NSF-OEDG Manoomin Science Camp Project: A Model for Engaging American Indian Students in Science, Technology, Engineering, and Mathematics

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ABSTRACT

The Manoomin "wild rice" Science Camp program, a partnership between the University of Minnesota, the Fond du Lac Tribal and Community College, and the Fond du Lac Band of Lake Superior Chippewa is an example of how a community-based participatory research project can become the catalyst for STEM learning for an entire community, providing effective learning opportunities for grades 5–12 and undergraduate students, elementary and secondary school teachers, and scientists from the reservation, tribal college, and university. Focusing the research on a resource (wild rice) that has important economic, cultural and spiritual meaning for a community, we promote place-based education and support the development of strong science/teacher/community partnerships. Key components of this approach are the Circle of Learning, a conceptual framework that emphasizes trust- and relationship-building between researchers, teachers, students, and American Indian community members, and the Seven Elements of STEM Learning, a pedagogical framework derived from an extensive review of the literature on American Indian education that focuses on a holistic approach to learning that emphasizes the whole student. © *2014 National Association of Geoscience Teachers*. [DOI: 10.5408/12-408.1]

Key words: informal science, American Indian/Native American, place-based, hands-on, traditional knowledge, traditional culture, student research

INTRODUCTION TO THE PROBLEM AND BACKGROUND

The Manoomin Science Camp program (NSF, GEO OEDG [Directorate for Geosciences, Opportunities for Enhancing Diversity in Geosciences]) was developed to meet a national need for broadened participation of American Indians in the geosciences. American Indians exert sovereignty over vast amounts of United States land and water resources, yet are underrepresented in the disciplines that train our nation's future land and water resource managers (Tano, 1999; James, 2001; Watts, 2011). American Indians are underrepresented in STEM and especially in Earth sciences (Watts, 2011). Natural and anthropogenic processes are continuously altering Tribal lands. The geosciences provide highly relevant tools for wise and effective resource management. However, few American Indians choose Earth sciences for their major (Watts, 2011). Given that American Indian Tribes and Tribal Confederations are involved in the management of over approximately 20% of our nation's natural resources (U. S. Department of Energy, 2012), the need for professionals versed in geo- and hydro-technical skills greatly outpaces availability throughout Indian country. There is an immediate need for culturally responsive, place-based environmental education and research with a focus on American Indian students and communities. If there were more scientists from Native communities, science would strengthen Tribal communities from within rather than challenging Tribal sovereignty and identity by forcing Tribes to rely on outsiders (James, 2001).

Multiple measures of achievement suggest that the disproportionately low level of representation of American Indians in STEM has its roots in the precollege years. According to the Status and Trends in Education of American Indians and Alaska Natives (AI/AN), American Indians still show an achievement gap compared to their non-Native peers on every measure of academic achievement in the report (DeVoe and Darling-Churchill, 2008). For example, AI/AN students get lower scores than non-AI/AN students in math and science on the National Assessment of Educational Progress (NAEP) test and on college entrance exams (Ross et al., 2012). AI/AN rates are lower than nearly

Received 15 December 2012; revised 23 April 2013, 5 August 2013, 4 October 2013, 1 December 2013, and 26 December 2013; accepted 31 January 2014; published online 28 May 2014.

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every other ethnic group for completion of core academic courses and advanced coursework, taking AP exams, high-school graduation rates, and completion of college degrees (DeVoe and Darling-Churchill, 2008). AI/AN also have by far the highest percentage of high-school dropouts and unemployment than any other ethnic group (Ross et al., 2012).

The graduation gap exists in Minnesota as well. The AI/AN 4-year graduation rate for 2012 is 45.5% versus 84% for Caucasian students. For some Minnesota school districts, the AI/AN high-school graduation rate is as low as 23% (Minnesota Department of Education, 2014). This gap also exists in test scores and other measures of success. For example, American Indian and other underserved students at South Ridge (K–12) in Independent School District (ISD) 2142, from which we draw 40% of our student participants, perform better than the state averages for American Indian students, but are still less proficient in math, science, and reading than their Caucasian peers statewide. Secondary school math proficiency in 2012 was 47.1% for South Ridge American Indians versus 38.9% for American Indians statewide. At the elementary level, South Ridge students did much better, with American Indian students at 68.8% proficient and Caucasian students at 82.1% proficient in 2012. However, there is a sharp drop in proficiency from elementary to middle school for all students at South Ridge, with Native students falling from 68.8% proficient to 47.1% proficient in a few short years. In order to increase participation by students in STEM careers, these challenges need to be overcome.

The Manoomin Science Camp is a new program of *gidakiimanaaniwigamig* (Our Earth Lodge in Ojibwe) American Indian youth science immersion program which was initiated in 2003 by the National Center for Earth-surface Dynamics (NCED; www.nced.umn.edu), an NSF-funded Science and Technology Center. More than 400 students have participated in *gidakiimanaaniwigamig* camps and other activities over the past decade. The Manoomin Science Camp collaborators include Tribal resource managers from the Fond du Lac Band of Lake Superior Chippewa Resource Management Division (FDLRMD), scientists and educators from Fond du Lac Tribal and Community College (FDLTCC), educators from local K–12 schools, and scientists and educators from the University of Minnesota (UMN).

Development of the Manoomin Science Camp program incorporates (1) American Indian traditional learning methods (The Circle of Learning); (2) best practices for Native American STEM learning, as articulated in American Indian Science and Engineering Society (AISES), 1995; and (3) the Seven Elements of STEM Learning, as derived by Dalbotten through an unpublished survey of research on STEM teaching (see Eti et al., 2013), culturally appropriate pedagogical practices for American Indian and other minority students, and research on preparing students to be academically ready for STEM majors and STEM careers. Dalbotten's survey was undertaken to compare NCED's *gidakiimanaaniwigamig* program and application of the Circle of Learning with best practices identified in most recent publications. Figure 1 maps the relationship between the Circle of Learning principles, the best practices from current research, and the Seven Elements of STEM Learning.

BUILDING A STRONG LEARNING ENVIRONMENT WITHIN AND WITH A NATIVE COMMUNITY

Manoomin Science Camp Program

Place-based education invigorates learning, especially for Native students (Enos, 1999; Riggs, 2005; Semken, 2005; Davidson-Hunt and O'Flaherty, 2007; Semken and Butler Freeman, 2008; Watts, 2011). Incorporating "community-inspired" research projects—projects that arise out of community needs—holds the potential for even broader impacts (James, 2001; Fisher and Ball, 2003; Richmond et al., 2008). Additionally, research on wild rice (*Zizania palustris*; *manoomin* in Ojibwe) is an ideal focus for a Native-oriented STEM program for Ojibwe students because: (1) FDL students care deeply about wild rice because of its cultural significance to Ojibwe; and (2) students often do not realize that the people who are managing the wild rice lakes on the Reservation are scientists, and that these are possible careers.

A meeting was held in 2008 at Fond du Lac (FDL), in response to a request for proposal from NSF GEO OEDG Program. The meeting brought together stakeholders from FDL, FDLTCC, and UMN. The stakeholders included senior staff of the FDLRMD, the FDLTCC Biology Instructor (Andrew Wold, an NCED PI), and UMN researchers and staff from NCED and LacCore, the National Lacustrine (lake) Core Facility at UMN. Resource managers from FDLRMD spoke about the environmental issues which most concerned them. While many were voiced, protecting wild rice and its habitat was the topic that kept coming up because of the central role this resource plays for the tribe. It was agreed then that student participants and researchers in this new project would investigate how long and where wild rice has been growing in the Reservation lakes, using lake sediment core samples and other methods, and what conditions promote the presence of wild rice so that its future could be assured. The result was an OEDG award (NSF GEO-0914694) "Manoomin: Investigating the past, present and future condition of wild rice lakes on the Fond du Lac Band of Lake Superior Chippewa Reservation." Science activities for the Manoomin Science Camp project were created keeping in mind the ultimate objective of the OEDG program, which is to increase the number of Earth scientists from traditionally underrepresented groups.

