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Gaa-Noodin-oke (Alternative Energy/Wind Power): A Curriculum Implementation on the White Earth Reservation

S. Selcen Guzey
Purdue University

James Nyachwaya
North Dakota State University

Tamara J. Moore
Purdue University

Gillian H. Roehrig
University of Minnesota

Abstract

A wind energy focused curriculum for grades 4-8 was designed and implemented to promote the understanding of wind energy concepts with American Indian students. 57 students who participated in the summer program of the "Reach for the Sky" (RFTS) Science, Technology, Engineering, and Mathematics (STEM) received the curriculum. The two week long curriculum allowed students to engage in various STEM activities. Students completed design challenges such as building and testing table-top wind turbines and anemometers. Students were asked to keep a notebook where they designed and recorded scientific experiments, recorded data and observations, and drew conclusions and reflections. Student notebooks and pre and post assessments were analyzed to evaluate the effectiveness of the curriculum on students' learning of the wind energy concepts. We found that the curricular activities and the use of notebooks enhanced American Indian students' achievement.

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Non-formal programs such as summer school and afterschool programs have proved to be very helpful to low-income students or students in underserved groups (Mahoney, 2000; Mahoney, Eccles, & Larson, 2004). Participation in non-formal programs provides various opportunities for low-income students to have similar experiences that middle-class students have (Posner & Vandell, 1999) and to increase attitudes toward school (Davalos, Chavez, & Guardiola, 1999). However, students in economically distressed communities are least likely to participate in such programs (Davalos, Chavez, & Guardiola, 1999; Furstenberg, Eccles, Elder, & Sameroff, 1999) for various reasons such as the limited number of programs that are being offered to them. Low-income, marginalized students need to be involved in programs that are designed to increase their knowledge of and interest in science, technology, engineering, and mathematics (STEM) disciplines, to enhance their motivation to learning, and to have positive impact on students' attitudes toward school. STEM skills and knowledge can be effectively increased by spending quality time learning the subject matter and connecting it to traditional knowledge and students' everyday life experiences (Demmert, 2001).

If low-income, underserved students participate in non-formal STEM programs they can develop their skills and confidence and consider a career in a STEM area. The National Research Council (NRC) released a report on STEM education in the U.S., which addresses the need for improving STEM education and preparing students to choose future careers in STEM fields (NRC, 2011). The report also points out that there are significant gaps in achievement in STEM disciplines between students in underserved groups of black, Hispanic, American Indian, and low-income students. There is a growing concern about increasing the participation of low-achieving group of students in STEM education. This paper will provide details about a wind energy focused curriculum for grades 4-8 that was designed and implemented to promote the understanding of wind energy concepts in an out-of-school program with American Indian students. Results from a study of student artifacts related to student understanding will also be presented.

The Need for Intervention

American Indian students have been underserved for many years. Past studies on the education of American Indians have identified problems such as low enrollment and graduation rates, large percentage of absenteeism, suspension and expulsion, low achievement scores on math, science, and reading, and the high dropout rates as ones that are commonly associated with American Indian students' education (Bradley, 1984; National Center for Educational Statistics [NCES], 2008; Nelson, Simonsen, & Swanson, 2003; Preston, 1991). American Indian students have a number of factors in their social and educational environments that put them at a disadvantage compared to other student populations (NCES, 2008). The 2008 NCES report identified these factors as lack of learning opportunities at home, the limited use of a computer at home, less-educated parents, and lack of educational opportunities at home such as access to books, encyclopedias, and newspapers and magazines among others. The report notes that less than 30 % of American Indian students read anything for fun at home. According to NCES (2008), these trends are associated with students coming from single parent homes, living in poverty, having parents who don't have a college degree, and having parents whose primary language is different from English, which is the language of instruction in schools. According to the U.S. Department of Education (2001), these risk factors make students lag behind in their reading and mathematics abilities. Interventions in school that address these factors will therefore be critical in helping these students catch up to their white counterparts, who are usually not as disadvantaged.

Preston (1991), noted that American Indian students have different learning styles, where their learning is environment dependent, and that their thinking styles are more relational than analytic. To effectively instruct these students, Preston (1991) suggests that instructors use experiential learning and cooperative learning to both improve their problem solving abilities and reduce anxiety related to science and mathematics. He advocates using hands-on activities, and making education relevant to students' everyday lives, through workshops, summer activities and after school programs. Pewewardy (2002) found that American Indian students are visual learners, who learn best by 'seeing' and when/if they are involved in activity based science programs. Instruction should therefore involve all senses.

