support their students were not necessarily involved with snow snakes in other ways, but it is worth mentioning because it denotes community identity development which is part of the figured world of the bounded case of this study (Holland, Lachicotte Jr., Skinner, & Cain, 1998). Interest and action represent times where family members were moved to act or project actions because of their interest in snow snakes and the associated activities. Interest and action are notable because these impacts show that families are willing to invest in culturally-based STEM curriculum initiatives that resonate with preexisting cultural paradigms. Although outside the scope of this study it is reasonable to conclude that similar interest and action would be less evident for curricular initiatives unrelated to culturally-based contexts.

The restoration of the traditional game of snow snakes is another noteworthy community impact. Even though snow snakes could be considered just a game by individuals associated with this curricular initiative, there are important cultural implications for its rejuvenation. Regal, the tribal elder partnering on snow snake efforts once commented that one of his desires for snow snake curricular efforts was to make knowledge that was once common, common again. When students called upon the community knowledge around snow snakes it was found that many generations had

passed without experiencing the cultural stories and practices associated with the game of snow snakes. By restoring the tradition associated with snow snakes there is a hope that many of the traditional stories and ways of knowing will also be restored. Snow snakes represents just one context. It is reasonable to conclude that there are many other culturally-based contexts that could benefit from incorporation into K-12 structures by developing culturally-based and integrated STEM curricula around them.

Revisiting the Overarching Research Question

Coming full circle, the overarching research question was: How does a culturally-based and integrated STEM curriculum impact a student's science agency? To satisfactorily answer this question, four points will be made that highlight certain aspects of the discussions around the sub-questions. The intent is to effectively tie the study together and expound upon the overarching outcomes associated with the implementation of a culturally-based and integrated STEM curriculum within a specific contextual setting.

The first way a culturally-based and integrated STEM curriculum impacts students' science agency is by providing authentic STEM experiences that support the goals of a culturally-based context. This study has shown that by connecting a culturally-based context with authentic and meaningful STEM content, students respond positively and therefore a basis is established for the development of science agency. This is consistent with the literature for both curriculum integration as well as Indigenous epistemologies. Concerning the former, curriculum integration takes an authentic, contextualized problem and calls upon the relevant content for the purposes of solving

the problem (Beane, 1995). Integration around an authentic, contextualized problem is also consistent with integration strategies in STEM fields (Berlin & Lee, 2005; Frykholm & Glasson, 2005; Furner & Kumar, 2007; Koirala & Bowman, 2003; McComas & Wang, 1998; Sanders, 2009). For the latter, Indigenous epistemologies are holistic and interconnected (Cajete, 1994, 1999, 2005; Deloria, 1992) which support constructs associated with an integrated STEM education. Both seek to incorporate knowledge bases that make sense for the solving of problems. Both avoid compartmentalizing knowledge or content. Therefore, by coupling Indigenous epistemologies with integrated STEM education, a model of a culturally-based and integrated STEM education approach to curriculum development is mobilized.

The second way a culturally-based and integrated STEM curriculum impacts students' science agency is by valuing community and cultural representations therein. As noted previously, agency is closely associated with identity. Identity development in students is affected by many factors not least of which are their home lives, community and the associated cultural paradigms. By designing culturally-based curricula in a manner consistent with this study, the community becomes an integral part of the implementation process. With the community established as a legitimate partner in curricular activities, students are less likely to experience a disconnect between the world of community/culture, and the world of academic learning. The culturally-based and integrated STEM curriculum for this study explicitly involved community in both the planning and implementation. By bringing the community alongside curricular design and development efforts, the resultant implementation stands to motivate students to learn

because the context of learning is familiar to them and useful to the livelihood of the community (Battiste, 2002; Kawagley, 1995; Lipka, Mohatt, & The Ciulistet Group, 1998).

The third way a culturally-based and integrated STEM curriculum impacts students' science agency is by leveling the playing field for all learners to experience success and engage with STEM content which is full of meaning. Traditional academic structures have the tendency to track students into achievement projections based on past performance and social milieu. The track a student finds him or herself in is by no means permanent but at any given time it does have the tendency to dictate future performance and achievement. This study indicated that a culturally-based STEM curriculum supports both over and under achieving students in being successful and developing science agency. In both the Barton and Tan (2010) and the Basu et al. (2009) studies, students that had traditionally struggled academically and posed classroom management issues emerged as powerful agentic voices. This was in response to curricular structures that allowed students to express themselves through cultural representations and the disarming of traditional hegemonic structures within the formal and informal science setting (see also Pruyn, 1999). Leveling the academic playing field is done in part by coupling authentic and meaningful contexts that are associated with problems to solve or situations to address (e.g. Sanders, 2009); and an inclusion of cultural representations such as: Language, community, and Indigenous ways of knowing (Demmert & Towner, 2003).

And finally, the fourth way a culturally-based and integrated STEM curriculum impacts students' science agency is by fostering an environment that relates familiar and/or meaningful contexts with relevant content for transformational learning. The environment designed for in the culturally-based STEM curriculum of this study was a highly coordinated undertaking containing three carefully integrated elements: (1) a culturally-based game, (2) an explicit integration of STEM content, and (3) a hybrid educational approach known as Adventure Learning (AL) which utilized both online and face-to-face learning environments. By carefully integrating the aforementioned elements, this study showed that the dynamics of the learning environment were such that science agency could be fostered in students. Doering (2006, 2007) explained that the AL framework can transform student learning through authentic experiences exploring real-world issues that leverage collaborative opportunities designed for in the learning environment. Through the expert chats and other collaborative mechanisms, students were able to develop their understanding of snow snakes and STEM content by gaining insight into the perspectives of others. These new perspectives came from experts, teachers, and peers, as well as expressions of their own understanding for the benefit of others. When the hybrid educational approach of AL is coupled with a robust culturally-based context and meaningful STEM content, there is great potential for transformational learning as evidenced by the outcomes of this study.

Implications

The results of this study have implications for a variety of audiences. In this section implications associated with students, teachers, and the community will be

discussed. Beginning with students, implications relate to the potential experiences available to students by experiencing content through contexts that resonate with their cultural identities and the ramifications therein. The next audience is teachers. Implications will be presented concerning the types of curricular experiences that should be designed for and the results that can be expected from such efforts. And lastly, implications that affect the community associated with enacted culturally-based STEM curriculum and the potential impacts and associated opportunities will be discussed.

Students

This study was primarily interested in the impacts of a culturally-based and integrated STEM curriculum on students. Students were the primary unit of analysis as represented in their designation as embedded units through a case study research design (Yin, 2003). Because of this focus and the lens by which student experiences were analyzed in the data, there are three important implications to discuss: Engagement, classroom management, and future achievement. Each implication by nature has organic overlaps with the others. The explanation of student implications that follow will tease apart their differences.

Student engagement in and around snow snake curricular activities was heightened as evidenced by data from all entities: students, teachers, administrator, parents, and elder. Each interviewee at some point during the course of the three interview sequence commented on how engagement was greater during snow snake activities compared to traditional school activities. Relevance is also an important factor. When the STEM tasks are relevant to the context that resonates with students, they are

more apt to invest energy into solving problems and strive for success. Contrast the engagement of students through experiencing a culturally-based STEM curriculum to that of a decontextualized curricular experience, and the differences are clear.

Building from the implications for engagement is the natural connection to classroom management. When students are engaged in a task in authentic and meaningful ways they do not pose classroom management issues. On multiple occasions, teachers Parker and Bruce mentioned that when doing snow snakes there was not one classroom management issue. When time and attention can be fully given to instruction by both teachers and students instead of dealing with behavior issues due to lack of engagement, learning more easily occurs.

A natural result of engagement is achievement. Although this study did not look at achievement in a traditional sense through standardized test mechanisms, an implication and a possible area for future research would be to look at the achievement of students as a result of experiencing a culturally-based STEM curriculum. The argument could be made that by making curricular experiences more contextually relevant to students, it enhances engagement which then increases achievement.

Teachers

It is obvious that teachers are directly involved with the implications associated with students. It is necessary to look at implications from a teacher point of view as well to get a fuller sense of how culturally-based STEM curricula could impact student learning. No matter what the ability or expertise of a teacher, it could be reasonably stated that a goal of a teacher is to meet the learning needs of their students. Often times

attempts at meeting learning needs of students is done through decontextualized and unrelated curricular experiences. Building upon what has been stated previously, by taking a context such as snow snakes, associating important STEM content through a carefully structure pedagogical sequence, students academic needs are more accurately met.

After a teacher experiences the outcomes of implementing a culturally-based STEM curriculum, it could be inferred that they will associate value to teaching using curricula of this nature. The problem is that designing culturally-based and relevant curricula is a complex undertaking that requires much more effort on the teacher's part than some of the alternatives that are readily available. Once a teacher commits to teaching in such a manner there are a myriad of possibilities for curricular design and innovation. The local environment presents vast possibilities for leveraging contexts familiar to students. Once these contexts are identified as being fruitful avenues for exploration, teachers can infuse appropriate STEM content. From this point, a teacher can then reasonable expect the aforementioned student implications to resound.

Community

When considering culturally-based contexts to integrate within existing curricular expectations in a K-12 setting, the associated local community presents an invaluable resource and partner. The way science and mathematics have traditionally been taught in K-12 schools does not readily call upon the community to the extent that community and cultural needs are considered and utilized. From this research and the associated findings,

it is clear that there is a desire within the community to be involved in K-12 academic structures that are associated with a culturally-based STEM curriculum.

Using the example of snow snakes, there are organic collaborative opportunities within the community to be realized for the benefit of students. The parents and extended families associated with students participating in snow snake activities showed interest in being involved and calling upon their knowledge and resources to benefit students as evidenced in the findings chapter (chapter five). Often times figuring out how to involve the community in meaningful ways can be problematic and contrived. By developing culturally-based STEM curricula that highlight community needs and contexts during initial planning versus attempted inclusion after curricular design in near completion, the community becomes a vested partner where collaboration is organic instead of forced.

The community, once on board and vested, represents a valuable resource commanding a wealth of knowledge that can be utilized. In the case of snow snakes, the community was called upon to build a knowledge base of a game that had not been played for generations. The community was explicitly called upon as an important partner in building meaning; a meaning that could not be found anywhere else. The community in the form of parents and extended family also mobilized their traditional ecological knowledge to come up with ways to enhance the performance of snow snakes for student competitors. In the case of snow snakes, efforts were made by parents and the extended family of one of the students to secure bear grease to be used as a friction reducing agent. This is but one example of a way in which the community has expressed earnest interest in partnering with academic objectives. When thinking about other ways

in which the community could be leveraged to support culturally-base STEM curriculum initiatives, the possibilities are endless.

A school's identity does not necessarily reflect the identity of a community. A variety of reasons can be associated with this dichotomy. In the case of Eagle Soaring School, traditional means to rally a community together such as intermural sports are nonexistent. Athletic teams are extracurricular by nature and only involve a small portion of any given student body. Although snow snakes is a game, this fact is secondary to the cultural richness of the context and the STEM content learned. In addition, culturally-based STEM curricula such as the one developed around the snow snake context are all inclusive, giving students of every physical and cognitive ability an opportunity to participate and succeed. By including all students and including the community in authentic and meaningful partnerships, the associated identity development within the community will promote an investment into academic structures.

Suggestions for Future Research

There are three areas that should be considered for future research initiatives as a result of this study. These areas are: Science agency, integrated STEM education, and the identification of culturally-based contexts.

Beginning with science agency, one of the reasons science agency was considered as the outcome of interest for students experiencing the culturally-based and integrated STEM curriculum is because there was and still is a dearth of research and subsequent literature on the topic. Given the theoretical underpinnings of agency, and science agency in particular, it was recognized as an important outcome in students. Future research

efforts should continue to mobilize our understanding of how the development of science agency in students occurs through culturally-base and integrated STEM curricula and make connections to science agency and achievement on formative and summative assessments. If the research community can build from this study and the literature that came before it to understand those mechanisms that foster science agency development, valuable curricular experiences can be designed that increase achievement as a result of increased science agency.

Further research is also needed in the area of integrated STEM education. This study and the associated culturally-based STEM curriculum framed science, technology, engineering, and mathematics as an integrated construct with each individual discipline informing the other. As noted previously, the snow snake curriculum explicitly applied mathematics (scaling and data), and science (force and motion) to an engineering prototype iteration that used available materials and tools (technology). Although this worked well for the snow snake context, further research needs to be conducted on the value of using STEM as an integrated construct and the student outcomes therein. From the data associated with this study there was some confusion in students on what constituted science and what constituted engineering because of the closeness by which they were referenced during instruction. Research should look at ways in which STEM can be leveraged as an integrated construct for meaningful curricular experiences and at the same time keep the fidelity of the disciplines and their respective foundational paradigms intact.

And lastly, further research is needed to develop a model for the identification and mobilization of culturally-based contexts that can be interwoven with meaningful content. As noted previously, any community presents endless possibilities for the identification of meaningful culturally-based contexts that can be leveraged for inclusion into K-12 curricular structures. Not just any culturally-based context will do. It is important that the context identified has characteristics that lend to the content to be incorporated with. Thus, the context needs to be robust in nature. A model or framework needs to be researched and developed that will allow researchers and practitioners to accurately identify these contexts using the presence of specific indicators.

Conclusion

The seeds for this study were planted some 20 years prior in the early 1990's when elders at White Earth expressed the need to inquire into the game of snow snakes for possible rejuvenation. The inquiry would have implications for young and old alike. The game of snow snakes had not been played for quite some time yet had important cultural and spiritual implications. From this seed a culturally-based and integrated STEM curriculum was born. The snow snake curriculum afforded experiences that removed geographical barriers and brought students, teachers, experts and communities together in meaningful ways.