Science Camp Activities

Manoomin Science Camp research starts with the analysis of multiple sediment cores from lakes on the Reservation, combined with geophysical profiling, maps (including Google Earth), and historical research. These efforts supplement FDLRMD's long-term lake sampling and monitoring program. The structure of Manoomin Science Camp activities is designed to include students from different age groups, provide professional development for teachers, involve scientists from UMN, FDLRMD, FDLTCC, and other institutions, and maintain a level of involvement of all participants such that the research project becomes a central part of the lives of the participants. Participants come together in monthly science camps. Activities for the camps are developed by the K–12 teachers and university researchers who work together in small teams. The science focus is developed in advance of each camp, and all lessons revolve

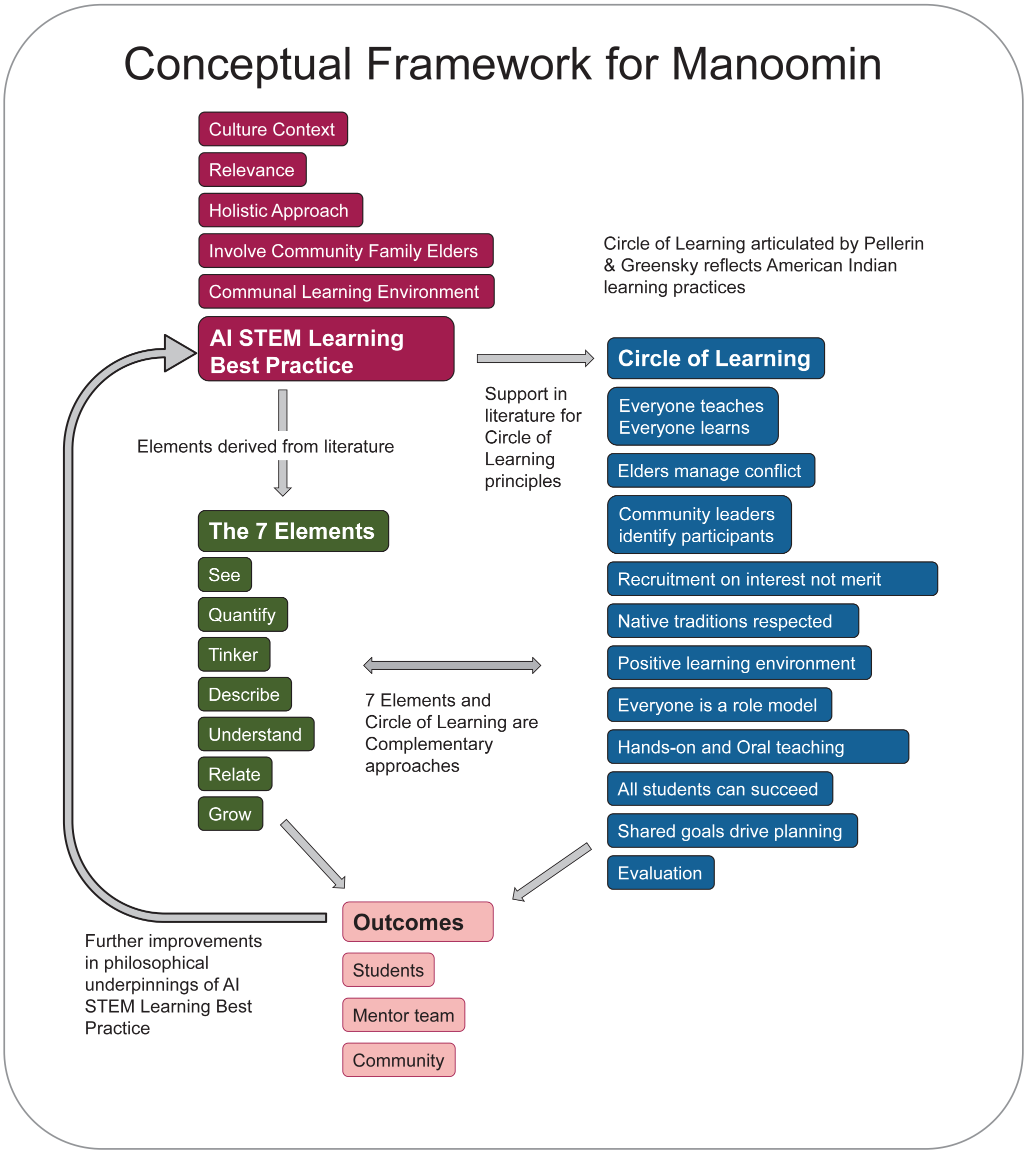


FIGURE 1: American Indian/Alaskan Native (AI/AN) STEM Best Practice guidelines (AISES, 1995; Aikenhead, 1997; Cayton Swisher and Tippeconnic, 1999; Demmert, Jr., 2001; McREL, 2005) are reflected in the framework of the Circle of Learning articulated by the elders, Holly Pellerin and Lowana Greensky, and in our Seven Elements pedagogy which has been guided by the Circle of Learning even before we found the similar ideas articulated in the AI/AN STEM Best Practice.

around that camp's main topic. Fun, culturally appropriate math, geography, history, art, craft, or literature activities are also designed that stress science-across-the-curriculum. Research and supplemental activities occur from Friday evening to Sunday morning. At Sunday morning gatherings for parents and anyone else from the community who wants to attend, small groups of students prepare and deliver presentations of their Friday–Saturday activities. This also provides closure to students and gives them time to reflect on what they did and learned. Camps are held at a UMN research facility adjacent to the FDL Reservation (the UMN's Cloquet Forestry Center), at FDLRMD, and at FDLTCC, reinforcing the connection between the academic world and the students' community.

Goals and ideas from FDL resource managers and educators have driven the original and evolving research directions of the project. The central aim of the research is to develop an understanding of the long-term environmental history (hundreds to thousands of years) of the Reservation's wild rice lakes and surrounding landscapes, through the analysis of sediment core samples. All members of the Manoomin Science Camp community contribute to the project. The research is interdisciplinary by nature: numerous parameters can be quantified in cores, including sedimentary characteristics (lithology, composition, texture, magnetic properties) and biological remains (pollen, phytoliths, diatoms, zooplankton, plant macrofossils, charcoal). Sedimentary strata represent a historical record that can be compared with other histories (oral or written) and records (instrumental or geological). Many sedimentary components viewed microscopically are aesthetically pleasing and appealing. Thus students and teachers with different backgrounds and interests can contribute to the group project in ways with which they feel comfortable (Myrbo et al., 2011).

Lakes are familiar features on the landscape, and their characteristics can be described without using scientific jargon, as most students have been exposed to some concepts of water quality, food webs, climate change, etc. The FDL lakes hold sedimentary records of about 10,000 years (since the end of the Pleistocene when the lakes were formed), but many students find it most compelling to reconstruct the recent past—several hundred to few thousand years—so the project has focused on these short paleorecords, which are easy to collect and include tractable numbers of samples (tens instead of hundreds). The scope of a study can likewise be readily scaled up or down to fit an afternoon workshop, a weekend camp, or a science fair project. Over the period of the project, the approach described in this paper has enabled a diverse group of students to conduct authentic and original research that has applications to management and planning issues for Tribal resource managers (see next paragraph), and to develop skills that are portable to other management and academic settings. The research was (and is) authentic and original because the mentor team was not guiding the students through a research project whose outcome was already known, like most lab experiments in formal classroom teaching.

FDLRMD has been the driver of where, when, and for what purposes field and lab work have been conducted. FDLRMD personnel lead each sampling trip, with collaborative input from LacCore scientific staff; FDLRMD has chosen each lake for study, and selected locations where wild rice is currently or was formerly abundant. For Year 4, a lake with little wild rice was cored and studied at the request of the FDLRMD. They were seeking permission to alter the lake level by controlling the gates installed on ditches in an attempt to bring back wild rice to the lake. Granting of the permission depended on the proof that the lake at one time hosted wild rice. Presence of wild rice phytoliths, identified by the Camp participants, provided this necessary piece of evidence. FDLRMD staff members have a tremendous depth of long-term knowledge—not just scientific information but traditional environmental knowledge as well—about the wild rice lakes and the surrounding landscape. FDL and UMN scientists frame, support, and advise student projects for all ages. Making FDLRMD the center of the research gives students further examples of relevant STEM-based careers, besides those in academia modeled by participating tribal college and university faculty and researchers. This approach can help develop more Native scientists, who are needed to fill positions in growing Tribal resource management departments in many parts of the country (Tano, 1999; Watts, 2011).

For the first two years of the project, one "lake team" of about six middle/high-school and two undergraduate students, with two teachers, took ownership of each of the six wild rice lakes targeted by FDLRMD for study. Each team went out on the frozen surface of their lake during a winter camp (one weekend a month in January, February, and March) to collect cores, with the help of FDLRMD and LacCore, and two weeks later traveled to Minneapolis (~2 hours) to visit LacCore to log, split, and describe their cores in the same way as any scientific team working in that lab (Schnurrenberger et al., 2001). On that visit, students also learned to identify sedimentary components under the microscope and conduct some processing and analysis of samples.