A number of ways have been suggested, which can help address problems associated with the American Indian Youth. These include parental involvement (NCES, 2008), the use of culturally relevant curriculum (Preston, 1991), the application of Native American pedagogy (Hankes, 1998), and well-trained teachers who can meet the particular needs of American Indian students (Bradley, 1984). The application of the learning theory called "situated learning" (Lave & Wegner, 1991) can also be helpful in improving American Indian students' achievement. Situated learning theory claims that learning is situated within the activity, context, and culture (Lave & Wegner, 1991). Social interactions and communications among the learners are very critical in their learning. The learning activities should allow the learners actively participate in a "community of practice" in which learners share similar beliefs and behaviors and aim to improve their knowledge through active participation. The curriculum that we present theoretically aligns with the situated learning theory. Activities allow students to acquire knowledge by "doing", they participate in authentic activities through involvement in a community of learners.

It is important to provide opportunities for American Indian students to participate in STEM education programs so that they can have an education needed to meet the demands of today's economy. Participating in non-formal STEM education programs can help American Indian students to increase their knowledge in STEM disciplines and interest in STEM majors and careers. To this end, Reach for the Sky (RFTS) was created to develop a specific program for American Indian students to enhance their STEM learning and dispositions toward STEM.

Reach for the Sky Program

The innovative "Reach for the Sky (RFTS)" program was developed as a summer and after school program to serve a specific group of American Indian youth – Anishinabe – who live on the White Earth Indian Reservation in Minnesota. The goal of the RFTS project was to make the STEM disciplines more culturally relevant to the Anishinabe youth.

The RFTS program was a three-year collaborative project funded by the National Science Foundation (NSF) at three different schools on the White Earth Reservation of Minnesota that targets 60 middle, high school and out-of-school children, 9 teachers and 6 after school staff each year. The program involved bringing science and engineering curriculum with hands-on activities to the out-of-school time summer and after-school programs: five weeks during summer and weekly during the academic year. During summer sessions, students attended the program 4 hours a day, four days a week for 5 weeks while during the academic year; they attended the program for two hours for a day per week for 30 weeks. The summer school programs partnered with the 21st Century Grant training staff in the subject areas of science, technology, and engineering. The major purpose of the summer program was to avoid summer learning loss and engage youth in STEM and IT subject matter that was likely new to these students. Each year, the program focused on different topics related to alternative energy and energy transfer. The emphasis was placed on the mechanical energy in the first year of the program. During the second year, the activities focused on electrical energy through wind and water energy. For the final year of the program, bio-energy and solar were chosen as focal concepts. We tied these traditional Western science topics to the Anishinabe Medicine Wheel – specifically air, water, earth, and sun/fire. Special emphasis was placed on developing life skills where students could gain first hand skills and knowledge about science careers in related fields that are needed in reservation communities. All the activities were designed to be connected to the national and state science and mathematics education standards. The National Educational Technology Standards were also integrated into the activities. Students completed various projects that required them to use technology tools such as video analysis, Google Earth, and design software programs. RFTS also provided training for teachers and out-of-school staff at the schools to help them teach curricula designed by the RFTS team and allow for sustainability of program activities after the award period.

The parental and community engagement was a critical component of the program. At the end of each summer school program, a festival was held to allow students to share their projects with the community. The RFTS program partnered with the Land Recovery Project at White Earth and worked closely with a Tribal College. The reservation's Tribal College played a key role in helping students to connect STEM concepts to their culture. Faculty from the Tribal College and Tribal Elders brought expertise and knowledge to the challenges of making science and engineering relevant to native youth. Furthermore, the community elders were invited to come to the summer school programs to share their knowledge and experiences with students. Finally, community elders and school administrators were asked to give comments and suggestions on the curricular activities. Thus, the design and implementation of the whole program was a community endeavor.

The Wind Energy Curriculum

The emphasis of the curriculum described here is on wind energy since the community in the White Earth Indian Reservation was actively looking for ways to use renewable energy sources. There are several ongoing wind turbine projects on the reservation. Currently, the main energy source in the reservation is coal. Since the use of coal has been associated with global climate change, and given that it is not a renewable energy source, new local wind initiatives on White Earth Reservation have been developed as an alternative source of energy. However, public education is required to increase the awareness and understanding of alternative energy and the wind energy projects on the reservation. Thus, through this curriculum, students would gain a better understanding of wind energy as an alternative energy source, and specifically about wind energy projects on the reservation.

Curriculum Design

To design the wind energy curriculum, we used the "backward design process" (Wiggins & McTighe, 2005). Our curriculum design also emphasized content integration, meaning that the curriculum integrated and connected the content from STEM subject areas giving weight to learning objectives from multiple STEM areas (Moore, Stohlmann, Wang, Tank, Glancy, & Roehrig, (2014). It has been shown that curriculum integration is very critical in improving students' deeper understanding of the concepts and motivation to learn (Czerniak, Weber, Sandmann, & Ahern, 1999). The "backward design process" entails three stages: establishing goals, defining assessment strategies to gather evidence of learning, and planning instructional activities.