The research study explored questions associated with the development of science agency in students as a result of experiencing the snow snake curriculum. Implications for the community were also of interest. Findings showed that agency and science agency in particular are tenuous and nuanced constructs, especially as represented in upper

elementary students. Findings also revealed powerful implications for the combining of engineering design experiences (e.g. prototypes) with science and mathematics content for meaningful and engaging learning. Implications for communities associated with the delivery of culturally-based STEM curricula also emerged in the data and present strong evidence for fostering such curricular development approaches.

Snow snakes as a context proved to be meaningful and robust when making explicit connections to STEM content. A community need was expressed and by coupling this need with curricular expectations placed upon K-12 education, a powerful outcome was realized. In other words, students learned about an important cultural representation as well as STEM content through the snow snake curriculum.

I will close this narrative with one last story. The story as it appears was shared with Regal during our last interview conversation about snow snakes. The story highlights an experience that could very well be mere coincidence. The story could also mean much more. The timing and the pageantry of it all was not lost on me, or Regal, and provided yet one more piece of evidence that what we were collectively doing for students was the right thing to do.

> Brant: I wanted to share a story with you. On Friday I was working the track and it was toward the end of the day. I was going to head back and put the finishing touches on the track and so I was walking back out onto the running track and I was coming around that big pine and I look up and an eagle comes over the bleachers on that north side and it came over the football field, kind of toward that

end zone and it did a loop and then it threw on the brakes and went and perched in the tree that was directly at the opposite end of that first track I had built.

Regal: Wow, huh [laughter]. Cool

Brant: Just as I came around I look at this and just stood there like, wow, that's pretty meaningful, right at the end of the day.

Regal: Yeah, checking it out.

Brant: Like maybe we're doing something right.

Regal: Yeah, yeah, that's good. That's a good story.

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REFERENCES

Agency. (2009). Retrieved on August 19th, 2009 from http://dictionary.reference.com/browse/agency.

American Association for the Advancement of Science. (1989). *Science for all Americans*. New York: Oxford University Press.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

Apple, M. (1982). *Education and power*. London: Routledge.

Baker, D. R. (2003). Equity issues in science education. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education* (pp. 869-895). Dordrecht, the Netherlands: Kluwer Academic Publishers.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, *52*, 1-26.

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

Barton, A. C., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. *Journal of the Learning Sciences, 19*, 187-229.

Basu, S. J., Barton, A. C., Clairmont, N., & Locke, D. (2009). Developing a framework for critical science agency through case study in a conceptual physics context. *Cultural Studies of Science Education*, (4), 345-371.

Battiste, M. (2002). *Indigenous knowledge and pedagogy in First Nations education: A literature review with recommendations*. Ottawa: Indian and Northern Affairs Canada.

Beane, J. A. (1995). Curriculum integration and the disciplines of knowledge. *Phi Delta Kappan, 76*(8), 616-622.

Belgarde, M., Mitchell, R., & Arquero, A. (2002). What do we have to do to create culturally responsive programs? The challenge of transforming American Indian teacher education. *Action in Teacher Education, 24*(2), 42-54.

Berlin, D. F., & Lee, H. (2005). Integrating science and mathematics education: Historical analysis. *School Science and Mathematics, 105*(1), 15-23.

Bogdan, R., & Biklen, S. (2003). *Qualitative research for education: An introduction to theory and methods* (4th ed.). Needham Heights, MA: Allyn & Bacon.

Brayboy, B., & Castagno, A. E. (2009). Self-determination through self-education: Culturally responsive schooling for Indigenous students in the USA. *Teaching Education, 20*(1), 31-53.

Bureau of Indian Affairs. (1996). *American Indian standards for science education*. Washington, DC: Author

Bybee, R. W. (2010). What is STEM education? *Science, 329*, 996.

Cajete, G. (1994). Look to the mountain: An ecology of indigenous education. Skyand, NC: Kivaki Press.

Cajete, G. (1999). Igniting the sparkle: An indigenous science education model. Skyand, NC: Kivaki Press.

Cajete, G. (2005). American Indian epistemologies. *New Directions for Student Services, 109*, 69-78.

Cajete, G. (2008). Seven orientations for the development of indigenous science education. In N. K. Denzin, Y. S. Lincoln & L. T. Smith (Eds.), *Handbook of critical and indigenous methodologies* (pp.487-509). Thousand Oaks, CA: Sage.

Castagno, A. E., & Brayboy, B. (2008). Culturally responsive schooling for indigenous youth: A review of the literature. *Review of Educational Research, 78*(4), 941-993.

Clark, A. C., & Ernst, J. V. (2007). A model for the integration of science, technology, engineering, and mathematics. *The Technology Teacher, 66*(4), 24-26.

Cleary, L. M., & Peacock, T. D. (1998). *Collected wisdom: American Indian education*. Boston: Allyn & Bacon.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Culin, S. (1975). *Games of the North American Indians*. New York: Dover.

Czerniak, C.M., Weber, W.B., Sandmann, Jr.A., & Ahern, J.(1999). Literature Review of Science and Mathematics Integration. *School Science and Mathematics*, 99(8), 421-430.

Deloria, V., Jr. (1992). Relativity, relatedness and reality. *Winds of Change* (Autumn), 35-40.

Deloria, V., Jr., Wildcat, D. R. (2001). Power and place: Indian education in America. Golden, CO: Fulcrum Resources.

Demmert, W. G. (2001). *Improving schools' academic performance among Native American students: A review of the research literature*. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.

Demmert, W., & Towner, J. (2003). *A review of the research literature on the influences of culturally based education on the academic performance of Native American students*. Portland, OR: Northwest Regional Educational Lab.

Denzin, N. K., & Lincoln, Y. S. (2008). Introduction: Critical methodologies and indigenous inquiry. In N. K. Denzin, Y. S. Lincoln & L. T. Smith (Eds.), *Handbook of critical and indigenous methodologies* (pp. 1-20). Los Angeles: Sage.

Doering, A. (2006). Adventure learning: Transformative hybrid online education. *Distance Education, 27*(2), 197-215.

Doering, A. (2007). Adventure learning: Situating learning in an authentic context. *Innovate-Journal of Online Education, 3*(6). Retrieved on August 30, 2008 from http://innovateonline.info/index/php?view=article&id=342.

Doering, A. & Miller, C. (2009). Online Learning Revisited: Adventure Learning 2.0. In I. Gibson et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2009* (pp. 3729-3735). Chesapeake, VA: AACE.

Doering, A., & Veletsianos, G. (2008). Hybrid Online Education: Identifying Integration Models using Adventure Learning. *Journal of Research on Technology in Education, 41 (1), 101-119.*

Efficacy. (2010). Retrieved on November 1st, 2010 from http://dictionary.reference.com/browse/efficacy.

Freeman, C., & Fox, M. (2005). *Status and trends in the education of American Indians and Alaska Natives*. Washington, DC: National Center for Educational Statistics.

Freire, P. (1970). *Pedagogy of the oppressed*. Ramos, M., trans. New York: Continuum.

Frykholm, J., & Glasson, G. (2005). Connecting science and mathematics instruction: Pedagogical context knowledge for teachers. *School Science and Mathematics, 105*(3), 127-141.

Furner, J. M., & Kumar, D. D. (2007). The mathematics and science integration argument: A stand for teacher education. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(3), 185-189.

Gilliland, H. (1995). *Teaching the Native American*. Dubuque, IA: Kendall/Hall.

Giroux, H. (1984). Ideology, agency, and the process of schooling. In Barton, L. and Walker, S., (Eds.), *Social Crisis and Educational Research* (pp. 306-334). London: Croom and Helm.

Gramsci, A. (1971). *Selections from the prison notebooks*. Medea, Q. and Smith, N., eds. and trans. London: Lawrence and Wishart.

Graves, K. D., & Ebbott, E. (2006). *Indians of Minnesota* (5th ed.). Minneapolis, MN: University of Minnesota Press.

Hall, M. (1996). Full circle: Native educational approaches show the way. *Journal of Experiential Education, 19*(3), 141-144.

Hermes, M. (2000). The scientific method, Nintendo, and eagle feathers: Rethinking the meaning of “culture-based” curriculum at an Ojibwe tribal school. *Qualitative Studies in Education, 13*(4), 387-400.

Hill, N. (1991). AISES: A college intervention program that works. *Change, 23*, 24-26.

Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (1998). *Identity and Agency in Cultural Worlds*. Cambridge, MA: Harvard University Press.

Hughes, J. E. (2003). Toward a model of teachers’ technology-learning. *Action in Teacher Education, 24*(4), 10-17.

Inden, R. (1990). *Imagining India*. Oxford: Blackwell.

Jackson, D. B. (2003). Education reform as if student agency mattered: Academic microcultures and student identity. *Phi Delta Kappan, 84*(8), 579-585.

Katehi, L., Pearson, G., & Feder, M. (Eds.). (2009). *Engineering in K-12 education: Understanding the status and improving the prospects*. Washington, DC: National Academies Press.

Kawagley, A. O. (1995). *A Yupiaq worldview: A pathway to ecology and spirit*. Prospect Heights, IL: Waveland Press.

Kawagley, A. O., & Barnhardt, R. (1999). Education indigenous to place: Western science meets Native reality. In G. A. Smith & D. R. Williams (Eds.), *Ecological education in action: On weaving education, culture, and the environment* (pp. 117-140). Albany, NY: SUNY Press.

Kawagley, A. O., Norris-Tull, D., & Norris-Tull, R. A. (1998). The indigenous worldview of Yupiaq culture: Its scientific nature and relevance to the practice

and teaching of science. *Journal of Research in Science Teaching, 32*(2), 133-144.

Kincheloe, J. L., & McLaren, P. (2005). Rethinking critical theory and qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (3rd ed., pp. 303-342). Thousand Oaks, CA: Sage.

Klug, B., & Whitfield, P. (2003). *Widening the circle: Culturally relevant pedagogy for American Indian students*. New York: Routledge.

Koirala, H. P., & Bowman, J. K. (2003). Preparing middle level preservice teachers to integrate mathematics and science: Problems and possibilities. *School Science and Mathematics, 103*(3), 145-154.

Kuenzi, J., Matthews, M., & Mangan, B. (2006). *Science, Technology, Engineering, and Mathematics (STEM) Education Issues and Legislative Options.* Congressional Research Report. Washington, DC: Congressional Research Service.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-491.

LaDuke, W., & Alexander, S. (2004). *Food is medicine*. Minneapolis: Smart Set Inc.

Lee, O., & Luykx, A. (2006). *Science education and student diversity: Synthesis and research agenda*. New York: Cambridge University Press.

Lipka, J., & Mohatt,G. V., & The Ciulistet Group. (1998). *Transforming the culture of schools: Yup'ik Eskimo examples*. New York: Routledge.

Little, T. D., Snyder, C. R., & Wehmeyer, M. (2006). The agentic self: On the nature and origins of personal agency across the life span. In D. K. Mroczek & T. D. Little

(Eds.), *Handbook of personality development* (pp. 61-79). Mahwah, NJ: Lawrence Erlbaum.

Massachusetts Science and Technology/Engineering Curriculum Framework. (2006). Massachusetts Department of Education: http://www.doe.mass.edu/frameworks/scitech/1006.pdf

McComas, W. F., & Wang, H. A. (1998). Blended science: The rewards and challenges of integrating the science disciplines for instruction. *School Science and Mathematics, 98*(6), 340-348.

McKinley, E. (2007). Postcolonialism, indigenous students, and science education. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 199-226). Mahwah, NJ: Lawrence Earlbaum.

McLaren, P. (1994). Critical pedagogy, political agency, and the pragmatics of justice: The case of Lyotard. *Educational Theory, 44*, 319-340.

Meriam, L., Brown, R., Cloud, H., Dale, E., Duke, E., Edwards, H., et al. (1928). *The problem of Indian administration: Report of a survey made at the request of the Honorable Hubert Wrok, Secretary of the Interior, and submitted to him, February 21st, 1928*. Baltimore: The Brookings Institute.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.

Minnesota Academic Standards in Science. (2009). Minnesota Department of Education: http://education.state.mn.us/mdeprod/groups/Standards/documents/Publication/013906.pdf

Moran, R., Rampey, B. D., Dion, G. S., & Donahue, P. L. (2008). *National Indian education study 2007 part I: Performance of American Indian Alaska Native students at grades 4 and 8 on NAEP 2007 reading and mathematics assessments*. Washington, DC: National Center for Education Statistics. (NCES No. 2008457). http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2008457

Morrison, K. A., Robbins, H. H., & Rose, D. G. (2008). Operationalizing culturally relevant pedagogy: A synthesis of classroom-based research. *Equity & Excellence in Education, 41*(4), 433-452.

National Academies. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Governors Association. (2007). *Innovation America: Building a science, technology, engineering and math agenda*. Washington, D.C.: National Governors Association Center for Best Practices. Retrieved September 14, 2010, from http://www.nga.org/Files/pdf/0702INNOVATIONSTEM.PDF

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

Nelson-Barber, S., & Estrin, E. T. (1995). *Culturally responsive mathematics and science education for native students*. San Francisco: Far West Laboratory for Educational Research and Development.

Olitsky, S. (2006). Structure, agency, and the development of students' identities as learners. *Cultural Studies in Science Education, 1*(4), 745-766.

Parker, A. C. (1909). Snow-snake as played by the Seneca-Iroquois. *American Anthropologist, 11*(2), 250-256.

Pewewardy, C. (1998). Our children can't wait: Recapturing the essence of Indigenous schools in the United States. *Cultural Survival Quarterly, 22*(1), 29-34.