Since sufficient cores had been collected in Years 1 and 2, in the third year of the project, lake teams were reorganized as "research teams," each focusing on one paleoenvironmental "proxy" (a sedimentary component that signifies the past presence of an organism or the action of a process), as represented in one lake. For the three sessions of winter camps in the third year, the teams worked on answering specific research questions using these proxies: diatoms, plant macrofossils, and phytoliths. One example of a research project is the one described already, which used phytoliths to answer the question whether certain areas of a lake previously hosted wild rice plants. Another example involved using diatoms to investigate whether the beginning of eutrophication of a lake could be related to the construction of a horse farm on its shore. Plant macrofossils were examined to determine the effect on Reservation lake levels of the construction of drainage ditches that occurred predominantly during 1900–1916 (Association of Minnesota Counties, 2002).

PHILOSOPHICAL UNDERPINNINGS OF MANOOMIN SCIENCE CAMP PROGRAM

The Circle of Learning

In *gidakiimanaaniwigamig* science camps we collaborated with American Indian elders to develop a model for scientist–community partnerships based on traditional American Indian methods of sharing knowledge. Holly Pellerin is the Program Director for *gidakiimanaaniwigamig* and Manoomin Science Camps. She is a Native elder and has 40 years' experience working with youths at camps. She lives on the Fond du Lac Reservation and teaches dance and culture at the FDLTCC. Lowana Greensky is Director of Indian Education for the St. Louis County School District (ISD 2142) and teacher coordinator for *gidakiimanaaniwigamig* and Manoomin Science Camps. Together with Diana Dalbotten, NCED's Director of Diversity and Broader Impacts, they articulated the Circle of Learning principles which bring together Native traditional education methods, and our combined experience (see Fig. 1). The Circle of Learning model is cooperative—each member of the group brings to the learning circle their background of knowledge and experience to share with the others. The grounding assumption is that each person in the group is there to learn as well as to teach. Respect for elders, a fundamental American Indian value, is a basic principle of organization. Elders stress the importance of treating one another with respect, and help all participants—scientists, teachers, and students—to treat Mother Earth respectfully. In the *gidakiimanaaniwigamig* program, community educators, local teachers and scientists promote culturally appropriate STEM teaching using the Circle of Learning as illustrated in Fig. 2.

Holly Pellerin explains how the Circle of Learning has been used to build an effective learning community on the Fond du Lac Reservation: The Circle of Learning is not a new thing or an Indian thing. It has been around since people first began to learn. The way that we teach in our camp is in a small group with adults and students together learning about an idea or a problem. Everyone has a chance to contribute whether they are in the third grade or have a

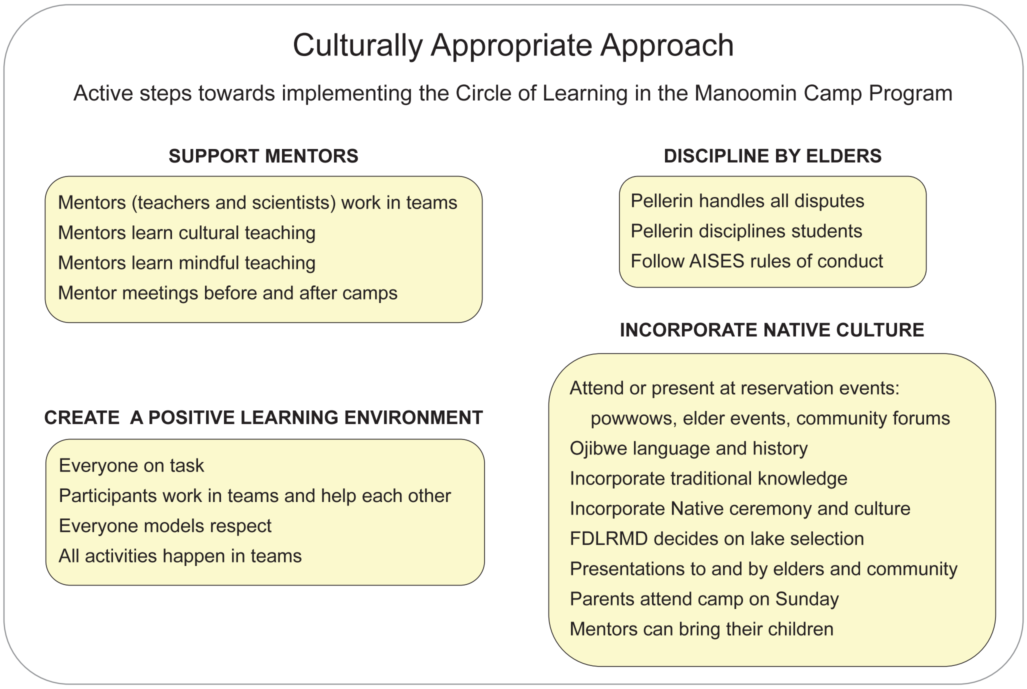


FIGURE 2. Our approach to the Manoomin Science Camp activities are permeated by the concepts of the Circle of Learning that have been articulated by the elders.

PhD. We listen respectfully, take turns and have open minds. We have hands-on activities to enhance what we are learning, and this all takes place at camp. When learning is reinforced by an activity that all participate in, and everyone gets to be a part of the group and play a real role in the process of discovery, then learning happens all around.

Educational Approach

Planning for Manoomin Science Camps incorporates current research on American Indian education to promote student success. A report by the American Indian Science and Engineering Society gives guidelines for improving STEM education for American Indians: "provide students with the opportunity to develop themselves as whole persons: emotionally, spiritually, physically, and mentally and include a needs analysis of student learning styles and cultures" (AISES, 1995). However, there has been very little research done to show exactly how one can take a holistic approach that strives to teach to the whole student and incorporate different learning styles.

In order to implement these guidelines in a practical form, we developed the Seven Elements of STEM Learning, to promote learning in Manoomin Science Camps that is both holistic and individualized and incorporates the "needs analysis of student learning styles" called for by AISES. In order to ensure that the activities develop the whole student in preparation for STEM undergraduate work, Dalbotten identified these Seven Elements that are essential to meeting the academic needs of the student (Fig. 1). In this section, we describe these Seven Elements and how they guide planning for the Manoomin Science Camp Program activities and allow Manoomin participants to develop "as whole persons: emotionally, spiritually, physically, and mentally" as called for by the AISES research. Dalbotten developed these Seven Elements by synthesizing information from research on American Indians and STEM learning, particularly that from AISES, as well as research on college readiness for STEM majors, and articles from government and industry outlining the STEM employee of the future and needed skills (e.g., AAAS, 1990; Nelson-Barber and Trumbell Estrin, 1995; Cajete, 1999; McGinn and Roth, 1999; Jones and Bouie, 2000; Peacock and Wisuri, 2002; Pewewardy, 2002; Bergstrom et al., 2003; Lauer et al., 2003; NAE, 2004, 2005; Freeman and Fox, 2005; Tyson et al., 2007; NSB, 2007a, 2007b; NSB, 2008; Stavridou and Kakana, 2008).

The *gidakiimanaaniwigamig* program developed a systemic approach (the Seven Elements) to informal education that encourages the student to: See, Describe, Tinker, Quantify, Understand, Relate, and Grow, accommodating participants' individual learning styles. The Elements in the order of listing become increasingly more difficult to incorporate into each individual 1.5 hour activity. Students' ability to Relate, for example, from identification of plant macrofossils in the sediment core, to visualizing the same plants growing today, and eventually relating each plant to water depth, does not happen overnight. Several such "eureka" moments add up to their taking ownership of the investigation, which is a central part of the Grow element.

The Seven Elements

See

Spatial thinking is an essential skill for science practice (CSTS, 2006). Visualizations are particularly powerful because they have a visceral impact and make things clear. Scientists use visualizations in their work in several different capacities: visualizations can *conceptualize* the entire system, they can be *data* (e.g., photographs and videotapes collected as data for experiments), they are a way of *displaying data* (e.g., graphs of numerical data), and they are a way of *communicating information* with other scientists and stakeholders such as the public or government agencies. Learning to interpret visual information is an essential skill (Mannel and Winkelman, 2005). Students with strong spatial thinking ability do better in math and science courses (McGinn and Roth, 1999; Stavridou and Kakana, 2008).

Quantify

Mathematical skills are those most frequently noted in articles on STEM student preparation and retention (Tyson et al., 2007). Gatekeeping courses, such as calculus, prevent or allow students to move forward in their STEM academic careers. Mathematics is a discipline where nationally, as in our Manoomin Science Camp community, American Indian students test behind the general public at the middle- and high-school levels (Rampey et al., 2006).