Stage 1: Establishing the goals of the wind energy curriculum. There are two key goals of the curriculum. First, the curriculum aims to introduce students to a variety of STEM activities that are relevant to American Indian culture. The curriculum allows students to explore new topics each day though engaging in various interdisciplinary activities. The curriculum development team, the authors of the paper, aimed that through the study of the curriculum students would improve their understanding of the science, technology, engineering, and mathematics concepts (e.g., energy transfer, renewable energy resources, electrical energy, wind energy, geometry, measurement, algebra, data analysis, and engineering design), develop a deeper understanding of science as inquiry approach, and improve critical thinking and problem solving skills. Second, the curriculum aimed at stimulating the interest of American Indian students' in STEM related careers. To do this, the curriculum focused on decreasing American Indian students' misconceptions about both STEM and American Indian culture by giving the students opportunities to work with science and mathematics educators, electrical engineers, tribal archeologists, tribal elders, and tribal biologists. Connecting subjects such as science and mathematics to students' everyday life experiences also helps students to see the connections among the disciplines and with the American Indian culture.

Stage 2: Defining assessment strategies. An important element of the curriculum was assessment strategies that were identified to evaluate student learning. We used two strategies to assess student learning: engineering notebooks and pre and post student content test.

In order to develop our use of engineering notebooks, we considered the literature base for the use of science notebooks, which has become increasingly popular in formal and informal learning settings. A science notebook is a tool for a student to record their understanding and reflections. It is important to note that science notebooks are different than journals, since journals include only student reflections and they are not structured as science notebooks (Campbell & Fulton, 2003). The advantages of keeping science notebooks on student learning have been demonstrated in several studies (e.g., Baxter, Bass, & Glaser, 2000; Nesbit, Hargrove, Harrelson, & Maxey, 2004). This literature helped us design our use of engineering notebooks. We promoted notebook writing for several reasons. First, engineering notebooks provided evidence of student learning. Notebooks contained students' records of observations and procedures, design and analysis of experiments and engineering design solutions, and their reflections. The written records of the investigations showed student understanding of the concepts and inquiry skills. Second, students' reflections about the activities demonstrated the effectiveness of the curriculum on their learning and motivation. Third, keeping engineering notebooks helped students to think critically and also work as engineers. Documenting the steps of design, their observations and thoughts about how to design, and the modifications of an investigation are very critical for engineers. Thus, it is very important to help students to gain the skills to keep well-structured notebooks. Fourth, the reflections helped promote and demonstrate conceptual understanding. In the reflections, a question was posed to students, which required them to apply knowledge from previous lessons in order to respond. The questions were such that they did not require mere recall of facts. For example, in one of the reflections, students were asked to explain to one of their tribal elders what factors need to be considered when deciding where to place a wind turbine. A sample reflection from one of the students: "You want to put a wind turbine where there is a hill, a lot of wind. You do not put it where spiritual grounds, or Indian mounds, swamp, trees, wildlife."

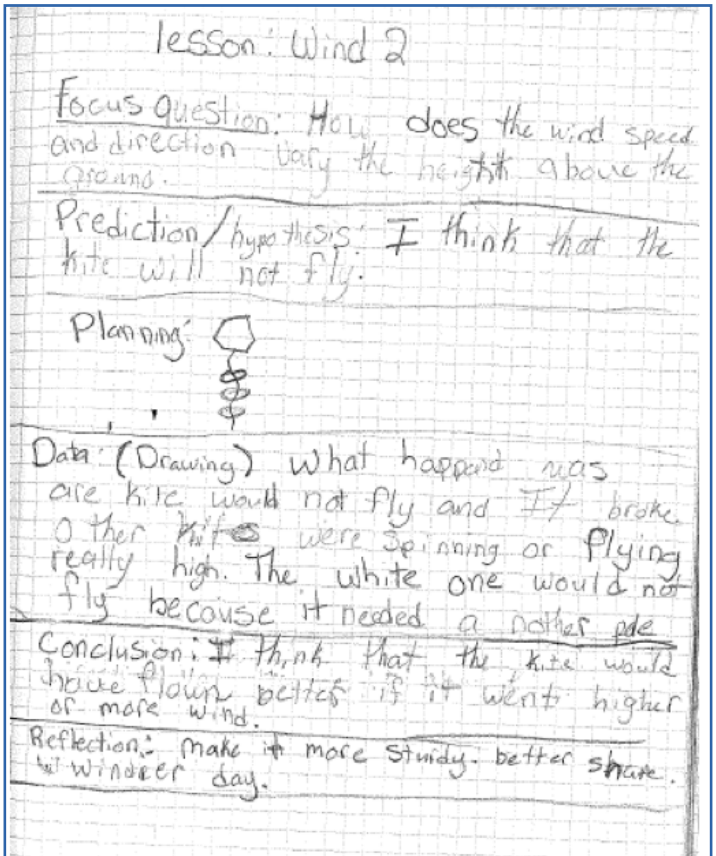

Figure 1.