Pewewardy, C., & Hammer, P. (2003). *Culturally responsive teaching for American Indian students*. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.

Prucha, F. (2000). *Documents of United States Indian Policy* (3rd ed.). Lincoln: University of Nebraska Press.

Pruyn, M. (1999). *Discourse wars in Gotham-West: A Latino immigrant urban tale of resistance and agency*. Boulder, CO: Westview Press.

Reagan, A. B., & Waugh, F. W. (1919). Some game of the Bois Fort Ojibwa. *American Anthropologist, 21*(3), 264-278.

Rhodes, R. (1994). *Nurturing learning in Native American students*. Hotevilla, AZ: Sonwei Books.

Sanders, M. (2009). STEM, STEM education, STEMmania. T*he Technology Teacher*, 68(4), 20-26.

Seidman, I. (2006). *Interviewing as qualitative research*. New York: Teachers College Press

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for

science education. *Science Education, 85*(1), 6–34.

Turner, E. (2003). *Critical mathematical agency: Urban middle school students engage in mathematics to investigate, critique, and act upon their world.* Unpublished doctoral dissertation, University of Texas, Austin.

Turner, E., & Font, B. (2003). *Fostering critical mathematical agency: Urban middle school students engage in mathematics to understand, critique and act upon their world*. Paper presented at the American Education Studies Association Conference, Mexico City.

U. S. Commission on Civil Rights. (2003). *A quiet crisis: Federal funding and unmet needs in Indian country*. Washington, DC: Author.

U.S. Department of Education. (2001). *American Indian and Alaska Native education research agenda*. Washington, DC: Author.

Walls, T. A., & Kollat, S. H. (2006). Agency to agentic personalities: The early to middle childhood gap. In D. K. Mroczek & T. D. Little (Eds.), *Handbook of personality development* (pp. 231-244). Mahwah, NJ: Lawrence Erlbaum.

White Earth Reservation Curriculum Committee. (1989). *White Earth: A history*. Cass Lake, MN: The Minnesota Chippewa Tribe.

Wolcott, H. F. (1990). *Writing up qualitative research*. Newbury Park, CA: Sage Publications.

Yin, R. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oak, CA: Sage.

APPENDIX A: INTERVIEW PROTOCOLS

Student Initial

Interviewer entry - "I am really interested in your ideas about your school and your community"

1. What are two things about learning activities at your school that you really like, or that are really important to you?

   Probes: Why is it really important to you? What do you like about it? What does it mean to you?

2. What are two things about learning activities at your school that you wish were different, or that you might like to change?

   Probes: Why would you like to change it? How do you wish that it was? What do you think you could do to change it? Do you think that would make a difference? What do you think would need to happen for it to change? Is there anything else you would really like to change?

3. What is your favorite subject in school?

   Probes: Why is it your favorite subject? Can you tell me a story about an experience with that subject that makes it your favorite?

4. What is your least favorite subject in school?

   Probes: Why is it your least favorite subject? Can you tell me a story about an experience with that subject that makes it your least favorite?

5. Do you feel like you are good at science? Explain.

   Probe: Can you tell me how you might use what you have learned about science through snow snakes in your life?

6. Do you think science can help you in your life? How?

   Probes: How did you learn these two things? Can you tell me about how you might use science in your life? For what purposes would you use science?

7. What would you say to your little brother or sister (or someone younger) if he or she were wondering what science was? What would you tell them? How would

you describe science to them? Are there other things that you think of? What would you say to a student at your school that said, "What's the point of learning science?" What would you say if the student said that they have learned enough science already?

Student Midpoint

1. What is a snow snake?

   Probes: Can you tell me about your experience with snow snakes to this point?

2. What snow snake experiences stick out in your mind so far? Highlights? Why are these experiences memorable to you?

   Probes: Classroom activities? Computer activities? Outside activities?

3. What have you learned about science, technology, engineering, and mathematics while working with snow snakes:

   Probes: Was there an area of science, technology, engineering and mathematics that stuck out more than another?

4. Can you tell me about an experience where you have felt success with snow snakes? To this point in snow snake activities, do you feel that you have been successful in what you have been asked to do?

   Probes: What made you feel successful? What did success feel like?

5. Do you feel like you are good at science? Explain.

   Probe: Can you tell me how you might use what you have learned about science through snow snakes in your life?

6. Can you tell me about your experience with snow snakes on the computer?

   Probes: What part of snow snakes on the computer have you liked the best? Why?

Student Final

1. In your mind, how were snow snake activities done in school different from other school activities? How were snow snake activities similar to other school subjects?

Probes: Were you more interested in snow snake activities compared to other school activities?

2. Are there snow snake activities that were memorable to you? Please explain. Are there snow snake activities that you feel were useful to you? Please explain.

   Probes: How could the things you have learned through snow snakes be used in other parts of your life?

3. Can you tell me two things you learned about science through snow snakes?

   Probes: How did you learn these two things? Can you tell me about how you might use science in your life?

4. Can you tell me two things you know about math through snow snakes?

   Probes: How did you learn these two things? Can you tell me about how you might use math in your life?

5. Can you tell me two things you know about technology through snow snakes?

   Probes: How did you learn these two things? Can you tell me about how you might use technology in your life?

6. Can you tell me two things you know about engineering through snow snakes?

   Probes: How did you learn these two things? Can you tell me about how you might use engineering in your life?

7. What would you say to your little brother or sister (or someone younger) if he or she were wondering what science was? What would you tell them?

8. Tell me about how your ideas from the snow snake prototypes worked in constructing your full size snow snake. Was making prototypes helpful to your thinking about how a snow snake travels and designing your full size snow snake? Can you explain?

9. Did you participate in the snow snake festival last weekend? If so, tell me about your experience.

   Probes: What was the best part about the snow snake festival for you?

10. Do you feel like you are good at science? Explain.

    Probe: Can you tell me how you might use what you have learned about science through snow snakes in your life?

Teacher Initial

Interviewer entry - "I am really interested in getting some background information about you as a teacher as well as your thoughts on the upcoming snow snake curriculum"

1. Can you tell me a little bit about your teaching background?

    Probes: Where have you taught before? For how long? How long have you been at this current teaching assignment? Any previous work experience that assists your think and planning around teaching?

2. What are your thoughts about teaching the snow snake curriculum?

    Probes: Have you had a chance to become familiar with the curriculum? How much time have you spent to this point preparing for delivering the curriculum? How much preparation will you give to the curriculum during implementation? Are you comfortable with the content of the curriculum? If there are content areas of the curriculum which are unfamiliar and therefore need more professional development, which would they be?

3. From what you currently know about the snow snake curriculum and activities, how is it similar and different from the current curriculum used at Pine Point School?

    Probes: Can you tell me at least two similarities? Two differences?

4. What is your current plan for snow snake curriculum implementation?

5. Can you talk a little bit about your observations of students around snow snakes to this point?

Teacher Midpoint

1. What are some general reflections you have about the snow snake curriculum to this point?

    Probes: What are some of the highlights (if any)? What are some of the complications (if any)? Is the implementation of the curriculum progressing as outlined?

2. Do you see student engagement changing as a result of snow snake curriculum activities?

    Probes: Have you observed any students emerging as authorities on snow snakes? Have you observed students teaching other students on a topic related to snow snakes?

3. From your perspective, what aspects of the curriculum have been the most powerful in the sense of student engagement and interest?

    Probe: Can you share a story about an observation you have made concerning students' responses to the curriculum and activities?

4. Are there any other issues related to snow snakes you would like to share or discuss?

Teacher Final

1. What are some general reflections you have about the snow snake curriculum at the conclusion of activities?

    Probes: What are some of the highlights (if any)? What are some of the complications (if any)? Did the implementation of the curriculum progress as outlined?

2. Did you see student engagement changing as a result of snow snake curriculum activities? Did you see student feelings and/or beliefs toward science changing as a result of snow snake curriculum activities?

    Probes: Have you observed any students emerging as authorities on snow snakes? Are there students who are more engaged, have stronger feelings, or are more expressive in their beliefs with snow snake activities than others?

3. From your perspective, what aspects of the curriculum were culturally relevant?

    Probes: What makes these aspects culturally relevant?

4. What are some of your overall reflections about the snow snake festival? Can you share any stories concerning student interest, engagement, and/or experience with the snow snake festival?

5. Do you have any final thoughts on the snow snake project?

Probes: How did delivery of the curriculum go? What are your final thoughts on the impact of snow snakes on student learning of STEM content?

Administrator Initial

1. Observations or things you have heard about snow snakes coming from students, staff, and community?
2. Discuss overall hope and/or expectations for snow snakes.
3. Discuss overall philosophy toward education. Education for Native American students.
4. Do you have any concerns about implementing a curriculum of this nature?

Administrator Midpoint

1. Recent observations around SS activities?
2. Have you heard students and/or staff talking about snow snakes? Can you tell me about what you have heard and your perceived significance of what you are hearing?
3. Do you have any stories you could share about snow snakes that highlight some of the important educational outcomes being secured through snow snakes from your perspective?
4. Any other comments about snow snakes thus far?

Administrator Final

1. I am interested in any observations around snow snake activities you have made since the last time we talked?
2. Have you heard students and/or staff talking about snow snakes? Can you tell me about what you have heard and your perceived significance of what you are hearing?
3. Do you have any stories you could share about snow snakes that highlight important educational outcomes?
4. Do you have any other final comments about snow snakes you would like to share?

Parent/Guardian Initial

1. From your perspective, I would like to hear about the snow snake festival from last year.
2. Can you tell me what you have heard about snow snakes from this year?
3. Has Catherine or Christopher talked about snow snakes? What have they had to say?
4. What are your overall thoughts about the education system at Eagle Soaring School or in general?
5. What have been your experiences with education generally speaking?
6. What do you hope or expect from the education system at Eagle Soaring School or in general?
7. What would an ideal education or education system look like? Produce?
8. Do you plan on coming to the snow snake festival on March 13th?

Parent/Guardian Midpoint

1. Since the last time we talked, can you tell me about anything you have heard or observed related to snow snakes?
2. Have you noticed a change in behavior in _____ since snow snake activities have begun? Explain.
3. How often, if at all, has snow snakes come up in conversations in the home?
4. Last time you had mentioned using materials such as bear grease to enhance the performance of a snow snake. Have you pursued this since we talked last?
5. How involved have you been in the snow snake project thus far? Other family members?
6. Can you talk a little about your interest in this project versus interest in more traditional or typical school subjects?
7. Is there anything else you would like to discuss about snow snakes? Is there anything you would like to say that we haven't had a chance to talk about yet?

Parent/Guardian Final

1. Since the last time we talked, can you tell me about anything you have heard or observed related to snow snakes?

2. Thinking about the last couple of months and doing snow snake activities in school, can you talk about any differences you have observed in Catherine and Christopher regarding school? For example, motivation, confidence, anxiety, excitement, focus, etc.

3. Have you noticed Catherine and/or Christopher's attitude or disposition change towards science since snow snake activities started a couple of months ago?

4. Have you observed Catherine and/or Christopher doing anything around snow snakes that was not directed by an adult or as part of prescribed school activities? Can you talk about any proactive measures Catherine and/or Christopher have taken towards snow snakes to promote success?

5. Are there any reflections on the snow snake festival that you would like to share?

6. What do you think the future holds for snow snakes at Eagle Soaring, White Earth, and northern Minnesota?

7. Is there anything else you would like to discuss about snow snakes?

Elder Initial

1. Could you talk a little bit about the observations you've made working with the kids here to this point and some of the positive aspects, or even negative aspects of maybe doing something that isn't the norm?

2. I really liked what you had to say about that transition from them realizing that this has been done for a long time, it allows them to be who they really are, so thinking about Anishinaabe youth and their future, how, in maybe a small way, how does SS prepare them for that future?

3. No I like that. You had mentioned a couple legends that you recently had come across, one of them about snakes being below each community and, but then there was also that similarity to the winter maker legend. Could you share, and I know you said they're complex and your still working them out, but could you share some of these recent legends, or these legends that you have come across recently that might have implications for what we are doing here?

Elder Midpoint

1. Since the last time we talked, can you tell me about anything you have heard or observed related to snow snakes?
2. Thinking about the last couple of months and doing snow snake activities in school, can you talk about any differences you have observed in Catherine and Christopher regarding school? For example, motivation, confidence, anxiety, excitement, focus, etc.
3. Have you noticed Catherine and/or Christopher's attitude or disposition change towards science since snow snake activities started a couple of months ago?
4. Have you observed Catherine and/or Christopher doing anything around snow snakes that was not directed by an adult or as part of prescribed school activities? Can you talk about any proactive measures Catherine and/or Christopher have taken towards snow snakes to promote success?
5. Are there any reflections on the snow snake festival that you would like to share?
6. What do you think the future holds for snow snakes at Eagle Soaring, White Earth, and northern Minnesota?
7. Is there anything else you would like to discuss about snow snakes?

Elder Final

1. Since the last time we talked, can you tell me about anything you have heard or observed related to snow snakes?
2. Thinking about the last couple of months and doing snow snake activities in school, can you talk about any differences you have observed in Catherine and Christopher regarding school? For example, motivation, confidence, anxiety, excitement, focus, etc.
3. Have you noticed Catherine and/or Christopher's attitude or disposition change towards science since snow snake activities started a couple of months ago?
4. Have you observed Catherine and/or Christopher doing anything around snow snakes that was not directed by an adult or as part of prescribed school activities? Can you talk about any proactive measures Catherine and/or Christopher have taken towards snow snakes to promote success?

5. Are there any reflections on the snow snake festival that you would like to share?
6. What do you think the future holds for snow snakes at Eagle Soaring, White Earth, and northern Minnesota?
7. Is there anything else you would like to discuss about snow snakes?