Tinker

The importance of hands-on learning is well-documented, particularly for STEM disciplines (White and Frederickson, 1998). In addition, research on how American Indian students learn supports hands-on learning (Freeman and Fox, 2005). Ironically, in our increasingly technological world, students are losing the ability to just tinker—use tools to build and create. Students who do have excellent mechanical abilities often fail to see how that relates to STEM careers or how STEM careers are relevant to their interests and hobbies. Tinkering adds fun to learning.

Describe

Manoomin Science Camp participants are encouraged to use the written word and develop increasing ease and sophistication in communicating in scientific and academic settings. Communication is at the top of the list of desired skills for STEM employees (NAE, 2004). Recent research indicates that an important aspect of student success is the ability to take part in scientific discourse (McGinn and Roth, 1999). Minority students may have a particularly difficult time breaching this wall if they haven't been exposed to specialized vocabularies of science in their homes or communities (AAAS, 1990). Our "Describe" focus is designed to get our students to create a discourse pathway:

- Think about their target audience(s) and who they are.
- Think about what it is they want to communicate and why it might be interesting to their audience.
- Think about the level of "discourse" they need to use as a pathway between themselves and their audience.

Some examples of various audiences Manoomin Science Camp students give presentations to include younger children, high-school students (peers), community members, scientists, nonscientists, and elders. In keeping with Ojibwe tradition, "everyone learns together," people of many ages and knowledge levels are combined in a learning environment, and thus it is particularly important to think about the audience(s) and even to speak at different levels simultaneously (e.g., to use technical words but to immediately define them using everyday words). Another important aspect of "everyone learns together" is that the teacher/speaker/writer is also a pupil, that is, everyone teaches each other. In every case, whether students are giving a talk, creating a PowerPoint, or writing something, we want them to learn this process. Scientists and mentors in the program are also being asked to adopt this process as they learn to teach to various audiences.

Understand

At the core of scientific and mathematical activity is the ability to conceptualize (Donovan et al., 1999; CSL, 2007). Understanding systems, building a conceptual framework, understanding sources of information and ways of knowing, finding and using historical information, understanding reliability of information sources, and understanding various perspectives enrich the learning process and thus support American Indian students in STEM. Traditional Native sciences present alternatives that can provide relevance for the students and offer new perspectives (Suzuki and Knudtson, 1992). Students also learn underlying concepts, such as self-organization, that help them understand physical phenomena. Students see real-world applications of fundamental chemical, mathematical, and physical laws and properties. Students make interdisciplinary connections. Encouraging students to share traditional philosophy and spirituality is an important starting point for teaching research ethics. Systems thinking allows students to see the global impact of local decision making.

Relate

Incorporating various perspectives such as social, cultural, political, and economic factors helps students place what they are learning into a wider context. In addition, American Indian students learn more when work is relevant to their lives (Mannel and Winkelman, 2005). In Manoomin Science Camps, this is achieved by helping students connect the STEM learning to their lives and cultures, from local to global. As the world grows increasingly global, working on diverse teams and in diverse communities is an increasingly important skill (NAE, 2004, 2005; NSB, 2007). Making these relational connections helps develop this ability.

Grow

Recent research on informal STEM education stresses the need for programs to go beyond building excitement and content knowledge, and make sure supports are in place to help the student move from one step to the next in their academic and career lives (Jolly et al., 2004). Manoomin mentors, who include scientists, elders, and teachers, teach students to figure out how, where, and from whom to get help and where they can help themselves. Students need to have good information about preparing for college and careers, but they also need help in developing life skills, such as self-confidence, maturity, metacognitive skills (White and Frederickson, 1998); respect for others and for themselves (for their physical and intellectual selves; Donovan et al., 1999); and respect for the Earth, elders, and other cultures. Research also points to the value of constructing a *self*-centered academic identity, which allows students to present a "variety of authorial and rhetorical perspectives" (Williams, 2007), which supports bicultural American Indian education. Manoomin Science Camps guide students to find information about Earth sciences and other STEM careers, to help them develop a positive image of science as a career, to motivate students to develop an early identity as an engineer

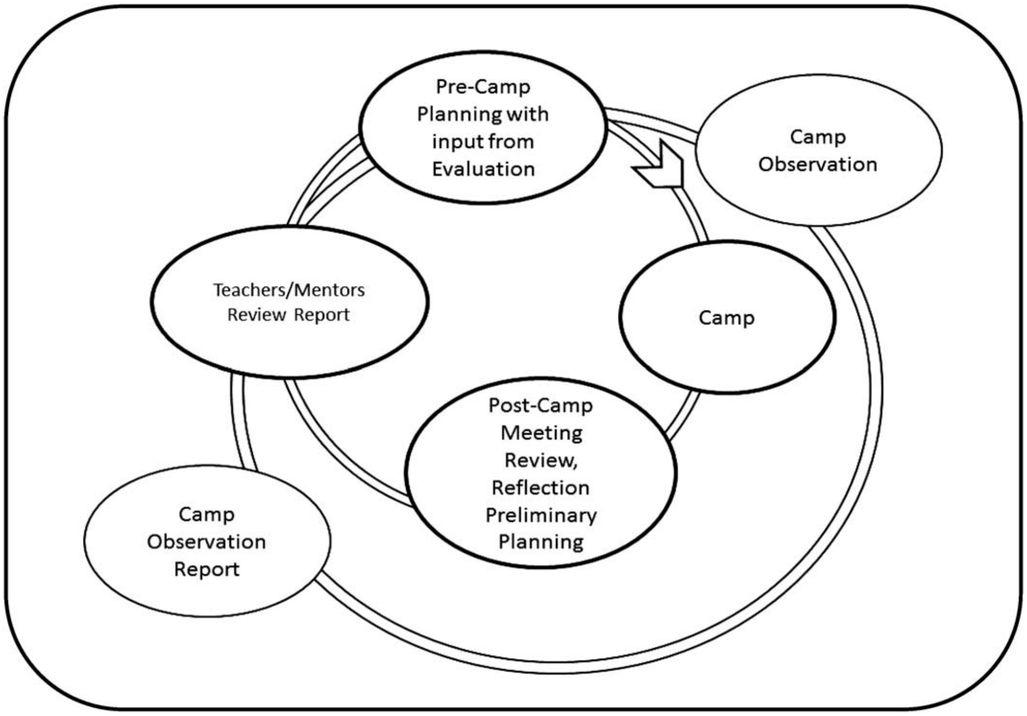


FIGURE 3. Schematic diagram illustrating feedbacks between camp observation and planning. Planning from camp to camp is informed by observation reports from our external evaluators.

or scientist (NSB, 2007b) and to help reconcile these identities with their Native identity.

Incorporating the Seven Elements in Science Camp Activities

The Seven Elements are implemented in the planning for each camp during any particular year in a circular process (Fig. 3):

1. Using camp observations conducted by our outside evaluators, we are able to pinpoint which of the Seven Elements were not strongly incorporated into the activities of the past camp.
2. Our teacher/scientist partners work together from this feedback to develop and review plans for the upcoming camp, discussing their plans through the perspective of the Elements. It is impossible to incorporate all Seven Elements into each activity, but the goal of the planning is to make sure that every camp emphasizes all of these learning styles at some point.
3. After each camp, a meeting of all teachers, mentors, scientists, and elders takes place to review the camp and begin planning for the next event.
4. The external evaluation team delivers a report approximately one week after the camp. This feeds back into planning (see #1 above).

The Seven Elements act as a guide when we review the activities of the previous year and plan for the next. The annual review/planning process have taken place involving the entire team—teachers, mentors, scientists, and elders—whenever possible. The overall plan when the proposal was written was to focus on sediment core acquisition and initial core description during the first 2 years, on more detailed proxy record analyses and historical research involving interviews with elders during Years 3 and 4, and on producing a report during the 5th and final year summarizing the first 4 years. Within this overall plan, detailed planning for each year's activities are informed by the evaluations from the previous year and our own reflections, and build in flexibility to respond to new directions in our education and research goals. Before the beginning of each school year, a rough plan for each camp is developed, with specific themes for each camp that meet that year's learning objectives. Climate Change was highlighted in Year 4; all camps included concept mapping involving climate change; fall camps were developed around (a) a lake tour (September); (b) science fair planning (October); (c) a plant survey and coring Bang Lake (November); (d) proxy analysis (January and February); (e) poster construction (March); and (f) community presentation of results (April).