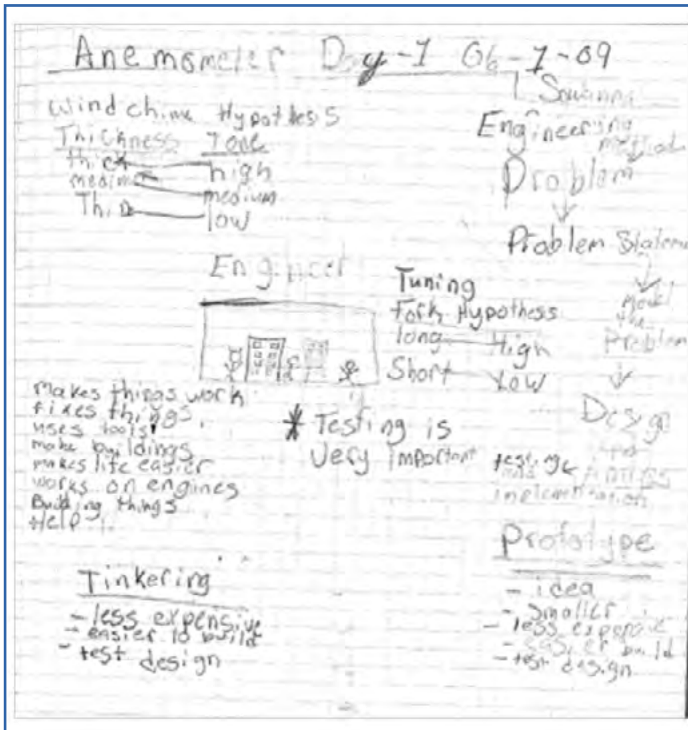

Figure 2.

Engineering notebooks can be also used as assessment tools (Ruiz-Primo, Li, & Shavelson, 2004). In the RFTS program, students' understanding was assessed through evaluating notebook entries in addition to the content assessment. Students in our program were asked to keep engineering notebooks during the implementation of the curriculum. Each day, they completed different activities and recorded their observations, experimental designs, questions, and illustrations. At the beginning of each day, students also summarized what they learned in the previous day in their notebooks, in form of a reflection. Each entry of each student was analyzed to measure student understanding. Figures 1 and 2 provide two sample notebook entries.

We also designed a pre- and post-content test to measure student learning. We designed the test with the help of content specialists based on the content being taught in the curriculum. The pre- and post-test were equivalent and included the same number of true false questions, fill in the blank questions, and open-ended questions.

Stage 3: Planning instructional activities. After determining the goals of the curriculum and assessment strategies, we defined the most appropriate activities and the teaching methods. While defining the goals of the curriculum and the assessment strategies, we decided which concepts should be included in the curriculum. Then, we organized them into four parts: building and testing table-top wind turbines, designing and building anemometers, wind turbine placement Model Eliciting Activities (MEA), and Google Earth activities (http://earth.google.com/). All these four parts complement each other while contributing to the larger curriculum. The organizing theme of the curriculum was wind energy and each element of the curriculum integrated one or more disciplinary parts. For example, the first part of the curriculum, building and testing table-top wind turbines integrates content from science, engineering, and mathematics, while at the same time, the wind turbine itself is a technology.