APPENDIX B: CODES

Agency

Agency

Any sentiment that could be perceived to have agenic qualities, however subtle or overt.

Connecting snow snake experiences to outside contexts

Any expression where a student makes a connection or extension from what was done at any point during the snow snake curriculum activities to a context clearly outside of snow snake activities.

Emergent leaders

Any expression that depicts an unlikely student emerging as an authority and/or leader around an aspect of snow snake activities.

Facility with science

Any expression by a student that exhibits the use of science for snow snake success, either currently or in the future.

Agency protection

Any expression of positioning oneself to hold onto the status and therefore level of agency already attained. These types of behaviors may illuminate the tenuous nature of the existing agency.

Agency recognized by others

Any expression of a student seeking the knowledge of another student because they have recognized the other student's expertise around snow snakes. Also teachers seeking the knowledge of a student.

Disposition towards agency

Any sentiment that leads me to believe that this particular student has an inherent disposition towards developing agency regardless of what kind of agency it is. This could be coupled with a competitive nature and the will/drive to succeed.

Loss of agency

Specific to Catherine and Christopher Blue, after having developed agency around snow snakes as a result of past success, a lack of success resulted in a loss of agency.

Potential agency

Any notion of budding science agency.

Snow snake agency

Any expression of agency that is specific to snow snakes and does not necessarily include science.

Case

Case material

Any material that can be used to develop Eagle Soaring School as a bound case and students in the 2009/2010 6th grade class as the embedded units.

Current science experiences

Science experiences prior to snow snakes.

Figured world of Eagle Soaring School

The culture, norms, and conscious efforts of students and staff to make an atmosphere that aligns with the stated mission of the school and personally held convictions of what education at Eagle Soaring School should reflect. This material can also be looked upon as integral to Eagle Soaring School case development.

Pride

Any expression of pride related to snow snake performance or outcomes

Relationship to snow snakes

Self explanatory code title

Staff and student dispositions

Self explanatory code title

Structure of school activities

Any expression that talks about the structure of activities or the school day at Eagle Soaring School that could be pointed to as having positive or negative impacts on school atmosphere.

Science ability and sentiment

Self explanatory code title

Science definition

Self explanatory code title

Snow snake history at WE

Any comments relating to the history of snow snakes at White Earth regardless of source.

Community Impact

Community Impact

Any reference that has implications beyond Eagle Soaring School involving individuals other than students and staff directly or referencing the future.

Connecting people

Any expression that talks about snow snakes as an activity that connects people. Whether it is students from different communities or individuals that did not have a specific reason to reach out to one another and therefore connect as a result of being associated with snow snakes.

Family involvement and impact

Any excerpt displaying the impact of snow snakes on family members.

Opportunity for competition and sportsmanship

Self explanatory code title

Restoration of tradition

Any expression that denotes something that was lost now being found or restored. Or the rejuvenation of an important aspect of traditional cultural living.

Secondary ownership

Any expression of ownership of snow snakes by an individual not directly involved with curriculum and activities.

Set in motion

Any expression that denotes the beginning of something that has important implications for the community.

Future plans

Student intentions for the future, general or specific.

Culturally-based

Cultural relevancy support

Any expression that supports snow snakes as being culturally relevant to Ojibwe culture.

Curriculum

Curriculum extensions

Any reference to activities that have been integrated beyond the prescribed curriculum.

Curriculum value

Any expression that attaches a value to the snow snake curriculum either as it aligns with current educational objectives at Eagle Soaring School or on standalone merits.

Teacher explanation of implementation

Self explanatory code title

Hybrid learning environment

Limitation of AL environment

Any expression that highlights the AL environment not being used to its potential or as prescribed by the curriculum. This is not a limitation of the environment itself but a limitation on the impact due to non-use.

The value of using educational technology

Any outcome that could be contributed to using technology in any number of ways as designed into the curriculum framework of Adventure Learning.

AL Highlight

Self explanatory code title

Connecting people

Any expression attributed to an AL component that has connected individuals in meaningful and unexpected ways.

Media and text

Any expression that highlights media and/or text as being a valuable experience to student engagement and understanding of snow snakes.

Motivating participation

Any expression that attributes a student's motivation to participate to the use of technology or the online environment.

Observations

Home dialogue and observations

Any expression of dialogue about snow snakes between Catherine, Christopher, and parents. Observations of behavior that can be attributed to snow snake activities.

Observations of students

Any observation by an adult associated with snow snake activities in some capacity.

STEM

Prototype

Any discussion around snow snake prototype impacts.

Science content

Any reflection of science content either curriculum prescribed or an extension of the curriculum that was not explicitly found therein.

STEM content

Any explanation of STEM as an integrated construct. Sentiment aligning with STEM as intentioned in the snow snake curriculum.

Shushumay (Snow Snake) Curriculum and Activities

January – March, 2010

Acknowledgements

This curriculum is the result of a very thoughtful collaboration between the people of the White Earth Indian Reservation and the University of Minnesota. More importantly, this curriculum would not have been possible if it were not for the tribal communities that created this beautiful game and have kept the tradition alive amidst the technological age in which we all live. A special thank you is extended to the knowledge keepers that keep the flame of tradition, language, and sport burning. This curriculum was also made possible in part through the National Science Foundation (Information Technology Experiences for Students and Teachers). #0737565. Reach for the Sky: Integrating technology into STEM outcomes for American Indian Youth

Alert!

Boozhoo future leaders! As you may know it is wintertime in the North Country. Wintertime brings with it many challenges and opportunities. Challenges may include staying warm and travel due to wintery conditions. Opportunities may include building relationships with family and friends during the long and dark winter evenings as well as recreation provided by winter conditions. It is this last point, recreation, which provides the challenge and opportunity we will be actively pursuing for the next couple of months. Have you heard of snow snakes? In Ojibwe snow snakes are called shushumeg (plural), and shushumay (singular). Shushumeg is a wintertime game played by tribes in the United States and Canada where the climate is conducive to snow and ice, kind of like Northern Minnesota. Each person has a shushumay (or two or three) made from wood found in a nearby forest. This wood can be maple, basswood, oak, willow, etc. Once you find a snakey piece of wood, work can begin. Much of the detail for this project will be explained as we go. For now all you need to know is that you will have a shushumay made out of wood that you will use to play the game.

The game is simple. Each competitor throws there shushumay down an ice track and the farthest shushumay wins the game. Although the rules of the game are simple, the shushumay itself can be somewhat complex depending on how you go about crafting it. Again, more details about this later. For now, we need to get to talking about the challenges related to this game.

There are four grand challenges related to shushumeg leading up to the Shushumay Festival in the middle of March. Challenge #1: Throwing a shushumay for distance (human powered). Challenge #2: Releasing a shushumay for distance (gravity powered, i.e. release shushumay down a hill/decline). Challenge #3: Throwing a shushumay for accuracy (predefined target at a reasonable distance from point of throwing). And Challenge #4: Aesthetics (the most visibly appealing shushumay design, traditional and modern).

The challenge is up to you! You can choose to take on all four challenges or focus your efforts on fewer. All of your efforts will be highlighted during the Shushumay Festival when all schools participating in this project will join together to celebrate efforts and build community. Good luck future leaders!

Curriculum Overview

The purpose of the snow snake curriculum is to foster contextually rich and cultural relevant experiences while at the same time promoting science, technology, engineering and mathematics (STEM) content. To do this, a hybrid environment has been developed where an interactive web-based interface is coupled with face-to-face (F2F) components to bring a highly contextual real-time experience to students who participate in the program.

The website being utilized is - http://snowsnakeden.ning.com/

It is recommended that the snow snake curriculum commence in early January 2010 (see calendar). Students will progress from an introduction of snow snakes through to development and use of snow snakes during the festival on March 13th, 2010. At the core of the snow snake program will be a standards based curriculum that can be followed during the delivery of the snow snake activities within a science or culture class setting. Curricular components touch upon history, science, technology, engineering, mathematics, art, and physical education. Throughout the curriculum, every effort will be made to provide students with the opportunity to share their culture and to contribute to the overall curriculum experience for all students.

The online environment will provide a place for students and teachers to interact and collaborate with other schools participating in snow snake activities. There will be many collaboration opportunities for those schools involved with the program. The following list is just a small part of the potential of this hybrid learning environment:

- **Collaboration zones**: Students will have specific locations to upload pictures, video, and audio documenting their progression through the snow snake construction process.
- **Journey Blog**: Each week students and teachers will have the opportunity to document their journey on the program blog. The blog will allow each class the opportunity to express their successes, struggles and questions pertaining to snow snakes.
- **Expert Chat**: During select weeks throughout the curriculum an expert will join the program to discuss a certain aspect of snow snakes. Experts will include Tribal Elders, Mathematicians, Engineers, Artists and Scientists. The expert chat will provide an opportunity for students to deepen their understanding of content and the significance of snow snakes as a pastime to indigenous peoples in climates conducive to snow snake activities.

The curriculum is made up of five phases. Each phase represents an important foundation in the sequence of the shushumay program. Through the phases students will have the

opportunity to secure important information and have experiences that will assist them in meeting the four grand challenges. A synopsis of the five curricular phases is as follows:

Phase One – Background– Shushumeg (Snow Snakes). There are two parts to phase one. Part one provides students with the opportunity to seek and secure local knowledge around shushumeg. Part one will provide a brief introduction to what shushumeg are with a following homework directive to collect information/stories from their home and community. Part two will provide students the opportunity to share what they have found as a result of inquiring about shushumeg. Building from this base knowledge, academic literature will be shared and discussed. At the conclusion of phase one, students will have background knowledge of shushumeg that encompasses local knowledge as well as a brief foray into academic literature related to shushumeg from various traditions.

Phase Two – Prototype Construction and Testing. Phase two has four parts. The overall objective of phase two is to provide students with experiences and data that will inform their construction of a full size shushumay in a later phase of the curriculum. The four parts of phase two foster looking at a shushumay prototype from a variety of angles. Through these angles or lenses, students will see how science, technology, and mathematics can be used to inform engineering design challenges.

Part one introduces the idea of a prototype with an opportunity for students to freely explore the bounds of shushumay prototype construction. Connections will also be made to other wintertime recreational activities such as skiing, ice skating, and tobogganing.

Part two introduces scientific concepts associated with force and motion and situates this information as being helpful in meeting the grand challenges.

Part three introduces scientific concepts associated with energy. Similar to part two, energy concepts will be highlighted to inform prototype construction initially, and full size shushumay construction ultimately.

Part four provides students with an opportunity to collect data around prototype iterations. As a result of data collection on multiple variables, students can begin to draw conclusions as to how different variables affect shushumay performance. A model can then be created to inform full scale shushumay construction.

Phase Three – Full Size Design and Construction. Phase three has two parts. Part one encompasses a majority of the full size shushumay construction efforts. Students will revisit the shushumay blanks which were collected and stored for the winter during the previous fall. Along with the basic forming of shushumeg, students will integrate prototype model characteristics. Part two of phase three will involve aesthetic rendering.

Students can choose to pursue traditional artistic designs as guided by various resource books, physical artifacts and/or elder descriptions. Students may also choose to pursue a more modern artistic style. This route could therefore take on any number of flavors.

Phase Four – Body Mechanics. Phase four provides students with an opportunity to wield their shushumay. At each participating site, efforts should be made to construct an ice track close to the school grounds. This will allow students to become familiar with the gross motor skills necessary to successfully propel a shushumay. If an ice track is not possible, the gymnasium will suffice. Students should work on throwing shushumeg for distance, and accuracy as well as making observations of shushumay characteristics for future adjustments prior to the festival. Local competition is encouraged within phase four activities.

Phase Five – Shushumay Festival. The fifth and final phase is a one day event that will culminate shushumay efforts across all participating sites. There will be four competitions throughout the day that align with the four grand challenges. The four competitions are: A student propelled distance competition; a gravity driven distance competition; a throwing accuracy competition; and an aesthetic show. Students may compete in any or all competitions throughout the day.

Calendar

January

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
4	5	6	7	8	9
11	12	13 Phase 1, Part 1	14	15	16
18	19	20 Phase 1, Part 2	21	22	23
25	26	27 Phase 2, Part 1	28	29	30

February

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3 Phase 2, Part 2	4	5	6
8	9	10 Phase 2, Part 3	11	12	13
15	16	17 Phase 2, Part 4	18	19	20
22	23	24 Phase 3, Part 1	25	26	27

March

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3 Phase 3, Part 2	4	5	6
8	9	10 Phase 4, Part 1	11	12	13 Shushumay Festival
15	16	17	18	19	20
22	23	24	25	26	27

Objectives and Standards

Objectives

Students will:

1. Learn about the game of shushumeg (snow snakes) through historical accounts, local traditional explanations, and modern first hand experiences.
2. Complete a snow snake prototype to test design variables. (engineering)
3. Engage in scientific thinking and activities such as: explanations through evidence, testing variables, collecting data, scientific questioning, and experimentation. (science)
4. Utilize technological innovations for the purpose of providing a greater chance of success for various tasks. (technology)
5. Utilize data to inform design decisions. (mathematics)
6. Construct a full size competition shushumay (snow snake) using knowledge and data gleaned from earlier shushumay (snow snake) curricular activities.