The Seven Elements provide a mindful approach to mentors as they plan camp activities to ensure multiple learning styles are accommodated and students learn to adapt to different, less-comfortable, learning styles. Some of the Seven Elements are easily applied to normal camp activities. As a rule, for example, students keep laboratory notebooks of observations, questions, data, and so forth as a Describe activity, but mentors may be able to find other ways to support students in verbal skills such as Relate activities that ask students to interview elders or read newspaper articles about issues that relate to wild rice. The Quantify element—asking the students to build a table of diatom counts, work out the surface area of a lake, or estimate the total time scale represented by a core—can often be easily

TABLE I: Applying the Seven Elements of STEM Learning: typical Manoomin Science Camp activities.

Activity	Elements	Objectives: Students are able to . . .
Typical Activities for Fall Camps (September, October, November)		
Tour of rice lakes on reservation with mapping exercise.	See, Relate	Relate aerial maps to familiar local landscape.
Journaling and PowerPoint preparation and presentation.	Describe	Use science terms correctly, document what they see and do, present appropriately to audience.
Phenological observations of local area.	See, Describe	Observe seasonal changes on the Reservation.
Science fair.	All Seven	Design and complete a research project.
FDL GIS activity using http://mapserv.fdlrez.com/fdlgis/.	See, Relate, Understand	Use the FDL GIS program, which incorporates layers relating to wildlife, culture, property rights, treaty rights, landscape features, etc.
Discussion of best practices for homework organization.	Grow	Develop good homework practices.
Ojibwe Bingo and Ojibwe Math word problems.	Relate, Describe, Quantify	Use new scientific terms, gain knowledge of Ojibwe vocabulary, and improve math skills.
Discussion of Ojibwe treaty rights and resource management of reservation lands.	Relate, Grow, Understand	Gain knowledge of management practices on the Reservation and connect to geoscience careers.
Typical Activities for Winter Camps (January, February, March)		
Coring of wild rice lakes. Students go on frozen lakes with mentors and take lake core samples.	Tinker, Relate	Experience field research first hand, collect data, and connect to work in the laboratory later in the winter.
Core extruded, split, observed, and described.	Tinker, Observe, Describe, Quantify	Learn science methods and practices, relate applied mathematics to science practice.
Students weigh, measure, sort, and sift contents of core.		
First attempt to date the core from known events.	Quantify, Understand, Relate	Relate spatial to temporal.
Creation of timeline.		
Visit to the LacCore facility on the University of Minnesota campus.	All Seven	Work in a science laboratory, prepare cores using same methods of any scientist, see scientists engaged in their careers, visit a university, learn content through inquiry-based and applied math activities.
Use technical equipment, including high-resolution scanner for imaging and examination of smear slides under high-powered microscope.		
Ojibwe sports, language, games, and crafts.	Relate, Understand, Tinker, Grow	Participate in a variety of cultural activities, relate science activities to Ojibwe culture, learn about traditional knowledge and perspectives on science.
Analysis of collected numerical data.	Quantify	Improve abilities in mathematics.
Online math tutoring with support of camp mathematics teacher.		
Photographing/videotaping local area and science activities.	See, Describe, Tinker, Relate	Incorporate various technologies into presentations.

incorporated if mentors are mindful about the need to include this element. Research activities generally involve a hands-on or Tinker component. We encourage the mentors to go further, including things like making a Play-Doh model of the diatoms and phytoliths to support their ability to understand what they are seeing under the microscope: students make 3-dimensional models that can be rotated into different orientations to help them observe the 2-dimensional objects under the microscope. This not only supports the Tinker element, but also the See, Describe, and Relate elements. The Quantify, Tinker, See, and Describe elements are almost always present in the science research component of Manoomin Science Camp, but the Understand, Relate, and Grow elements cannot be reliably incorporated into each individual 1.5 hour activity. External evaluators' observation report and mentors' self-reflections led us to a realization that time must be built into a camp for summarization, reflection, questions, and reporting. As we move into our final year of the current project, we are emphasizing incorporation of these three elements in the research activities that will focus on digital and written reports summarizing the first 4 years.

As important as the research component is to Manoomin Science Camp, the activities we build around the

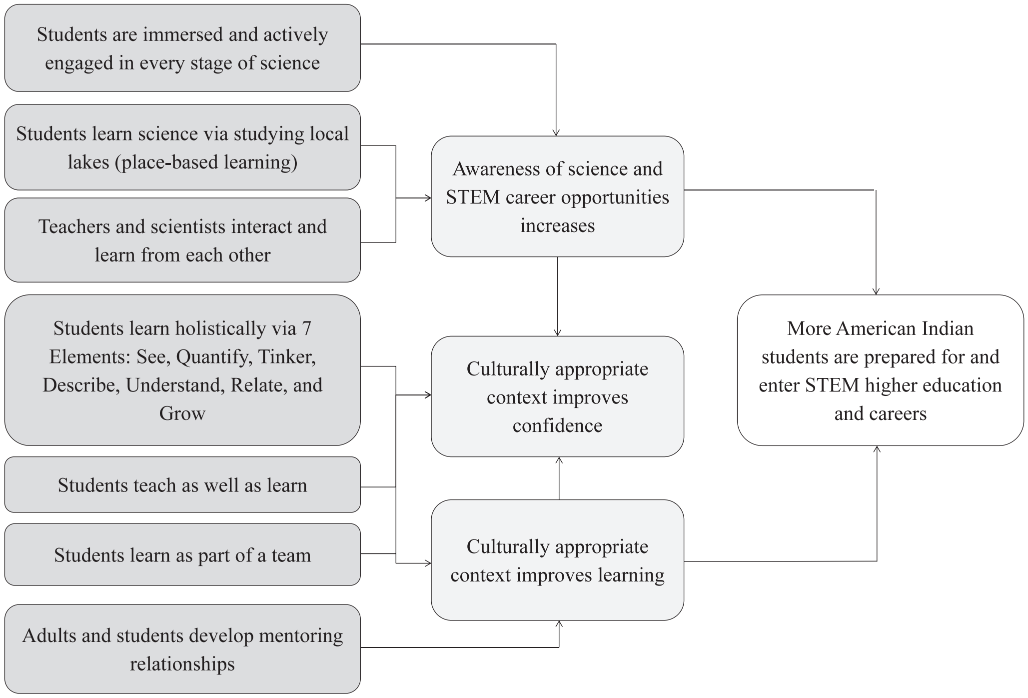


FIGURE 4. Rationale or Program Change Model developed with the evaluation advisory committee over first 2 years of the Manoomin Science Camp to articulate activities. The model provided a foundation for the evaluation activities and analysis.

research are equally or more important, especially as we work to incorporate learning through the Understand, Relate, and Grow elements. Mentor teams work to develop these other activities to incorporate Ojibwe practices and traditional knowledge, support conceptual learning, and support students' metacognitive growth. Activities include: visiting a rice camp, learning traditional Ojibwe games and crafts (such as whittling snow snakes), doing traditional and other art projects that support conceptual and spatial learning and help students follow directions (i.e., making a quilt or doing their own watercolor inspired by work of Ojibwe artists), spending time outdoors to collect plants, then making sunprints from those plants and coming indoors to identify them. We also encourage students to get physical and have fun by doing activities like snowshoeing, a snow snake race, or a GPS scavenger hunt. We have visitors come to camp from the community who talk to the students about Ojibwe history, language, culture, and especially the history of wild rice. The Grow element is also addressed outside of planned activities, as mentors talk individually with students about their postgraduation plans, help them to deal with problems at home or school, or help them to prepare for science fairs, and job and college applications. For further information on what specific activities have been implemented to address the Seven Elements, please see Table I.

TABLE II. Example of observation protocol questions regarding implementation of the Seven Elements.

Element	Brief Description	Extent	Quality
See	Participants are using visualizations in the activity in several capacities.	Great	Good
Quantify	Participants are calculating, estimating, or measuring.	Some	Excellent
Describe	Participants are describing or sharing what they learned (e.g., answering questions, presenting, writing).	Not at all	—
Tinker	Participants are doing something with their hands (e.g., coring, model building).	Great	Excellent
Grow	Participants think about their own learning styles and next steps for their education and careers through the activity that just took place.	Some	Good
Relate	Participants relate their new understanding to previous knowledge or experiences through the activity that just took place.	Great	Adequate
Understand	Participants conceptualize interdisciplinary connections between traditional knowledge and science through the real-world activity that just took place.	Not at all	—

TABLE III. Winter camp participation and preliminary postsecondary education outcomes.