Figure 3. Students building a table-top wind turbine

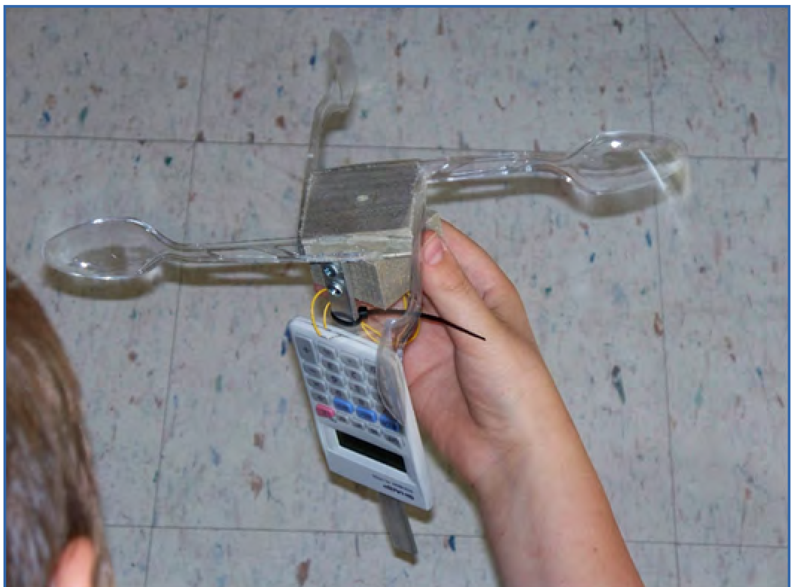

Figure 4. A students building an anemometer

Part I: Building and testing table-top wind turbines. Activities of this part required students to be involved in several projects that integrated the engineering design cycle (Atman, Adams, Cardella, Turns, Mosborg, & Saleem, 2007) and inquiry features (NRC, 2000). Students were first introduced to concepts such as types and sources of energy, renewable energy, and wind. Students were then involved in a project to investigate how the wind speed and direction varied with the height above the ground. Students in groups of 2-3 designed and built kites to investigate their ideas. Once students completed their project, they learned about types of wind-turbines (e.g., small and commercial), wind turbine design (i.e., vertical and horizontal), and components of a wind turbine (i.e., generator and gear box, rotor, blades, tower, and foundation). They then engaged in several design challenges that included building table-top wind turbines. Students completed six inquiry projects that involved testing blade variables (i.e., number, length, shape, material, angle) and gear ratio combinations (a wind turbine has a gear box that is connected to the shaft) to find the effects of design elements on electricity output (see Figure 3). These inquiry activities allowed students to engage in five essential elements of inquiry identified in NSES (NRC, 2000): learner (1) engages in scientifically oriented questions, (2) gives priority to evidence in responding to questions, (3) formulates explanations from evidence, (4) connects explanations to scientific knowledge, (5) communicates and justifies explanations.

These six projects were guided inquiry activities in which students were provided with a research question (e.g., how does the number of blades affect the amount of power a table-top wind turbine can generate?). Students designed their own experiments, collected and analyzed data to find an optimal blade design and gear ratio (Also see figure 1 for sample notebook entry for an inquiry activity). Students shared their data, analysis, and interpretations and critiqued each other's research design and findings.

Part II: Anemometers. This part of the curriculum focused on electricity and anemometers. Students learned about electricity concepts such as basic circuits, magnetic fields, and electricity causing motion through investigating magnets, motors, and generators. Students were first introduced to magnetic fields through an experiment with bar magnets, iron filings, and paper. They then used their creativity and problem-solving skills to take apart and reassemble these small toy motors/generators in order to gain understanding of how the transfer of mechanical to electrical (and vice versa) happens in a motor/generator. The students were asked to draw a pictorial model of the motor/generator and develop explanations as to how the transfer of energy occurred in their engineering notebooks. They shared their models with their group members and the instructor and then, after making necessary modifications to their explanations, they reassembled their motors/generators. After learning about basic electricity concepts through the toy motor/generator activity,

Figure 5. Students working on the MEA

students then built handheld anemometers. An anemometer is a device that measures wind speed. Using materials such as plastic spoons and wood blocks students made simple anemometers and measured and record the wind speed (Figure 4). Students used the knowledge gained in the motor/generator activity to build and test their anemometers. These anemometers worked by programming a calculator to add 1 as each rotation of the spoons occurred. Each group of students developed a mathematical process for calculating the wind speed. They compared their processes to a digital anemometer and calibrated their processes to ranges of wind speed using the Beaufort scale that was developed in 1805 by Francis Beaufort.

Part III: Wind turbine placement. The next part of the curriculum had students engaged in a Model-Eliciting Activity (MEA) (Lesh & Doerr, 2003; Moore, 2008), which is a problem-based design activity focusing on solving real world problems. Students worked in groups of three to four to create a procedure to choose a location in the reservation to place a wind turbine. The solution of the activity was a procedure for how to make the decision of where to place wind turbines, so that students were providing decision-making advice for the tribal elders who would have to make this decision multiple times over the following years. This activity was purposefully designed to show students how the curriculum that they studied in the other areas connected to wind energy was connected to their everyday lives. There is an on-going wind project on the reservation and through this activity students were able to learn more about this project. During the curriculum implementation, students were taken on several field trips to see bird species, sites earmarked for wind turbine placement, and an actual wind turbine on the reservation. A group of tribal archeologists and biologists who work in the project were also invited to share their experiences with the students. To develop their process for choosing a location for wind turbines, students in groups of four analyzed wind, topographic, and archeological maps of the reservation. Each group then shared their place of choice for wind turbine placement with classmates, and they discussed the advantages and disadvantages of building the wind turbine on those proposed sites. They presented their procedures at the end of the unit using trifold boards (Figure 5).