Standards

Minnesota Academic Standards in Science 2009

Standard The student will understand that…	**Code**	**Benchmark**
Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review.	5.1.1.1.1	Explain why evidence, clear communication, accurate record keeping, replication by others, and openness to scrutiny are essential parts of doing science.
	5.1.1.1.2	Recognize that when scientific investigations are replicated they generally produce the same results, and when results differ significantly, it is important to investigate what may have caused such differences.
	5.1.1.1.3	Understand that different

		explanations for the same observations usually lead to making more observations and trying to resolve the differences.
	5.1.1.1.4	Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain.
Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.	5.1.1.2.1	Generate a scientific question and plan an appropriate scientific investigation, such as systematic observations, field studies, open-ended exploration or controlled experiments to answer the question.
	5.1.1.2.2	Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation.
	5.1.1.2.3	Conduct or critique an experiment, noting when the experiment might not be fair because some of the things that might change the outcome are not kept the same, or that the experiment is not repeated enough times to provide valid results.
Men and women throughout the history of all cultures, including Minnesota American Indian tribes and	5.1.3.2.1	Describe how science and engineering influence and are influenced by local traditions and beliefs.

communities, have been involved in engineering design and scientific inquiry.		
Mathematics help scientists and engineers see more, measure more accurately, and do things that they could not otherwise accomplish.	5.1.3.4.1	Use appropriate tools and techniques in gathering, analyzing and interpreting data.
An object's motion is affected by forces and can be described by the object's speed and the direction it is moving.	5.2.2.1.2	Identify the force that starts something moving or changes its speed or direction of motion.
	5.2.2.1.3	Demonstrate that a greater force on an object can produce a greater change in motion.
Engineers create, develop and Manufacture machines, structures, processes and systems that impact society and may make humans more productive.	6.1.2.1.2	Recognize that there is no perfect design and that new technologies have consequences that may increase some risks and decrease others.
	6.1.2.1.4	Explain the importance of learning from past failures, in order to inform future designs of similar products or systems.
Engineering design is the process of devising products, processes and systems that address a need, capitalize on an opportunity, or solve a specific problem.	6.1.2.2.1	Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system that solves a problem.
Current and emerging technologies have enabled humans to develop and use models to understand and	6.1.3.4.1	Determine and use appropriate safe procedures, tools, measurements, graphs and mathematical analyses to

communicate how natural and designed systems work and interact.		describe and investigate natural and designed systems in a physical science context.
	6.1.3.4.2	Demonstrate the conversion of units within the International System of Units (SI, or metric) and estimate the magnitude of common objects and quantities using metric units.
The motion of an object can be described in terms of speed, direction and change of position.	6.2.2.1.1	Measure and calculate the speed of an object that is traveling in a straight line.
	6.2.2.1.2	For an object traveling in a straight line, graph the object's position as a function of time, and its speed as a function of time. Explain how these graphs describe the object's motion.
Forces have magnitude and direction and govern the motion of objects.	6.2.2.2.1	Recognize that when the forces acting on an object are balanced, the object remains at rest or continues to move at a constant speed in a straight line, and that unbalanced forces cause a change in the speed or direction of the motion of an object.
	6.2.2.2.2	Identify the forces acting on an object and describe how the sum of the forces affects the motion of the object.
	6.2.2.2.3	Recognize that some forces between objects act when the objects are in direct contact and others, such as magnetic,

		electrical and gravitational forces can act from a distance.
	6.2.2.2.4	Distinguish between mass and weight.
Energy can be transformed within a system or transferred to other systems or the environment.	6.2.3.2.1	Differentiate between kinetic and potential energy and analyze situations where kinetic energy is converted to potential energy and vice versa.

American Indian Standards for Science Education

Grades 5-8	
Science as Inquiry: Content Standard A	Indian students should develop the ability to articulate examples of the scientific inquiry necessary to develop and improve technologies employed by early American Indians, such as tempered pottery, corn agriculture, and arched roof structures. [*understandings about scientific inquiry*]
Physical Science: Content Standard B	Indian students should develop an understanding of the principle of changes of properties in materials applied in the daily activities of early Indians, such as evidenced in the preparation of wood splints for basketry, the production of glue from the hooves of a deer, and the preparation of natural dies. [*properties and changes of properties in matter*]
	Indian students should develop an understanding of how energy was transferred through the use of early Indian hunting tools, such as the act of throwing a spear with an atlatl. [*transfer of energy*]
Science and Technology: Content Standard E	Indian students should develop an understanding of the technological design process and how it was applied in the development of various tools and technologies employed by early American Indians, such as fish weirs, salmon spearing platforms, and road and building construction technologies. [*abilities of*

	technological design, communicate the process of technological design]
History and Nature of Science: Content Standard G	Indian students should develop an understanding of ways in which reasoning, insight, energy, skill and creativity were demonstrated in the scientific achievements of early American Indians – architecture, tools, health and medicine [*science as a human endeavor and history of science*]

Technology Emphasis & Considerations

We will use the website: http://snowsnakeden.ning.com/ for the online environment for our snow snake curriculum. The online environment will take on extra importance as we strive to connect with each participating site in meaningful ways. To do this we will be utilizing three features within the online environment to meet these ends.

- **Photo and video uploads**: It will be important to see how each site is progressing through the prototype and full scale phases of snow snake construction and testing. To do this each site is strongly encouraged to take photos and videos daily of activities and post them online. An extension to the overall curriculum could be the editing of videos before posting using video editing software such as iMovie. The more frequently that photos and videos are uploaded the more momentum we will build toward the festival.

- **Blogging (text and/or audio)**: Each site will be responsible for blogging about their progress. This task can be delegated in a variety of ways. What is important is that during any given week snow snake blogs are maintained to inform on the progress being made. By doing so, each site is able to monitor the progress of the other sites which promotes friendly competition and community building. Everyone is working on the same challenges and the opportunity to showcase their efforts.

- **Expert chats**: During most weeks during the curriculum implementation window there will be a synchronous expert chat highlighting an important topic related to snow snakes. The format for the expert chats will vary depending on the week. Complete directions and information can be found on the project website as expert chats are coordinated. At each site the instructor will field questions from their respective students and choose the best question to post online. The expert will then author a reply. This will go back and forth in this manner for the period of one half hour. Stay tuned to emails and the project website for details on these events.

Each school/class site will need to determine how to best engage students with the online environment. Some schools may have access to a computer lab and therefore each student will have the opportunity to interact with the program site individually. Other sites may only have a teacher computer connected to an LCD project. For these sites the teacher will moderate engagement orchestrating full class interaction via one computer. It must be noted that for **each individual to participate in the online environment, a valid email address will need to be used** to set up a user account within Ning (the program site host). Each school/class is strongly encouraged to troubleshoot online environment access prior to formally beginning snow snake curriculum activities.

Phase One

Background– Shushumeg (Snow snakes)

Part One

Central Question(s)

What is the local community/family knowledge around shushumeg (snow snakes)?

Rationale/Goal

It is believed that there are pockets of knowledge concerning shushumeg throughout local reservation communities. These pockets of knowledge could be clearly known as expressed by individuals and families who play the game and speak of its merits. There are other pockets of knowledge that remain under the surface and are waiting to be revealed through a timely and pointed question or inquiry. The goal of this activity is to elicit local knowledge around shushumay tradition and begin to build a body of knowledge within local settings. This local knowledge can then be built upon and preserved.

Background

Excerpt from American Indian History, Culture and Language Curriculum Framework: Oral Tradition. Minnesota Department of Education:

> American Indian oral traditions, which include storytelling, teachings, family and tribal history as well as contemporary Indian literature, lie at the heart of tribal culture. It is largely through oral tradition that American Indian cultures have been preserved and transmitted through the generations.
>
> American Indian stories, teachings and oral histories are rich in cultural context. They provide great insight into the worldview, values and lifestyle which are an integral part of the heritage of American Indians.
>
> For American Indians, the oral traditions must be treated with respect. Many of the stories are seasonal. Most often, the winter months are the season for stories. For the Dakota it is believed that the time to tell sacred stories is when snakes and other animals that hibernate underground are covered with snow. Their spirits, if above ground, would use the sacred knowledge against the storyteller. For the Anishinabeg, the belief may differ from area to area, but the practice is similar.

Sacred stories, particularly those about Nanabozho (Manabozho or Manabush) are to be told only in the winter. Other stories can be told throughout the year. If possible, elders in the community should be consulted regarding timing and customs for specific stories.

It is customary on the part of one who requests a specific story to offer tobacco or some other gift to the storyteller. The storyteller uses tobacco to show respect for the spirits who live in the stories and whose names are mentioned.

The stories passed down to American Indians by their ancestors are very important because they express what American Indians value and believe. In addition, the stories help people to understand the meaning of their existence, and the existence of other things in the world. From these stories, young children learn how people came to be; they receive explanations of why things are the way they are and instructions on how to live properly.

Time Considerations

3 class periods/1-3 hours of out-of-school investigation

Materials

- "Alert!" podcast. Audio can be found in the "Music" section of project website.
- Shushumay introductory video(s). Videos can be found in the "Video" section of project website
    - Snow snakes from out East
    - Snow snakes from Wisconsin
- Notebook
- Pen/pencil

Standards Addressed

Minnesota Academic Standards in Science 2009

5.1.3.2.1

American Indian Standards for Science Education

G

Procedures

1. Formally begin snow snake curriculum activities by introducing/reviewing what snow snakes are and how the snow snake game works. Say to students, *for the next couple of months we will be spending some time each week learning about snow snakes while at the same time learning about science, technology, engineering and mathematics (STEM). We can use STEM with snow snakes to help us understand how a snow snake travels down an ice track.*
2. Play the "Alert!" audio for students. Say to students, *we will now listen to a short podcast that will talk about the snow snake project and some of the things we will be doing with snow snakes this winter.* Discuss the video after it is shown.
3. Ask students, *how many of you have heard of snow snakes?* Field responses, probing further for individual experiences with snow snakes. Explain that the Ojibwe word for snow snakes is "shushumeg" pronounced zhoozhoomeg. This is the plural form. The singular form is "shushumay". Explain to students that the literal translation means to slide or slider.
4. If necessary talk about the basics of snow snakes in this way: *Snow snakes is a traditional American Indian game and a physical object. The game is played in villages in the United States and Canada where the weather is cold and snowy. A snow snake (object) is a carved piece of wood that is said to look like a snake as it travels down an ice/snow track. The game is played to see who can throw a snow snake down an ice track the farthest.*
5. Introduce and show two videos about the snow snake game being played in Wisconsin and New York. After videos have been watched, discuss student thoughts around the videos. Probe for interest and questions related to the videos.
6. Present the homework assignment. Say to students, *I have a very important homework assignment for you tonight. I want you to go home and ask your mother, father, aunty, uncle, grandparents, whoever, about snow snakes. If they have never heard of snow snakes ask them about wintertime activities. Listen to the stories that are shared and remember them as best you can to share with the class the next time we meet. Feel free to write down the stories if it would help you remember them. I look forward to hearing stories from everyone! Any questions?*

Break Point

7. After students have had a chance to complete the homework assignment, enter into a discussion around what they heard/found. Say to students, *I am very interested to hear about what you have found out about snow snakes and other*

wintertime activities. Who would like to start us off by sharing a story? The teacher should facilitate this discussion/story time until all students have had a chance to share their experience and ask question of one another.

8. After the discussion around the homework assignment has concluded, transition into a time spent on computers within the project website (http://snowsnakeden.ning.com). Say to students, *what I would like to do now is share some of the stories we have just heard with our friends in other schools participating in the snow snake project. What I would like for you to do is to add a blog entry or a soundtrack telling your story*. You may work in partners if you would like. While you are on the site, spend some time looking at photos, reading blogs, and listening to audio blogs (podcasts) from other schools.*

   * This is assuming that students have become somewhat familiar with the project website. It is recommended that students spend a minimum of one class period becoming familiar with the different functions on the project website, i.e. blogging, uploading pictures, video, and audio; using the chat tool, etc. If your school does not have access to multiple computers, digital cameras, or audio recording devices, many of these activities can be done with fewer resources within a full class setting.

Break Point

9. Expert Chat - Coordinate previous efforts with the scheduled synchronous expert chat. The expert chat can stand alone if need be. It is ideal if the expert chat happens at this point in the curriculum sequence following step 8 in phase one, part one. Tell students, *we will now be participating in an expert chat. The expert chat gives us an opportunity to learn about a specific snow snake topic from a person knowledgeable on the subject. When the expert chat starts we will type our questions into the computer and read the response from the expert. Many other schools will be participating. Before the expert chat starts I would like for each group to think about and write down a question you have about the topic for today.* The project website will provide specific details regarding the expert chat. Follow the website closely for forthcoming details on expert chat events and others.
10. Website Interaction – Make time to interact with the project website. Things for students and teachers to do on the site include: View and upload photos and video; listen to and upload podcasts (audio blogs) and music; read and write blogs about the snow snake experience.

Assessment

Upon completion of this activity students should:

- have an understanding of local snow snake traditions as well as other wintertime recreation activities.
- understand the basic premise of the game of snow snakes, including rules.
- understand the desired outcomes of snow snake efforts, in this case a snow snake festival where four grand challenges can be explored.

Part Two

Central Question(s)

- What can be learned about shushumeg through scholarly literature?
- What can be learned about shushumeg through other tribal traditions throughout the United States and Canada?

Rationale/Goal

Much can be learned through documents such as literature or through visual depictions of shushumeg that will benefit the exploration of shushumeg for students in the local setting. The goal of this activity is to become familiar with literature, images, and video that provides information about shushumeg within the local community and beyond.

Background

Accounts of shushumeg activity date back to the early 18th century and it is speculated that shushumay activities very likely occurred much earlier than this.

Time Considerations

4 class periods (3 for readings – one period for each reading – two readings read aloud and discussed. The excerpt from *Games of the North American Indians* should be read in small groups and then discussed within large group setting. Each small group highlighting aspects they prefer or that interest them. The fourth period will be for the expert chat.)