ID	Number of Camps Attended Per Year				Total Camps Attended	Max. # of Camps[1]	Status[2]	Postsecondary Plans	Postsecondary Enrollment Status
	2010	2011	2012	2013					
184	3				3	3	2010	CC[3]	Fall 2012
187	3	2	0	0	5	12	**11**		
7	3	0	3	3	9	12	2013	Tribal CC	Fall 2013
8	3	3	3	3	12	12	**9**		
205	2	2	0	0	4	12	12		
215	3	0	0	0	3	12	**8**		
118	3	2	1	3	6	9	2012	CC	Fall 2013
117	2	3	1	2	8	12	12		
12	3	2	3	1	9	12	2013	Tribal CC	Fall 2013
11	3	3	2	2	10	12	**11**		
16	2	2	2	2	8	12	12	PSEO[4]/TCC[5]	Fall 2012
125	2	2	0	0	4	12	2013	University	Fall 2013
124	3	3	0	0	6	12	2013	University	Fall 2013
9	2	2	2	3	9	12	12		
10	2	2	3	3	10	12	12		
17	2	3	3		8	9	2012	PSEO/TCC	Fall 2011
18	2	2	2	3	9	12	**11**		
13	3	3	2	2	10	12	2013	Tribal CC	Fall 2013
22	3	2	2	1	8	12	12		
134	2	2	0	1	5	12	**11**		
133	2	3	0	1	6	12	2013	4-Year College	Fall 2013
267	2	3			5	6	2011	Tribal CC	Fall 2012
14	X	2	3	3	8	9	**11**		
19	X	3	3	1	7	9	2012	Trade School	Pending
333	X	0	3	1	4	9	2012	Tribal CC	Fall 2012
23	X	3	2	3	8	9	2013	CC	Fall 2013
1	X	X	2	3	5	5	2013	TCC	Fall 2013
3	X	X	2	3	5	5	2013	TCC	Fall 2013
319	X	X	0	3	3	5	**10**		
6	X	X	1	2	3	5	**9**		
292	X	X	1	3	4	5	**10**		
295	X	X	1	3	4	5	12		
299	X	X	1	3	4	5	**5**		
15	X	X	3	3	6	6	**8**		
303	X	X	1	3	4	5	**11**		
294	X	X	1	3	4	8	**8**		

☐ = Graduated from high school; 1 student (118) attended camps post-graduation
X = Not an enrolled participant for that year
[1]Maximum number of camps a student could attend, depending on first camp attended and high school graduation
[2]Either grade in high school for academic year 2013-14 or date of graduation
[3]CC = Community College
[4]PSEO = Post-Secondary Enrollment Options; high school student enrolled in college classes
[5]TCC = Tribal Community College

EVALUATION OF MANOOMIN WINTER SCIENCE CAMPS

An external team of evaluators from the University of Minnesota was contracted in 2009 to evaluate the Manoomin Science Camp throughout the lifetime of the program. One member of the evaluation team, Mary McEathron, worked with Greensky, Pellerin, and Dalbotten during the *gidakiimanaaniwigamig* program. Based on this previous relationship, the evaluation team was able to conduct a culturally responsive evaluation (LaFrance et al., 2012). As such, the evaluation was highly participatory, with a focus on supporting continuous improvement and learning by the staff. Cognizant of the long history of the dominant research culture's practice to conduct studies that extracted knowledge and resources from tribal communities (LaFrance, 2004; LaFrance et al., 2012; Smith, 2012), there was a strong commitment from the evaluation team to collect information that benefited the community. Greensky, who has training and experience in evaluation and a professional role in K–12 education, provided critical support as a liaison member of the evaluation team.

Setting Up the Evaluation Program

During the first two years of the program, the evaluation team met on a regular basis with an evaluation advisory committee comprised of the Manoomin leadership team and

TABLE IV. Implementation of Seven Elements in 2012 winter camps (24 activities total).

	January ($n = 10$)[1]			February ($n = 8$)			March ($n = 6$)		
	Great	*Some*	*None*	*Great*	*Some*	*None*	*Great*	*Some*	*None*
See	6	3	1	8	0	0	6	0	0
Quantify	4	1	5	1	5	2	2	4	0
Describe	8	2	0	4	2	1	6	0	0
Tinker	4	2	4	4	3	1	6	0	0
Grow	0	0	10	0	4	4	1	3	2
Relate	1	3	6	6	2	0	3	3	0
Understand	1	2	7	2	5	1	3	2	1
Total	24	13	33	25	21	9	27	12	3

[1]n = number of activities observed.

community members. The evaluators worked with the advisory committee to develop a program model, including a rationale or theory of change and an articulated set of activities. This model provided a foundation for the evaluation inquiry and has guided the evaluation activities and analysis (see Fig. 4 for an excerpt of the model focusing on the program rationale).

Manoomin is a complex project with numerous partners, goals, and activities. The multiyear evaluation focused first on the following implementation and process questions. These questions are further ordered by the sphere of influence: individual (student, teacher, or scientist), community, or program collaboration.

1. How well were the individual student-focused components implemented (science camps and "bridging" experiences such as pre-REUs and summer transition weeks)?
2. To what extent did the Manoomin program provide students with opportunities to experience and learn in each of the key areas (quantitative, Quantify; spatial, See; conceptual, Understand; social, Relate; mechanical, Tinker; metacognitive, Grow; and verbal, Describe)?
3. To what extent was the Manoomin program viewed as relevant by students?
4. To what extent has the Manoomin program affected teacher and faculty growth in knowledge and understanding across professional roles (i.e., how have teachers learned from scientists and how have scientists learned from teachers)?
5. To what extent did the Manoomin program provide a communal, placed-based learning environment?
6. To what extent were community tradition and knowledge incorporated into the Manoomin program?
7. To what extent was the Manoomin program viewed as relevant by the community?
8. To what extent did the Manoomin collaboration function effectively?

The student-focused evaluation outcome question, identified in discussion with the Manoomin evaluation advisory committee, was:

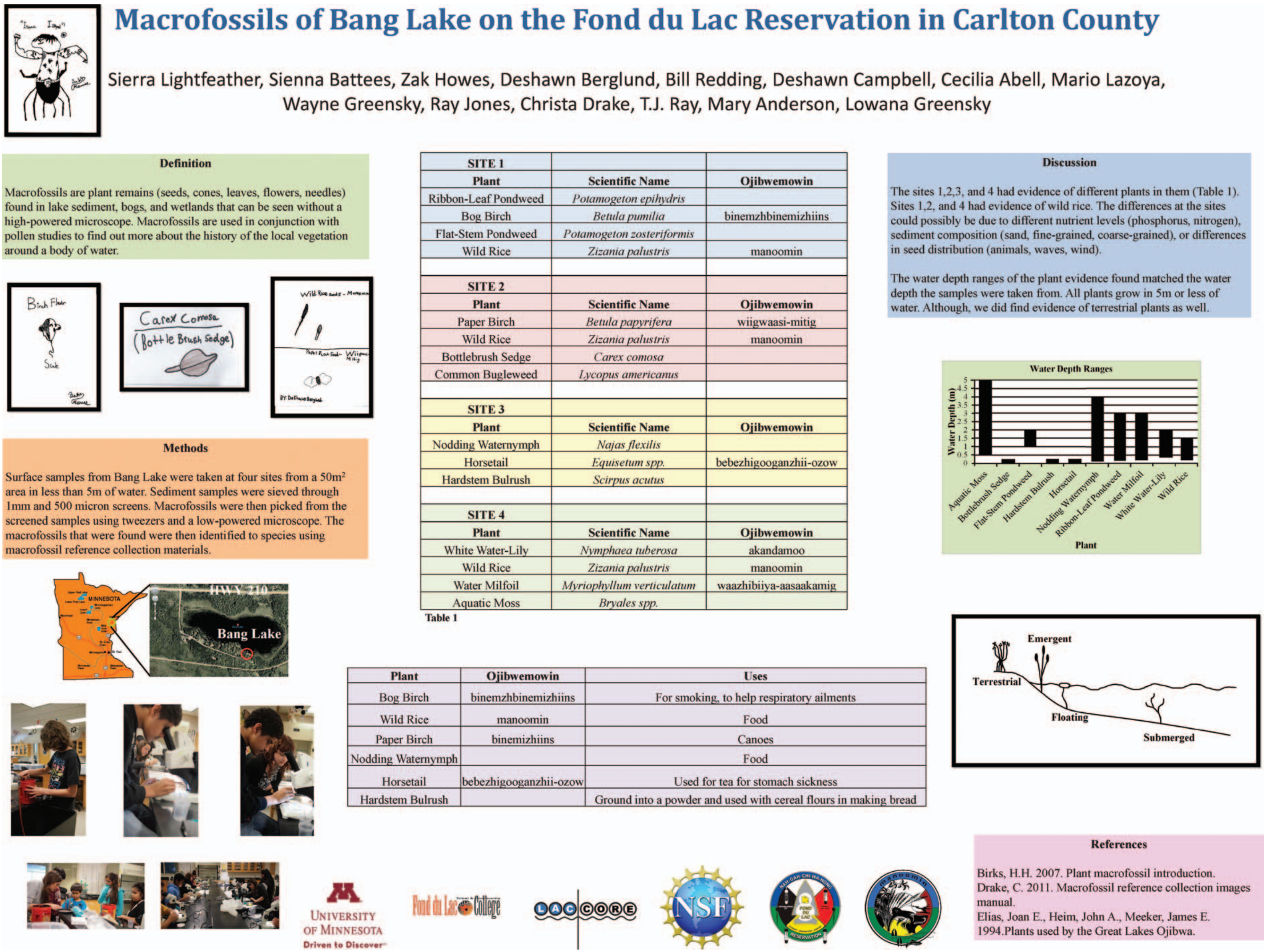
9. To what extent has the Manoomin program improved student:
   a. interest in STEM education and careers?
   b. math and science skills?
   c. 2-year and 4-year college readiness?