Part IV: Google Earth. In this part of the curriculum, students looked at features of the Google Earth applications, and practiced on using those features. The part of the curriculum that was relevant to the wind energy curriculum was to use the application to make decisions related to wind energy, particularly the placement of wind turbines (part three of the curriculum) (see Figure 6). Using Google Earth, students looked for features on the reservation that either made it possible or impossible to place a wind turbine at a given place. Students used Google Earth to learn more about the geology and ecology of the reservation. Students also searched the archeological sites on the reservation using Google Earth. They then integrated ideas developed from the placement MEA to decide on suitable sites for placement of wind turbines in the White Earth Reservation. Students also based their ideas on bird migration patterns and wind maps of the reservation.

Curriculum Implementation

The curriculum was implemented during the first two weeks of the second summer school of the RFTS program. 57 students received the curriculum. Students were grouped in four classes based on their grades (4th, 5th, 6th, and 7th/8th graders). There were four instructors (authors of the paper) who taught the different parts of the curriculum (building table-top wind turbines, anemometers, Google Earth, wind turbine placement). Thus, each

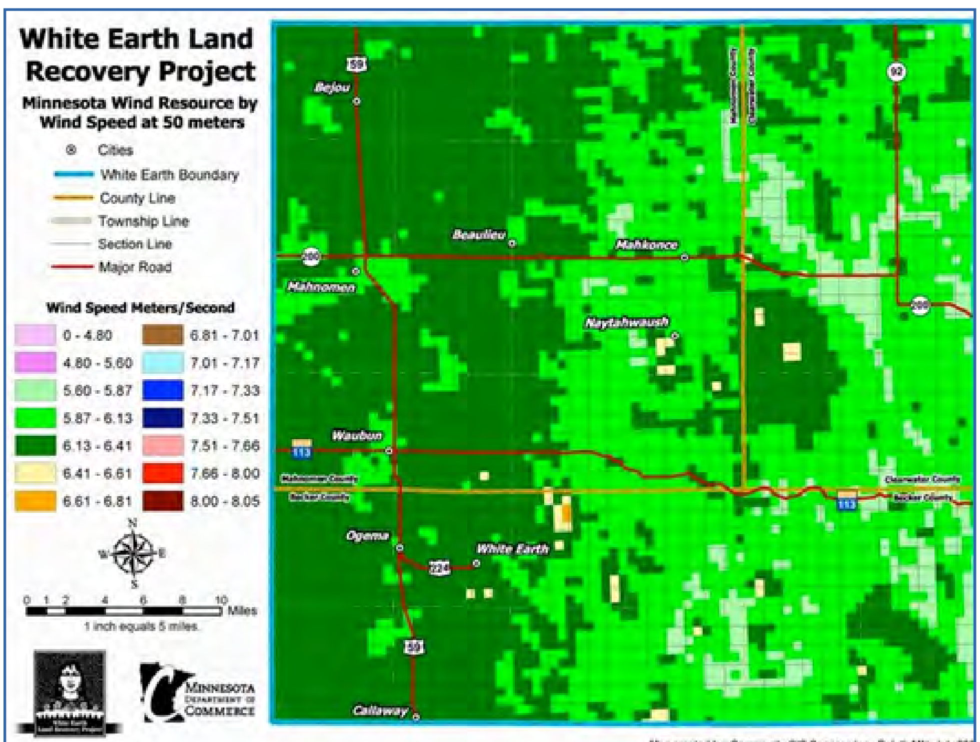

Figure 6. Wind map of White Earth Reservation

group of students rotated four classrooms each day. All the instructors used teaching strategies that allowed students to be actively involved in their learning. Since the curriculum design reflected situated learning, the activities included a combination of active learning and cooperative learning strategies, and links to their immediate environment. At the end of each day, the instructors reflected on their teaching and classroom activities. These informal discussions allowed them to make modifications on the next set activities if it was found necessary.

The Evaluation of the Curriculum

A quantitative study was designed to investigate the effectiveness of the curriculum on enhancing American Indian students' interest and understanding of wind energy concepts. As emphasized earlier, students' engineering notebooks and pre-and post content test scores were used as assessment tools.

The pre- and post-tests include open-ended questions in addition to multiple-choice items and fill in the blank questions. Thus, to score students' responses to open ended questions we first created a scoring rubric. Open-ended questions were scored in a three-point scale rubric (0, 1, 2). The fill in the blank questions and multiple-choice questions were scored as correct or incorrect (0 or 1). The rubric provided a more objective means of assessing student performance levels. To test the validity and reliability of the rubric, two researchers randomly chose two students' pre- and post- tests and scored the tests independently. When we compared the scores for each student, we found that the inter-rater reliability rate was 91%. Once we analyzed pre-and post test scores of 44 students (out of 57 students, 44 of them completed both the pre- and post-tests), it was found that the mean score for the pre-test was 27.4, and the mean score for the post-test was 43.3 out of a total of 100 (see Table 1). These results showed that students had a statistically significant higher mean score on the post-test compared with the pre-test. The paired t-test also showed a higher degree of students' understanding of wind energy concepts ($p<0.002$).