Materials

- Culin, S. (1975). *Games of the North American Indians*. New York: Dover.

- Parker, A. C. (Apr. – Jun., 1909). Snow-snake as played by the Seneca-Iroquois. *American Anthropologist*, New Series, Vol. 11, No. 2., pp. 250-256.
- Reagan, A. B., & Waugh, F. W. (Jul. – Sep., 1919). Some games of the Bois Fort Ojibwa. *American Anthropologist*, New Series, Vol. 21, No. 3., pp. 264-278.

Standards Addressed

American Indian Standards for Science Education

G

Procedures

1. Now that local knowledge has been shared around snow snakes, it is time to look at some historical literature about the subject. Tell students, *today we will begin reading about snow snakes from long ago in places close to home and also places very far away. I will be reading two articles aloud over the next couple of days. One article is titled "Snow-Snake as Played by the Seneca-Iroquois" and the other is titled "Some Games of the Bois Fort Ojibwa". After I read each article we can discuss what you thought about the article and any questions you have. The last thing I would like you to do is read a section out of "Games of the North American Indians" about snow snakes. I will give more directions on this last part when we get to it.*
2. Read "Snow-Snake as Played by the Seneca-Iroquois" aloud to students.
3. Conduct a discussion around this article after it is read.

Break Point

4. Review the article read during the previous session (Snow-Snake as Played by the Seneca-Iroquois) by discussing what students remember about the article. Say to students, *we just read about snow snakes as played by the Seneca-Iroquois 100 years ago. What were some things about the article that were interesting to you? Was there anything about the article that you could use for your own snow snake? Do you have any questions about the article that we didn't get a chance to talk about last time? Today we will be reading about snow snakes as they were played a little closer to home. The article today is titled "Some Games of the Bois Fort Ojibwa".*
5. Read "Some Games of the Bois Fort Ojibwa" aloud to students.
6. Conduct a discussion around this article after it is read.

Break Point

7. Review the article read during the previous session (Some Games of the Bois Fort Ojibwa) by discussing what students remember about the article. Say to students, *the last article we read talked about snow snakes a little bit closer to where we are. What were some things about that article that were interesting to you? Was there anything about the article that you could use for your own snow snake? Do you have any questions about the article that we didn't get a chance to talk about last time? The third and final article will be read by you. You can read the section from "Games of the North American Indians" in groups. I will give each group a range of pages to read and talk about. After everyone has read and discussed their section we will come back together as a full class and talk about what we have learned.*
8. Pass out copies of "Games of the North American Indians" to each student. Once students form groups divide article and assign pages to each group to read. Monitor and assist with reading progress by checking in with each group periodically.
9. After groups have completed the reading and discussed it sufficiently, bring attention back to the full group. Lead a discussion about each section. Say to students, *I would now like each group to share what they have learned about snow snakes through the section they have read with the rest of the class. Each group should plan on talking about some of the highlights of their section. Who would like to go first?*
10. Similar to teacher led discussions on the other articles, when it makes sense, enter into the following questions, *what were some things about this section that you found to be interesting? Was there anything about this section that you could use for your own snow snake? Do you have any questions about what we read and discussed that we didn't get a chance to talk about yet?*

Break Point

11. Expert Chat - Coordinate previous efforts with the scheduled synchronous expert chat. The expert chat can stand alone if need be. It is ideal if the expert chat happens at this point in the curriculum sequence following step 10 in phase one, part two. Tell students, *we will now be participating in an expert chat. The expert chat gives us an opportunity to learn about a specific snow snake topic from a person knowledgeable on the subject. When the expert chat starts we will type our questions into the computer and read the response from the expert. Many other schools will be participating. Before the expert chat starts I would like for each*

group to think about and write down a question you have about the topic for today. The project website will provide specific details regarding the expert chat. Follow the website closely for forthcoming details on expert chat events and others.

12. Website Interaction – Make time to interact with the project website. Things for students and teachers to do on the site include: View and upload photos and video; listen to and upload podcasts (audio blogs) and music; read and write blogs about the snow snake experience.

Assessment

Upon completion of this activity students should:

- have an understanding of snow snake traditions throughout the upper latitudes of the United States and Canada.
- have ideas about how traditional snow snake practices outside of their local setting can be used to benefit their own snow snake efforts.

Phase Two

Prototype Construction and Testing

Part One

Central Question(s)

- What is a prototype
- Why use prototypes
- What scientific principles from preexisting technologies can inform the development of shushumay prototypes

Rationale/Goal

The overall goal of this part is to begin the journey towards meeting the four grand challenges of the project which were mentioned previously. To do this a prototype iteration phase will be implemented.

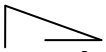
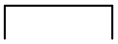
Background

Prototyping allows for the testing of multiple variables with meaningful data being collected. Cost and time are greatly reduced when using prototypes versus attempting to do similar tests with full scale models. Students will be able to design, test, and redesign shushumay prototypes multiple times with meaningful outcomes that will inform full size shushumay construction. The prototype design iteration is meant to expedite the development of a shushumay knowledge base that would heretofore take many years of careful observation and subsequent development of traditional ecological knowledge. Although the prototype design iteration is meant to speed up the aforementioned knowledge development, it is not a seamless replacement of what can be gleaned from years of experience.

Time Considerations

2-3 class periods

Materials

- Prototype snow snake photos. Photos can be found in the "photos" section of the project website.
- Worksheet titled "Can the design of other winter sports equipment help to decide a good design for a snow snake?" Worksheet can be found in the "Blog" section of the project website within the "Resources" link
- Popsicle sticks (various sizes/shapes)
- Small diameter wooden dowels (various sizes/shapes)
- Various metal fasteners
- Modeling clay
- Pennies
- 2'x4' table (general specification minimum) – needs to have the capability of folding one set of legs down.
  Look like this:  Instead of: 
- Outdoor prototype ice track (if available)

Standards Addressed

Minnesota Academic Standards in Science 2009

6.1.2.1.2

American Indian Standards for Science Education

E

Procedures

1. To introduce the idea of a prototype, students will be provided with an open time of exploration around the materials provided as well as any other materials to be found in the classroom that would assist their efforts. Say to students, *Now that we have an understanding of what snow snakes are and how the game is played; we are going to spend some time trying to figure out how to make the best snow snake possible. Throughout this process I want you to remember that there is no perfect design. Each design you come up with will have positive or negative aspects when we think about meeting the four grand challenges.*
2. Now would be a good time to introduce the four grand challenges for the project. Say to students, *for the snow snake project there are four grand challenges for us*

to work on. They are: Challenge #1: Throwing a shushumay for distance (human powered). Challenge #2: Releasing a shushumay for distance (gravity powered, i.e. release shushumay down a hill/decline). Challenge #3: Throwing a shushumay for accuracy (predefined target at a reasonable distance from point of throwing). And Challenge #4: Aesthetics (the most visibly appealing shushumay design, traditional and modern). To begin to think about how to meet these challenges we are going to use prototypes to learn valuable information about snow snakes. We will talk more about the importance of prototyping in a little bit. For now I want to talk about making snow snake prototypes.

3. Present the materials available for students to use to make a prototype snow snake. Reference the project website for some simple examples of prototype snow snakes. Explain to students that the goal for the next day or two will be to explore some of the possibilities in constructing prototype snow snakes with the materials available. Encourage students to think about other materials that could be use to make the prototype travel down the track faster.
4. There are two options for a prototype track. One option is indoors and involves folding the legs down on a rectangular table creating an angle that will allow gravity to pull the prototypes down the length of the table (recommended). A second option would be to use an outdoor prototype track. This track needs to be prepared the night before (i.e. creating ice) assuming temperatures are cold enough to freeze water.
5. Plan for logistics if students will be traveling to another location in the school or outside to test prototypes.
6. Say to students, *I would like for you to build and test as many prototype snow snakes as you would like for the remainder of the period. Keep in mind that you want to see how different designs or ways of building affect the way the snow snake travels down the track. This information will be helpful later on. Are there any questions?*
7. Encourage students to take digital pictures and video of one another when building and testing prototype snow snakes. Upload media to the project website in the appropriate location.
8. Monitor and assist students as they build and test prototype snow snakes.

Break Point

9. Explain to students that we can learn a lot about how best to construct snow snake prototypes by looking to other existing wintertime devices such as skis, ice skates, and toboggans. Say to students, *I would like to continue working on our snow snake prototypes but before we go any further I want you to think about how we*

can make our prototypes better. Can anyone think of human powered ways that we travel in the wintertime on snow and/or ice; or tools that we use to travel? Field student responses and guide towards skis, ice skates, and toboggans if they did not already come to those conclusions organically within the discussion.

10. Pass out the worksheet titled "Can the design of other winter sports equipment help to decide a good design for a snow snake?" Have students get into groups and read through the worksheet and answer the questions at the end by writing their answers on a separate sheet of paper. The answers should be a result of the small group discussion. Once students have completed this task, discuss as a large group/class.
11. Transition back into snow snake prototype construction. Say to students, *now that we have discussed some of the design aspects of winter sports equipment I would like for you to consider how these aspects might be integrated into our snow snake prototypes. Can someone give me an idea they have about using something we learned about skis, ice skates, or toboggans within their snow snake prototype design?* Field ideas and follow discussion threads as fruitful. Once some ideas are on the table encourage students to revisit their snow snake prototype designs and integrate new ideas. Provide ample time for this exploration and testing on the prototype track.
12. After the activity has run its course, say to students, *I would like to find out what you learned from this activity. Tell me about your prototype snow snake designs that traveled the fastest down the track. Why do you think these design elements worked better than others? Can you think of anything else you would like to try that might make a snow snake travel faster down the track?* Facilitate discussion around this topic.

Break Point

13. Review the experience of making prototype snow snakes. Say to students, *what did you think about making prototype snow snakes? Since we did the activity have you thought of any other designs you would like to try or materials you would like to use?* Facilitate the discussion and follow any paths that make sense around this idea of a prototype snow snake and how they performed when tested.
14. After the discussion introduce the expert chat around prototypes.
15. Expert Chat - Coordinate previous efforts with the scheduled synchronous expert chat. The expert chat can stand alone if need be. It is ideal if the expert chat happens at this point in the curriculum sequence following step 14 in phase two, part one. Tell students, *we will now be participating in an expert chat. The expert chat gives us an opportunity to learn about a specific snow snake topic from a*

person knowledgeable on the subject. When the expert chat starts we will type our questions into the computer and read the response from the expert. Many other schools will be participating. Before the expert chat starts I would like for each group to think about and write down a question you have about the topic for today. The project website will provide specific details regarding the expert chat. Follow the website closely for forthcoming details on expert chat events and others.

16. Website Interaction – Make time to interact with the project website. Things for students and teachers to do on the site include: View and upload photos and video; listen to and upload podcasts (audio blogs) and music; read and write blogs about the snow snake experience.

Assessment

Upon completion of this activity students should:

- understand what a prototype is.
- understand why prototypes are valuable and necessary when designing new products, in this case snow snakes.
- have an understanding of preexisting technology used in winter recreation equipment to help promote forward movement.
    - develop ideas that can be used within the snow snake prototype context as a result of learning about preexisting technology.

Part Two

Central Question(s)

- What scientific principles of force and motion inform the development of shushumay prototypes?

Rationale/Goal

Having an understanding of the scientific concepts of force and motion will enhance students' ability to apply sound design decisions to their snow snake prototype and subsequently their full scale snow snake. The goal for this part is to have students recognize and understand concepts of force and how force affects motion; and to use data to support these understandings. A final goal will be to differentiate between mass and weight.

Background

Force and motion are important scientific phenomena. Essentially force and motion explain how all matter moves or doesn't and the reason why movement occurs. Some key terminology to understand for this part is as follows:

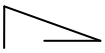
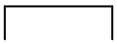
- **Force**
  Definition: A measurable strength or power that has an effect on an object.
  Context: Our world is full of forces that push and pull on everything in it.
- **Gravity**
  Definition: The force that attracts bodies toward the center of Earth, or towards any other physical body having mass.
  Context: Gravity pulls objects toward the Earth, keeping them from floating into space.
- **Inertia**
  Definition: The tendency of objects to resist changes in their states of motion.
  Context: Inertia causes motionless objects to remain motionless and moving objects to continue moving until they come in contact with an outside force.
- **Matter**
  Definition: Physical substance or material which occupies space and has mass.
  Context: Almost everything around you is matter.
- **Molecule**
  Definition: A substance made up of one or more atoms.
  Context: As matter changes from one state to another it is important to remember that changes are happening to the molecules inside the matter.
- **Motion**
  Definition: The act of changing position.
  Context: The marble's motion is slowed when it hits another marble.
- **Friction**
  *Definition:*The force that pulls or resists the motion of two objects or materials that are in contact with each other.
  *Context:*As the ice surface melts, the friction between the snow snake and the ice is reduced.

Time Considerations

2-3 class periods

Materials

- Graph paper and pencil
- Calculator(s)
- Measuring tape, yard stick, or ruler

- Stopwatche(s)
- Popsicle sticks (various sizes/shapes)
- Small diameter wooden dowels (various sizes/shapes)
- Various metal fasteners
- Modeling clay
- Pennies
- 2'x4' table (general specification minimum) – needs to have the capability of folding one set of legs down.
  Look like this:  Instead of: 

Standards Addressed

Minnesota Academic Standards in Science 2009

5.2.2.1.2
5.2.2.1.3
6.2.2.1.1
6.2.2.1.2
6.2.2.2.1
6.2.2.2.2
6.2.2.2.3
6.2.2.2.4

Procedures

1. Explain to students that the purpose of the previous activity was to become familiar with the materials being used for snow snake prototype construction. For the next activities using the snow snake prototypes, specific attention will be given to different scientific aspects that will help us to make the best snow snake possible.
2. Say to students, *Today we are going to work with our snow snake prototypes again. I want each of you to construct a design that you liked or that worked well from the last time we used the snow snake prototypes.* Provide enough time to have students construct or reconstruct their chosen prototype.
3. Once students have their snow snake prototype ready, say, *with our prototypes we are going to explore and discuss the concepts of force and motion.* Ask students for responses to what they think force and motion are. Follow this discussion path as long as it is fruitful.