In order to answer these questions the evaluation team conducted a number of data collection activities over the course of the last four years including observations of the science camps, interviews with Manoomin staff, interviews with student participants, and surveys of both staff and student participants. Attendance at the various activities was

TABLE V. Implementation of Seven Elements in 2013 winter camps (18 activities total).

	January ($n = 6$)[1]			February ($n = 5$)			March ($n = 7$)		
	Great	*Some*	*None*	*Great*	*Some*	*None*	*Great*	*Some*	*None*
See	6	0	0	5	0	0	6	0	1
Quantify	5	1	0	4	0	1	3	4	0
Describe	6	0	0	3	2	0	6	1	0
Tinker	4	2	0	4	1	0	4	2	1
Grow	5	1	0	1	2	2	4	2	1
Relate	5	1	0	2	3	0	3	4	0
Understand	6	0	0	1	2	2	2	4	1
Total	37	5	0	20	10	5	28	17	4

[1]n = number of activities observed.


Macrofossils of Bang Lake on the Fond du Lac Reservation in Carlton County
Sierra Lightfeather, Sienna Battees, Zak Howes, Deshawn Berglund, Bill Redding, Deshawn Campbell, Cecilia Abell, Mario Lazoya, Wayne Greensky, Ray Jones, Christa Drake, T.J. Ray, Mary Anderson, Lowana Greensky
Definition
Macrofossils are plant remains (seeds, cones, leaves, flowers, needles) found in lake sediment, bogs, and wetlands that can be seen without a high-powered microscope. Macrofossils are used in conjunction with pollen studies to find out more about the history of the local vegetation around a body of water.
Carex Comosa (Bottle Brush Sedge)
Methods
Surface samples from Bang Lake were taken at four sites from a 50m2 area in less than 5m of water. Sediment samples were sieved through 1mm and 500 micron screens. Macrofossils were then picked from the screened samples using tweezers and a low-powered microscope. The macrofossils that were found were then identified to species using macrofossil reference collection materials.
HWY 210
Bang Lake
MINNESOTA
SITE 1
Plant | Scientific Name | Ojibwemowin
Ribbon-Leaf Pondweed | Potamogeton epihydris |
Bog Birch | Betula pumilia | binemzhbinemizhiins
Flat-Stem Pondweed | Potamogeton zosteriformis |
Wild Rice | Zizania palustris | manoomin
SITE 2
Plant | Scientific Name | Ojibwemowin
Paper Birch | Betula papyrifera | wiigwaasi-mitig
Wild Rice | Zizania palustris | manoomin
Bottlebrush Sedge | Carex comosa |
Common Bugleweed | Lycopus americanus |
SITE 3
Plant | Scientific Name | Ojibwemowin
Nodding Waternymph | Najas flexilis |
Horsetail | Equisetum spp. | bebezhigooganzhii-ozow
Hardstem Bulrush | Scirpus acutus |
SITE 4
Plant | Scientific Name | Ojibwemowin
White Water-Lily | Nymphaea tuberosa | akandamoo
Wild Rice | Zizania palustris | manoomin
Water Milfoil | Myriophyllum verticulatum | waazhibiiya-aasaakamig
Aquatic Moss | Bryales spp.
Table 1
Plant | Ojibwemowin | Uses
Bog Birch | binemzhbinemizhiins | For smoking, to help respiratory ailments
Wild Rice | manoomin | Food
Paper Birch | binemizhiins | Canoes
Nodding Waternymph | | Food
Horsetail | bebezhigooganzhii-ozow | Used for tea for stomach sickness
Hardstem Bulrush | | Ground into a powder and used with cereal flours in making bread
Discussion
The sites 1,2,3, and 4 had evidence of different plants in them (Table 1). Sites 1,2, and 4 had evidence of wild rice. The differences at the sites could possibly be due to different nutrient levels (phosphorus, nitrogen), sediment composition (sand, fine-grained, coarse-grained), or differences in seed distribution (animals, waves, wind).
The water depth ranges of the plant evidence found matched the water depth the samples were taken from. All plants grow in 5m or less of water. Although, we did find evidence of terrestrial plants as well.
Water Depth Ranges
Water Depth (m)
Aquatic Moss
Bottlebrush Sedge
Flat-Stem Pondweed
Hardstem Bulrush
Horsetail
Nodding Waternymph
Ribbon-Leaf Pondweed
Water Milfoil
White Water-Lily
Wild Rice
Plant
Terrestrial
Emergent
Floating
Submerged
References
Birks, H.H. 2007. Plant macrofossil introduction.
Drake, C. 2011. Macrofossil reference collection images manual.
Elias, Joan E., Heim, John A., Meeker, James E. 1994.Plants used by the Great Lakes Ojibwa.
University of Minnesota
Driven to Discover
Fond du Lac College
LacCore
NSF

also tracked, along with student outcomes such as high-school graduation and postsecondary plans.

In addition to the development of the change model (Fig. 4), the advisory committee provided valuable feedback on the processes of collecting data for the identified evaluation questions. For example, relationships and trust are key factors in conducting a culturally responsive evaluation (see *Indigenous Evaluation Model* in LaFrance et al., 2012); therefore, members of the evaluation team attended nearly all of the Manoomin Science Camps as well as a number of additional activities over the last 4 years. Pellerin, in particular, instructed evaluation staff on the importance of being present and building relationships with the students. In a stepwise fashion that mirrored the level of trust, interviews were first conducted during the third year in small groups with Greensky present, followed by individual interviews with evaluation team members.

It is not possible to present all of the evaluation data or findings for Manoomin; therefore, two key areas (1) observation of science camps, and (2) correspondence between camp attendance and preliminary student outcomes related to college attendance, are reported in the Evaluation Results and Implications section, as they are particularly relevant to the scope of this Curriculum and Instruction article. College-readiness (Evaluation Question 9c) is measured by longitudinally tracking successful college enrollment and retention.

Observation of Manoomin Science Camps

The Manoomin Science Camps exemplify the complexity of conducting and evaluating informal science experiences for youth. Each camp, from the inception of the project, has been full of a variety of learning experiences. The evaluation team attempted to observe and characterize those experiences in order to more fully understand the implementation and outcomes of the program. The observation protocol was developed with specific input from Dalbotten, Pellerin, and Ito so that a clear set of observable behaviors corresponding to each of the Seven Elements were identified. The observations were first conducted by two evaluation staff members so that some measure of interrater reliability could be established. Observers completed brief overall descriptions of the activities and answered questions about the type of activity, level of student participation and engagement, inclusion of community knowledge and elders, degree of implementation of the Seven Elements, and instructional behaviors. Table II presents an example of the section of the observation protocol used to characterize the implementation of the Seven Elements within each activity (note that we are using a narrower definition for "understand" to focus on the traditional knowledge concepts). The observer used a menu to select the extent to which the element was present (to a great extent, to some extent, or not at all) and the quality (excellent, good, adequate, or poor).

Since each camp was comprised of new activities—that is, very rarely were any planned sessions repeated—it was not possible to create a standardized rubric. Therefore, we created scales that were at a level that we could make some determination no matter what was happening at camp that day. As was determined during our pilot testing of the observation form, one could easily make a determination between "not at all," "to some extent," and "to a great extent." In addition, the evaluation team discussed the rating and compared it to the narrative description of that camp activity prior to sending out the report. Finally, and most importantly, the purpose of the observation was to engage the project staff in program improvement. When the evaluation team sent out the camp reports (see Fig. 3), we encouraged staff to let us know if they thought the rating was inaccurate or if we missed anything. The camp evaluation reports were very successful in generating good conversations about camp activity plans and the use of the Seven Elements.