	N	*M*	*SD*	*t*	*df*	*p*
Pre	44	27.4318	11.35351	8.436	43	$<.002$
Post	44	43.3864	15.49226			

Table 1. Paired t-test Results

Type of entry	*Part I:* Building table-top wind turbines	*Part II:* Anemometers	*Part III:* Google Earth	*Part IV:* Wind Turbine Placement	*Part V:* Reflection	Percentage of entry %
1.Defining	2	2		6		10
2.Exemplifying		2				2
3.Applying concepts		4	6	6		16
4.Predicting/hypothesizing	12	8				20
5.Reporting results				2		2
6.Interpreting results and/or concluding		4				4
7.Reporting and interpreting results/concluding	6		6			12
8.Content questions/short answers		6				6
9.Reporting procedures				2		2
10.Reporting experiments	6	2				8
11.Designing experiments	6	2				8
12.Quick writes-reflections					10	10
13.Assessments						0
14.Do not care about the activity						0
						100

Table 2. The percentage of type of entry by students

Out of 57 engineering notebooks, we chose 16 of them to analyze. A specific strategy was followed to select and analyze the notebooks. There were four groups of students in the program (i.e., 4th, 5th, 6th, and 7th/8th graders). Each group had a similar number of students, and students in each group held similar academic abilities. Four students' notebooks in each group were selected based on the increase of the pre-post content test scores. From each group, four students, the two students with the highest percentage increase and the two students with the lowest percentage increase were selected. Each engineering notebook was scored following Ruiz-Primo, Li, and Shavelson's (2002) strategy to analyze the notebooks. Necessary modifications were made. For example, coding teacher feedback is a part of Ruiz-Primo et al.'s (2002) notebook analysis; however, since we did not provide any written feedback for the students, this unit of analysis was not a step of our procedure.

Before scoring the notebooks, we defined the type of student entries. Ruiz-Primo et al. (2002) defined 14 categories to code students' notebook entries. These codes were: defining, exemplifying, applying concepts, predicting/hypothesizing, reporting results, interpreting results/concluding, reporting and interpreting results/concluding, reporting procedures, reporting experiments, designing experiments, content questions/short answers, quick writes, assessments, and do not care about the activity. We found that, while the type of entries varied based on the parts of the curriculum, the types of entries most frequently found were designing and reporting experiments and content questions/short answers/quick writes (reflections). Table 2 shows the percentage of type of entry by students.
The percentage of type of entry by students

Each type of entry was also coded based on the characteristics of the entry (verbal- written/text, schematic-tables, list and graphs, or pictorial- drawings). Thus, each notebook was coded at two levels. We found that on average, while 37% of the entries had a supplemental graph or picture, 63% of the entries were verbal. All the schematic or pictorial entries were related to the content. In most cases, they were necessary for students to understand the content.

After finding the most frequent type of entries and the characteristics of the entries, we scored each entry of each student based on the quality of completeness, clarity, organization, and conceptual and procedural understanding (Ruiz-Primo et al., 2004). Completeness and clarity

Mean scores for understanding

	Student performance				
	Completeness	Clarity	Organization	Conceptual understanding	Procedural understanding
Mean ($\bar{X}$)	0.4	0.5	0.8	0.8	0.9

Note: Max mean for completeness and clarity is 1 while Max mean for organization, conceptual understanding, and procedural understanding is 2.

Table 3. Mean scores for understanding

were evaluated on a two point scale: 0 (No) and 1 (Yes). Organization was evaluated using a three-level score: 0- no organization, 1- minimal organization, and 2- strong organization. Conceptual and procedural understanding was evaluated on a four point scale: NA- not applicable (e.g., instructional task does not require any conceptual or procedural understanding), 0 - no understanding (e.g., completely incorrect examples or procedures), 1- partial understanding (e.g., partially accurate or incomplete relationships between concepts or descriptions of observations, 2- adequate understanding (e.g., appropriate, accurate, or complete descriptions of concepts or investigations), 3- advanced understanding (e.g., communication focuses on justifying responses, choices, procedures based on the concepts explores, or communication provides relevant data to formulate the interpretation).

To establish the inter-rater reliability, we first randomly chose a notebook and then individually scored it for completeness, clarity, organization, and conceptual and procedural understanding for each entry in that notebook. We compared our scores and found that the inter-rater reliability is 82%. Our disagreements were resolved through discussion. Then, the remaining notebooks were randomly assigned to each researcher to be scored. Table 3 shows the mean scores for completeness, clarity, organization, and students' understanding of the concepts for the sample notebooks that we scored.