4. Choose a student's snow snake prototype to demonstrate a few force and motion concepts. Arrange students so that they can all view the table (track) placed at an angle.
5. Say to students, *I am going to demonstrate a few things about force and motion and then I will give you an opportunity to explore these concepts.* Complete the following demonstrations:
    - Hold the snow snake prototype at the top of the track with one finger, release. Ask students what force is acting upon the prototype to make it travel down the track. Discuss gravity. Discuss friction in terms of how friction affects the speed of the prototype down the track because of the interaction between surfaces.
    - Adjust the angle of the table and release the prototype multiple times at the various angles. Discuss how the force of gravity is allowed to affect the prototype in lesser or greater ways depending on the angle of the track (table). Explain this as "producing a greater change in motion" as a result of track angle.
    - Place the table/track flat (either on the floor completely or with both sets of legs in "flat table position". Place a prototype at the normal starting position and release. Ask students why the prototype did not move. Explain that the forces acting upon the prototype are balanced. Discuss this concept further until students display understanding.
    - Lift the flat track allowing the prototype to slide off the end. Ask students what happened. Explain that the forces acting upon the prototype went out of balance. Repeat as needed.
6. From the discussion around gravity as a force and its effects on the prototype, segue into a discussion about mass versus weight. Ask students to define weight. Ask students to define mass. Discuss the differences and student ideas about these two terms. Once the discussion has run its course explain to students that:

    - Mass is a measurement of the amount of matter something contains, while Weight is the measurement of the pull of gravity on an object.
    - Mass is measured by using a balance comparing a known amount of matter to an unknown amount of matter. Weight is measured on a scale.
    - The Mass of an object doesn't change when an object's location changes. Weight, on the other hand does change with location (the moon for example).

7. Transition from this discussion into a time allowing students to explore some of these concepts with their personal snow snake prototypes on the track as time permits. Modify the track with one lane of wax paper or another material that will

change the amount of friction from the original table surface. Emphasize gravity, friction, force, and motion as students' progress through this time of exploration.

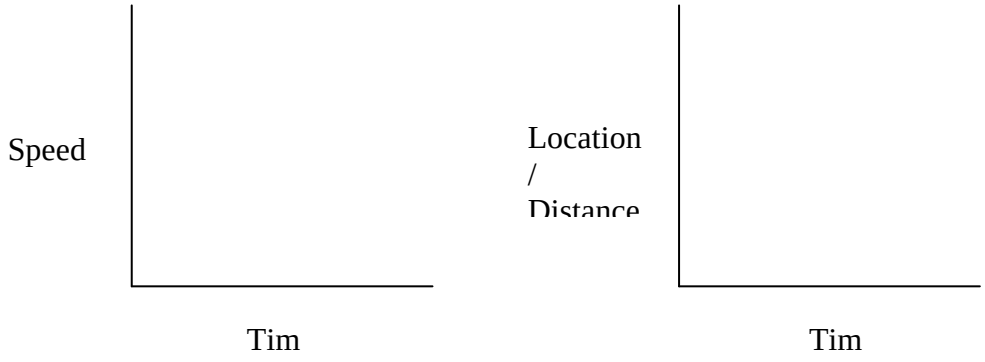
8. Identify a safe and accessible place for prototypes to be stored for their next use.

Break Point

9. Say to students, *we are now going to explore how we can calculate the speed of our snow snake prototypes.* Provide students with graph paper (or an equivalent) and demonstrate the data table and graph on the white/chalk board.
10. The data table can simply be:

Trial	Time	Distance (specify units)
1		

11. Once the data table is complete, explain the use of the following equation: speed = distance/time, or S = d/t
12. Have students calculate the speed of their snow snake prototype for each trial.
13. Have students average their speed.
14. Discuss and support students through the previous activities. Concepts such as calculating speed and determining an average may require further instruction on basic computation and conceptualization.
15. Once the speed calculations have been determined, graph the data as a class. Complete two graphs. One with speed as a function of time, and another with location/distance as a function of time. Make sure to denote units of measurement on the graphs (i.e. seconds for time). The graph should look something like this:



16. Additional measurements and times will need to be secured for the time as a function of location/distance graph. This can be done as a class demonstration/activity.
17. Discuss the graphs. Make a connection between what was done, the data collected, and how that data now looks through a graphical representation.

Assessment

Upon completion of this activity students should:

- understand concepts related to force and motion, including the associated terminology.
- understand the difference between mass and weight.
- be able to calculate the speed of their snow snake prototype and explain its movement through graphical representation.

Part Three

Central Question(s)

- What scientific principles of energy inform the development of shushumeg prototypes?

Rationale/Goal

The goal for this part of the snow snake project is to illustrate potential and kinetic energy through snow snake prototypes.

Background

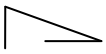
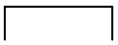
Potential energy is the same as stored energy. It isn't being used at the moment, but is waiting to do work. Think about a boulder sitting on top of a hill. Just sitting there, the boulder isn't doing anything. But because it is sitting on top of a hill, it has the potential to roll down and do some damage to a car or building below. The energy is stored in that rock because of its size (mass) and the distance it will travel once it starts rolling.

The word "kinetic" is derived from the Greek word meaning to move, and the word "energy" is the ability to move. Thus, "kinetic energy" is the energy of motion - its ability to do work. The faster the body (snow snake) moves the more kinetic energy is produced. The greater the mass and speed of an object the more kinetic energy there will be. As the snow snake accelerates down the track/hill the potential energy is converted into kinetic energy.

Time Considerations

1 class period

Material

- Paper and pencil
- Snow snake prototype(s)
- 2'x4' table (general specification minimum) – needs to have the capability of folding one set of legs down.
  Look like this:  Instead of: 

Standards Addressed

Minnesota Academic Standards in Science 2009

6.2.3.2.1

American Indian Standards for Science Education

B

Procedures

1. Review force and motion concepts from the previous activity. Discuss terminology making connections with concepts and snow snake prototype context. Say to students, *the last time we worked with our snow snake prototypes we were looking specifically at concepts of force and motion. I would like to talk about some of the terms we learned through that activity.* Reference the background section from Phase 2, Part 2 for a full list of terms.
2. Explain to students that today they will be learning about new scientific concepts that can be explored using the snow snake prototypes. Say to students, *today we are going to talk about energy. When I say the word energy what do you think of?* Field comments from students probing for depth where necessary and relevant. After this beginning question is exhausted, say to students, *we are going to talk about two specific forms of energy, they are potential and kinetic. Has anyone heard of these two types of energy before?* Again, field comments and continue at a logical point in the discussion.
3. Explain to students the difference between potential and kinetic energy. Solidify this explanation with a demonstration of the two forms of energy. Similar to demonstrating different aspect of force and motion, demonstrate potential and kinetic energy using a student's volunteered snow snake prototype. Probe for understanding with students once the demonstration has run its course.

4. Expand the concepts of potential and kinetic energy beyond snow snakes. Say to students, *I would now like for you to think about some examples of potential and kinetic energy from your life or from traditional ways of living. I would like for each of you to get out a piece of paper and either write or draw examples of potential or kinetic energy. After you complete the writing or drawing I will have you get into small groups and share your thoughts with the group.* Provide time for material collection and group forming. Once students are working on the task monitor the room for progress. When it looks like the activity has run its course ask the small groups to share with the large group/class about their examples of potential and kinetic energy from their life or what they know to be a traditional way.
5. Illustrate the bow and arrow or the atlatl as two tools that transfer energy from potential to kinetic in very distinct ways. Pursue this discussion as far as it makes sense.

Assessment

Upon completion of this activity students should:

- be able to differentiate between potential and kinetic energy.
- be able to provide examples of potential and kinetic energy that are relevant to their life or that are relevant to traditional ways of living.
- be able to demonstrate the difference between potential and kinetic energy using a snow snake prototype.

Part Four

Central Question(s)

- How can a prototype shushumay inform our construction of a full size shushumay?

Rationale/Goal

Thus far in phase two students have explored materials and the process of building shushumay prototypes. Students have also explored specific scientific content (force, motion, and energy) through the context of a shushumay prototype. In part four students will begin to collect data that will inform future full size shushumay development. Students will have the opportunity to design and test multiple shushumay prototypes. A data table will guide data collection types (i.e. time, weight, length, etc.) and the types of conclusions that can be drawn for this exercise.

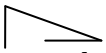
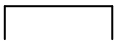
Background

Students will build upon the previous three parts of phase two during this final part. In addition to building upon experiences from the shushumay curriculum, students will exercise scientific and mathematical skills associated with instrumentation, measurement, observation, and synthesis.

Time Considerations

3 class periods

Materials

- Shushumay prototype data table. Data table can be found in the "Blog" section of the project website within the "Resources" link
- Popsicle sticks (various sizes/shapes)
- Small diameter wooden dowels (various sizes/shapes)
- Various metal fasteners
- Modeling clay
- Pennies
- 2'x4' table (general specification minimum) – needs to have the capability of folding one set of legs down
  Look like this:  Instead of: 
- Outdoor prototype ice track (if available)

Standards Addressed

Minnesota Academic Standards in Science 2009

5.1.1.1.1
5.1.1.1.2
5.1.1.1.3
5.1.1.1.4
5.1.1.2.1
5.1.1.2.2
5.1.1.2.3
5.1.3.4.1
6.1.2.1.4
6.1.2.2.1

6.1.3.4.1
6.1.3.4.2

American Indian Standards for Science Education

A

Procedures

1. This part will begin with an expert chat about STEM and how it can be used in an integrated fashion to inform and solve questions.
2. Expert Chat - Coordinate previous efforts with the scheduled synchronous expert chat. The expert chat can stand alone if need be. It is ideal if the expert chat happens at this point in the curriculum sequence following step 1 in phase two, part four. Tell students, *we will now be participating in an expert chat. The expert chat gives us an opportunity to learn about a specific snow snake topic from a person knowledgeable on the subject. When the expert chat starts we will type our questions into the computer and read the response from the expert. Many other schools will be participating. Before the expert chat starts I would like for each group to think about and write down a question you have about the topic for today.* The project website will provide specific details regarding the expert chat. Follow the website closely for forthcoming details on expert chat events and others.
3. Website Interaction – Make time to interact with the project website. Things for students and teachers to do on the site include: View and upload photos and video; listen to and upload podcasts (audio blogs) and music; read and write blogs about the snow snake experience.

Break Point

4. Begin by discussing the previous expert chat. Say to student, *what did you learn about science, technology, engineering, and mathematics (STEM) from the last expert chat? Can STEM be used to help us with our grand challenges? If so, how? Is there one part of STEM that makes more sense to you than another? Does it make sense to combine science, technology, engineering, and mathematics to try and help us with snow snakes? Now that we have a better idea of how science can be used along with other subjects such as mathematics, we are going to put this knowledge to work. Today we will be constructing and/or revising prototype snow snakes again. Similar to what we did before we will be building and testing*

prototypes snow snakes on a track. But this time we will carefully collect data that will help us figure out what parts of our prototype snow snake make it work best.

5. Hand out the "Shushumay prototype data table" and walk students through the different data to be collected. Depending on students' ability, it may be necessary to discuss the different measurements to be made (i.e. weight, length of snow snake prototype, time, and distance traveled). Once students are comfortable with the instrumentation and logistics of use, prototype building and data collection can commence.
6. Say to students, *each group will be responsible for completing a "Shushumay prototype data table" worksheet. Remember, the more accurate you are in making observations and collecting data, the better off you will be in using that information for the full scale snow snake.* Delegate responsibilities within the group as you see fit. Provide ample support and assistance as they progress through data collection.
7. Completing the worksheet and associated prototype snow snake construction and design iterations should take two periods.
8. Encourage students to take digital pictures and video of one another when building and testing prototype snow snakes. Upload media to the project website in the appropriate location.
9. Website Interaction – Make time to interact with the project website. Things for students and teachers to do on the site include: View and upload photos and video; listen to and upload podcasts (audio blogs) and music; read and write blogs about the snow snake experience.
10. Collect and keep "Shushumay prototype data table" worksheets in a safe place for use in the next phase.

Assessment

Upon completion of this activity students should:

- be able to compare and contrast design characteristics of their snow snake prototypes and explain why one design is more desirable than another for speed down the track.
- be able to justify their design decisions using data.
- be able to propose design modifications to be made on their full scale snow snake.

Phase Three

Full Size Design and Construction

Part One

Central Question(s)

- How can prototype model data be integrated into the construction of a full scale shushumay?
- What are the similarities and differences between the selected shushumay prototype and the completed full scale shushumay?

Rationale/Goal

The goal of phase three, part one is to have a completed functional shushumay, minus any artistic rendering. One way to look at phase three is to see it as a culmination of previous efforts in phases one and two. It is at this point that STEM knowledge gained previously will be put to use with the purpose of coming one step further to meeting one or more of the grand challenges.

Background

Review experiences from phase one considering aspects of snow snake construction both locally and beyond.

Time Considerations

3 class periods

Materials

- Completed Shushumay Prototype Data Table worksheet
- Shushumay blanks (redistributed from fall activities and storage for drying purposes)
- Sandpaper (coarse and fine grit)
- Hand saws
- Chisels

- Bench vise
- Carving knives
- Various weighting objects (i.e. lead fishing weights, screws, nails, etc.)