Overall, four evaluation staff members conducted observations at all major science camps throughout the course of four years. The process of conducting observations evolved along with the process of conducting the science camps. During 2012–2013 science camps, the evaluation team implemented a streamlined observation process via the use of an online survey tool along with a staff feedback and reflection questionnaire, which allowed for Manoomin program staff to receive a report the week following each camp. This immediate feedback provided staff with the information needed to make improvements and solidify planning for subsequent camps.

As a snapshot of the observation component of the evaluation, the evaluation team observed 24 activities during 2012 winter camps and 18 activities during 2013 winter camps. In 2012, the evaluation team observed 10 classroom/workshop activities, 9 laboratory analytical sessions, 4 presentations, and 1 outdoor activity (tree identification). In 2013, staff observed 10 classroom/workshop activities, 6 laboratory analytical sessions, and 2 presentations. Classroom activities ranged from concept mapping and science fair projects, to conversations on cultural issues and scientific tinkering games. Lab analyses on core samples included diatoms, plant macrofossils, or phytoliths, depending on the research team to which the student was assigned. Presentation activities included students presenting the results of their lab analyses or science posters, or showcasing the results of other camp activities.

Student Attendance

Since its inception in 2009, a total of 56 students have participated in at least one Manoomin Science Camp (summer, fall, or winter). Attendance not only indicates a level of engagement but also provides context for understanding student outcomes, based on the program change model (Fig. 4), which highlights the importance of participating in placed-based learning activities as a member of an engaged community of investigators. We focused on examining winter camp attendance since all of the major research activities occurred during those camps, thus constituting the central component of the Manoomin project.

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FIGURE 5. A poster made by the plant macrofossil team and its mentors at the end of the 2012 winter camps (end of Year 3). Significant guidance by the mentors is evident in the design, data presentation, and the analysis.


giiwenh nibi gitigade zhiigozhiigate ginwaa zaaga'igan
(The History of Plant Macrofossils in Bang Lake),
Rose Abramowski, Zak Howes, Deshawn Campbell, Willow Johnson-Fuller, Kyleigh Cloud, Victoria Defoe, Holly Pellerin,
Cecilia Abell, James Lozoya, Wayne Greensky, Elsie Greensky, Ray Jones, Christa Drake, Lowana Greensky, Carolyn Olson,
Bob Zimmerman, Lowana Greensky
terrestrial
emergent
floating
Submerged

Data indicate that Manoomin Science Camp was successful in retaining a consistent number of students throughout the program with a core group of 36 students having attended three or more winter camps since the beginning of the project in 2009 (see Table III). An additional 20 students attended one or two camps during the same time period. Retention of 36 students indicates a high level of student engagement, especially when the challenges of transportation (many students live in rural areas and small towns scattered in and around the Fond du Lac Reservation) and family resources are taken into consideration. Of the 36 students listed in Table III, 13 students were eligible for the free and reduced lunch, 4 were enrolled in a special education program, and 6 students were enrolled in both the free/reduced lunch and special education programs; 23 out of 36 students are in either one or both programs.

Evaluation Results and Implications

Preliminary Student Outcomes: 2-Year and 4-Year College Readiness

As can be seen from Table III, all 36 students in the core group both graduated from high school and had confirmed or pending postsecondary education plans, or are still in secondary school. Compared to statewide high-school graduation rates of 45.5% for American Indian students, the 100% high-school graduation rate of Manoomin Science Camp participants is remarkable. In addition, only 35% of Minnesota American Indians who graduated high school between 2007 and 2011 progressed directly to in-state postsecondary programs (numbers for out-of-state attendance are not tracked), while all of the Manoomin Science Camp participants who have graduated high school went directly into postsecondary programs, and all except one are still enrolled (Djurovich et al., 2011). This indicates that students in the Manoomin Science Camp program are making gains beyond their peers in college readiness.

Implementation of the Seven Elements

Tables IV and V indicate the level of implementation in exposing students to the Seven Elements during the winter camps in 2012 and 2013; values indicate the occurrence of that element for each observed activity (24 for 2012 and 18 for 2013). An element's presence (to a great extent, or to some degree) or absence (not at all) was weighted according to how thoroughly the element was incorporated in the activity.

The observation data indicate that Manoomin Science Camp students were exposed to the elements See, Tinker, Describe, and Quantify to a great extent during most of the activities in 2012 and 2013. The mentor team got better at incorporating all Seven Elements starting from a shaky January 2012, indicating that immediate feedback was having its desired effect.

Two considerations are worth noting. First, rather than have each individual activity incorporate all Seven Elements, which would have resulted in superficial application of some elements due to appropriateness or fit, each camp was structured so that the activities over the entire weekend resulted in an overall experience that included all Seven Elements. Some of the elements came into play over the course of the year, if not the entire project, rather than within individual camps or activities. The elements Understand and Grow, for example, could be better observed in a comparison of student posters from year to year. For each year's camp cycle, a plan for the Manoomin Science Camp research activities is developed in consultation with FDLRMD, which might include taking a lake core, working at the core laboratory to process the cores, or examining slides to identify phytoliths, plant macrofossils, or diatoms. Students make posters of this work at the end of the year and present them to a variety of audiences (a Describe activity). Figures 5 and 6 are examples of the posters students prepare at the end of each project year.

To illustrate how the Grow element is more observable over a longer timeframe, comparison of Figs. 5 and 6 shows quite plainly that students' participation in all aspects of the research grew significantly from 2012 to 2013. The heavy involvement of the mentor team in both the design and content of posters made at the end of 2012 winter camp is quite apparent (see Fig. 5): (a) Students were directed what information to include in the poster, (b) Mentors helped students construct tables and figures, and (c) Overall organization and layout of the poster was dictated by the mentors. At this point in the project, the students were still uncertain and floundering when it came to organizing the information for presentation. The poster made at the end of the 2013 winter camps shows that the students did all the design and illustration work themselves, and little guidance was given in deciding what content to include (see Fig. 6). Students decided to keep the text to a minimum and wrote it themselves, designed the overall poster layout and created the background drawing, created the tables independent of mentors, and decided to include the team-designed t-shirt on the poster. The mentors who were working with the plant macrofossil team in 2013 verified that they were able to step back and let the students drive the poster-making process.

CONCLUDING REMARKS

The Manoomin Science Camp program has shown the benefits of adding a specifically place-based project with a strong research focus, involvement of FDLRMD, and research centered on manoomin, which in a multitude of ways lies at the heart of FDL Ojibwe community. This benefit was demonstrated by consistent camp attendance and impacted student graduation rates (Table III). In order to have a positive impact on students, mentors from the University, the reservation, and the K–12 partner schools have all had to learn to work well with each other. Previous research has shown the challenge involved in bridging these communities (Nelson, 2005). Much of the evaluation for this

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FIGURE 6. A poster made by the plant macrofossil team, which has both continuing and new members for the winter 2013 camps (end of Year 4). Students needed little guidance from the mentors. Illustrations and the choice to include the team t-shirt illustrate that students have taken the ownership of the macrofossil study and how to report their study results.

program has focused on these relationships, on improving communication between these communities, and on developing systemic approaches that allow joint teaching and scientist/teacher/community interaction.

In summary, Manoomin Science Camp program depends on the following aspects for success:

1. Manoomin was developed on the foundations laid in the first 7 years of the *gidakiimanaaniwigamig* program. The Circle of Learning and the Seven Elements articulated by the *gidakiimanaaniwigamig* program created a rich learning community based on Native American culture that set expectations for all camp participants that are understood across the *gidakiimanaaniwigamig* community.
2. The science camps focus on research on manoomin, an important community resource with deep cultural significance, which encourages student engagement.
3. Manoomin leaders make sure that learning stays holistic by using the Seven Elements and also ensure that students engage with many different aspects of science, from data gathering to analysis to communicating results.
4. Students see research activities taking place on their own reservation that are conducted by scientists working at the FDLRMD, which also helps them see a potential career path.
5. In order to be successful, place-based and community-inspired research and education projects with American Indian or other communities will depend on consistency, patience, communication, time, and relationship-building across partnering cultures (Davidson-Hunt and O'Flaherty, 2007).

Acknowledgments

This project was supported by NSF awards 0949962 and 0914694. We thank our external evaluation team headed by Dr. Mary E. McEathron. The evaluation team included Hanife Cakici, Vidhya Shanker, and Elizabeth Mena. We also thank Gillian Roehrig, the Associate Editor and anonymous reviewers for their constructive comments.

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