The results of the analysis of the notebook entries demonstrated that the curriculum had positive impacts on the students. While it was found that the mean scores for completeness and clarity of the notebook entries were lower than the organization of the entries, the mean scores of conceptual and procedural understanding demonstrates that students understood the wind energy concepts that were presented in the program. One possible reason for low mean scores for completeness and clarity is that most students have low level of writing skills. We believe that these students would have provided higher-quality entries if they had had better writing skills. Also, most students indicated that they had not kept an engineering or science notebook before.

Conclusion and Implications

We found that American Indian students learn STEM content better when they actively engage in activities. All the activities in the curriculum that was discussed above were purposefully designed to allow students to engage in active learning. The implication of this finding is that hands-on activities and inquiry-based activities are very vital for this group of learners. Students also valued STEM learning that was active and engaged them in problem solving. Furthermore, the STEM activities that were tied to the culture or the needs of the community were highly valued. As previous research suggests connecting the concepts to students' culture and community is critical (Preston, 1991). Educators of American Indian students need to think carefully about how curriculum materials can be designed, implemented, and assessed.

Situated learning (Lave & Wegner, 1991) is becoming more prevalent with STEM educators. Because of the nature of the curriculum that we developed and implemented, we were able to tie much of the material to the students' immediate environment. The field trips they made to the Land Recovery Center at the reservation and the concepts of wind turbine placement were very relevant to their immediate environment and culture. Having built wind turbines and tested them in class, the concept of how the 'real' turbine worked was authentic. These findings support the previous research on American Indian students' learning, which indicates active, field-based, collaborative learning experiences work best for them (Pewewardy, 2002; Preston, 1991).

Keeping engineering notebooks was found to be helpful for American Indian students in learning STEM concepts. Using notebooks is an opportunity for teachers to engage students in inquiry activities that generate procedures and data worth keeping. Beyond engineering, teachers could use this to teach their students about the nature of science and practice of scientists.

However, documenting observations and experiments can be challenging for many students if they do not have previous experience with keeping engineering or science notebooks. The majority of the RFTS students did not use engineering notebooks before thus we provided for students a template for notebook organization. For example, for each notebook entry for inquiry activities, students were asked to write their research question and hypothesis, create a data table, and describe their explanations. Furthermore, we used writing prompts or frames (e.g., The variable that I will change ...) to assist students organize and structure their written responses. Providing such a structure helped students to reflect on their thinking and to state their understanding.

It is critical for teachers to guide their students in learning and maintaining the practice keeping notebooks to document their data and thinking about an investigation or activity. According to the grade level and needs of students teachers might select a different notebook structure or organization. From the assessment point of view, notebooks are very valuable tools for teachers to use as ongoing assessment tools to provide feedback for students and assess classroom instruction (Ruiz-Primo, Li, & Shavelson, 2004). In this study we used notebooks as a formative and summative assessment tools.

There is much agreement about the need to support American Indian students' STEM learning. Much is already known about the barriers and challenges regarding American Indian students' STEM education. More research needs to be conducted about what support and strategies should be developed to help American Indian students to be successful in STEM disciplines and develop interest in STEM majors/careers. Through the RFTS program and the research study that we conducted, we found that non-formal STEM education programs are critical in American Indian students' success in STEM disciplines since many of the students do not have adequate academic preparation in STEM fields (NCES, 2008). RFTS was specifically designed to meet American Indian students' needs and to encourage them to pursue an interest in STEM disciplines.

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S. Selcen Guzey is an Assistant Professor of Curriculum and Instruction and Biological Sciences at Purdue University. Her research and teaching interests focus on integrated STEM education.

James M. Nyachwaya is an Assistant Professor at North Dakota State University, with split appointments in the School of Education, and the Department of Chemistry and Biochemistry. He does research in Chemistry Education.

Tamara J. Moore, Ph.D., is an Associate Professor of Engineering Education at Purdue University. Dr. Moore's research is centered on the integration of STEM concepts in K-12 and postsecondary classrooms in order to help students make connections among the STEM disciplines and achieve deep understanding. Her work focuses on defining STEM integration and investigating its power for student learning. She is PI on EngrTEAMS: Engineering to Transform the Education of Analysis, Measurement, and Science an NSF Mathematics and Science Partnership grant that focuses on curriculum development and implementation of integrated STEM units in grades 4-8. She received a Presidential Early Career Award for Scientists and Engineers (PECASE) in 2012.

Gillian Roehrig is a Professor of STEM Education in the Department of Curriculum and Instruction at the University of Minnesota. She is Associate Director of the STEM Education Center where she is the PI of several large federal grants.