Standards Addressed

Minnesota Academic Standards in Science 2009

5.1.3.4.1

American Indian Standards for Science Education

E

Procedures

1. To begin, redistribute "Shushumay Prototype Data Table" worksheets.
2. Lead a discussion around the data secured in the worksheet. Say to students, *last time we talked about snow snakes we completed a worksheet where we were making measurements of various kinds related to how our prototype snow snake traveled down a track. What I would like to do now is see how the data can help us when we start working on our full scale snow snake.*
3. Prior to this discussion, spend some time with the worksheets and make sense of the data for yourself. Pay careful attention to the time and distance as it relates to weigh, length, and design information. The plan here would be to highlight how weight, length and design decisions affect the time and distance. From this point student can begin to identify characteristics that would be desirable in a full scale snow snake that would assist them in meeting the grand challenges.
4. Remind students of the grand challenges. Say to students, *do you remember the grand challenges we talked about in the beginning of the snow snake project? Can anyone tell me what they are?* Depending on the accuracy of this discussion share the following: *Challenge #1: Throwing a shushumay for distance (human powered). Challenge #2: Releasing a shushumay for distance (gravity powered, i.e. release shushumay down a hill/decline). Challenge #3: Throwing a shushumay for accuracy (predefined target at a reasonable distance from point of throwing). And Challenge #4: Aesthetics (the most visibly appealing shushumay design, traditional and modern).*
5. Say to students, *what conclusions can we draw from the data we collected? For example, I know that by adding X, the prototype snow snake will travel faster or*

slower down the track. Does anyone have any ideas about how the different variables affect how the prototype snow snake travels down a track? This discussion could take any number of directions. The important point to make is that data can be used to draw conclusion and inform future decisions, in this case, the construction/manipulation of a full scale snow snake.

6. As variables are defined as being desirable, discuss how these variables may translate to the full scale snow snake. For example, if students conclude that a certain amount of weight is desirable, discuss how weight might be added to the full scale snow snake. Again, these conversations may go any number of directions. The important point to make is that students identify variables that led to success in the prototype snow snake (i.e. faster down the track) and begin to think about how that variable can be translated to the full scale snow snake.
7. With each student make a plan either verbally or in writing for full scale construction and how the prototype experience will be used to inform this plan. For example student may choose sand/carve* the snake into a certain shape highlighting a design characteristic that was beneficial in the prototype design sequence.

   * Safety must be at a premium when using sharp implements. Make sure that students have been debriefed on proper use and considerations to make when using a potentially dangerous or harmful tool. Safety glass should be worn when any sharp objects are in use.

8. Once students have full scale design plans it is now time to begin crafting the full scale snow snake.
9. Say to students, *the remainder of this period and the next couple of days will be for you to develop the basic shape and design of your snow snake. When everyone's design is complete, we will begin the process of painting and preserving the snow snakes for competition.*

Assessment

Upon completion of this activity students should:

- successfully make connections between design characteristics of their snow snake prototype and how those characteristics are manifest in the full scale snow snake.
- appreciate how tools can provide an advantage in design implementation versus the absence of any such technology.

Part Two

Central Question(s)

- What do traditional shushumay artistic renderings look like?
- What are some common artistic themes within Ojibwe art?

Rationale/Goal

The final addition to the shushumay (short of adding waxes, sap, or paraffin prior to competition) is to customize it artistically. The primary goal of the artistic rendering is to make the shushumay appealing to the individual student. The secondary goal would be to satisfy an audience of peers, teachers, elders, and the community.

Background

Excerpt from American Indian History, Culture and Language Curriculum Framework: Art. Minnesota Department of Education:

> American Indian art is as complex and varied as the art traditions of Europeans or any other group of people. Artistic expression can be found in objects considered sacred and in objects which form a part of everyday life such as pottery and baskets. Through the centuries, American Indians have created art objects of extraordinary beauty reflecting the harmony and balance which are principles of American Indian philosophy. The arts include architecture as well as the visual arts. Sculpture, carving, painting, weaving, embroidery and a variety of other techniques have been used through the centuries to create art in clothing, pottery, baskets, jewelry, beadwork, wood and a variety of other mediums.

Time Considerations

3 class periods

Materials

- Paint
- Paint brushes
- Lacquer or equivalent finish

Procedures

1. This part will begin with an expert chat around traditional and contemporary Ojibwe art.
2. Expert Chat - Coordinate previous efforts with the scheduled synchronous expert chat. The expert chat can stand alone if need be. It is ideal if the expert chat happens at this point in the curriculum sequence following step 1 in phase three, part two. Tell students, *we will now be participating in an expert chat. The expert chat gives us an opportunity to learn about a specific snow snake topic from a person knowledgeable on the subject. When the expert chat starts we will type our questions into the computer and read the response from the expert. Many other schools will be participating. Before the expert chat starts I would like for each group to think about and write down a question you have about the topic for today.* The project website will provide specific details regarding the expert chat. Follow the website closely for forthcoming details on expert chat events and others.
3. Website Interaction – Make time to interact with the project website. Things for students and teachers to do on the site include: View and upload photos and video; listen to and upload podcasts (audio blogs) and music; read and write blogs about the snow snake experience.

Break Point

4. Review the expert chat to open the session. Say to students, *tell me about some of the things you learned about art from the last expert chat? Would anyone like to share some of their ideas about how they plan to decorate, paint, carve, and adorn their snow snake?* Once the discussion around the expert chat has run its course, transition into directives for the next couple days of beautification.
5. Say to students, *over the next couple of days you will have the opportunity to paint, carve, adorn, and preserve your snow snake. You will have the choice as to how you do this. I will provide materials for and can give you ideas about what to do if you would like. At the end of the two days spent on this task, you will have a functioning and beautiful snow snake ready for the festival.*
6. At this point explain logistical information concerning materials and material management.
7. Say to students, *by the end of this period you should have your design complete. This will allow time for drying if necessary. The next time we work on snow snakes we will put a protective finish on our snow snakes. The protective finish will serve a couple of purposes. One purpose would be to protect the design that*

you worked so hard to create. A second purpose would be to protect the wood from getting wet and therefore changing the way it travels down an ice track.

8. Encourage students to take digital pictures and video of one another when building and testing prototype snow snakes. Upload media to the project website in the appropriate location.
9. Direct students to begin working on their snow snakes. Monitor progress and assist students as needed.

Break Point

10. The last day of phase three, part two does not need to take an entire period. The primary objective is to put on a final coat of a thin lacquer to preserve the snow snake and protect it from water damage. Ample time should be given to drying before and after painting and lacquer events.
11. Proceed with directions that make sense for your specific situation concerning material distribution and logistics. Keep in mind proper safety and clean-up considerations.

Assessment

Upon completion of this activity students should:

- understand traditional and modern artistic conventions.
- apply a personally chosen route of artistry on full scale snow snake.

Phase Four

Body Mechanics

Central Question(s)

- What body movements need to coordinate in order to successful propel a shushumay forward?
- Are there different movements for distance throws versus accuracy throws?

Rationale/Goal

The goal of phase four is for students to gain a level of facility with using their shushumay, both for distance and accuracy. Having the opportunity to play the game of shushumeg with their crafted implement is a critical component to the efforts of the curriculum and overall program. Without an opportunity to see how the body works with the shushumay, students would miss out on one of the aspects that make shushumeg so engaging. It would be like building a paper airplane and not being able to fly it.

Background

The throwing motion for a snow snake can be derived from necessity and performance. The throwing motion is born of necessity in the sense that the ice track is generally low to the ground and therefore requires a bending at the waist of the participant to propel the snow snake down the track accurately. The throwing motion is born of performance in the sense that those who play want to be successful and therefore they will adjust body movements in order to enhance the chance of success. The literature only talks briefly about the throwing motion. Comments are made about “wrist movement” or “stooping toward the ground”. Much can be gleaned from the following picture concerning the throwing motion:

The size and shape of the snow snake will dictate the best way to throw it. Informal experimentation and repetition will provide students with the best information and chance of success during competition.

Time Considerations

3 class periods

Materials

- Completed shushumay
- Ice track(s)
- Gymnasium (as alternative)

Standards Addressed

American Indian Standards for Science Education

B

Procedures

1. This part will begin with an expert chat around playing the game of snow snakes.
2. Expert Chat - Coordinate previous efforts with the scheduled synchronous expert chat. The expert chat can stand alone if need be. It is ideal if the expert chat happens at this point in the curriculum sequence following step 1 in phase four. Tell students, *we will now be participating in an expert chat. The expert chat gives us an opportunity to learn about a specific snow snake topic from a person knowledgeable on the subject. When the expert chat starts we will type our questions into the computer and read the response from the expert. Many other schools will be participating. Before the expert chat starts I would like for each group to think about and write down a question you have about the topic for today.* The project website will provide specific details regarding the expert chat. Follow the website closely for forthcoming details on expert chat events and others.
3. Website Interaction – Make time to interact with the project website. Things for students and teachers to do on the site include: View and upload photos and video; listen to and upload podcasts (audio blogs) and music; read and write blogs about the snow snake experience.

Break Point

4. It is now time for students to become proficient at wielding their snow snake.
5. If an outdoor track is to be used, preparations should be made in advance (See snow snake videos for track construction ideas). Otherwise a gymnasium or hallway can be used to get the throwing motion down, working for accuracy and not distance.
6. Say to students, *it is now time to practice throwing our snow snakes. Keep in mind our grand challenges; we are interested in distance and accuracy when it comes to physically throwing our snow snakes. We will be going to a location where we can work on these challenges. Before we go I want to demonstrate the throwing motion.* As space permits, use a snow snake to model how to hold the snow snake and mimic how the snow snake would be thrown if you were to

actually do it. For example bend at the waste and mimic a side armed throwing motion. Field student questions about body mechanics associated with throwing a snow snake. When students appear to be ready to test their snow snake and abilities, proceed to the specified location.

7. When you arrive at the location, say to students, *we need to keep safety in mind when testing our full size snow snakes. To do this, everyone will throw their snow snake before any of the snow snakes are retrieved. Once the last snow snake is thrown then everyone can run out and get their snow snake for another round. When throwing, make sure that no one is in the path where you will be throwing. Are there any questions?* Further logistical consideration may need to be made depending on the site.
8. Encourage students to take digital pictures and video of one another when building and testing prototype snow snakes. Upload media to the project website in the appropriate location.
9. After students have had a chance to throw their snow snake multiple times, bring the class together and discuss what students learned from the experience. Say to students, *how did throwing your snow snake go? Did the snow snake travel as you expected? Why or why not? Can you think of any additions or changes you would like to make to your snow snake from this experience?* When this discussion comes to a logical end, give student another round of throwing experience if time permits.

Break Point

10. Review the body mechanics experience (throwing motion) from the previous session. Say to students, *today we will continue becoming familiar with throwing our snow snake. Along with paying attention to how your body moves when throwing, I want you to pay attention to how the snow snake travels after you throw it. From these observations I would like for you to think about changes that you could make to your snow snake that would make it travel down an ice track even better than it does now.* At this point a discussion on what to look for when watching the snow snake may be beneficial. For example, if the snow snake does not track (i.e. travel in a straight line), what could be done so that it does? A possible solution may be further carving of bottom tread or adding weight in strategic locations for balance.
11. Say to students, *you can think of the snow snake as a work in progress. Constantly getting better as you learn more about materials and how they interact with one another. Today we will again practice throwing our snow snake and in*

addition, I would like to have a friendly competition with an opportunity to make adjustments to the snow snake after throws are made.

12. Bring sandpaper, modeling clay, and possibly wax (if outside) for students to adjust variables on site. If practicing inside set up a target to emulate the accuracy grand challenge. If outside, any one of the grand challenges can be pursued given prior track preparation.
13. The remainder of the session will be given to informal competitions, snow snake adjustments in both throwing technique and variables. If time permits, conduct a closing discussion around what students learned from the experience of throwing the full scale snow snake and things they may want to change or consider prior to the festival competition.

Assessment

Upon completion of this activity students should:

- be comfortable throwing their snow snake for distance and accuracy.

Phase Five

Shushumay Festival

Rationale/Goal

To this point in snow snake project activities, each site has been operating in isolation with the exception of limited online interactions with other school sites. The festival provides the opportunity for all of the participating schools to come together, face-to-face, and celebrate the snow snake tradition. The goal of the festival is to build community amongst youth throughout northern Minnesota and beyond to strengthen the snow snake tradition and game as a viable form of recreation for youth and adults alike for years to come.

Background

Historically each tribe had unique variations to the game of snow snakes. The unique variations ranged from language used to track construction. Many tribes had implicit rules that governed who could play and who could not. For example, in some tribes snow snakes is consider a kids game yet in others it is a game enjoyed by adults and associated with betting on who would throw the farthest snow snake. For the purposes of this project, tradition may have been adjusted slightly to put forth an all inclusive invitation to students interested in the game. There will be a competition around the grand challenges for the traveling snow snake trophy. There will also be an open competition that allows visitors and curious bystanders to try their hand at snow snakes. The open class will welcome young and old, male and female, Indian and otherwise.

Time Considerations

1 day (Saturday March 13th, 2010)

Materials

- Appropriate winter clothing
- Competition ready shushumay
    - Special amendments of wax, sap, paraffin, etc. at conditions call for it.

Standards Addressed

American Indian Standards for Science Education

B

Procedures

Each teacher will be responsible for coordinating class attendance at the shushumay festival. Once on site for the festival, each teacher will represent the point of contact for their class. It is asked that all teachers would assist in the overall conduction of the day's activities. This will greatly enhance the potential for a successful day of activities.