Engaging High School Girls in Native American Culturally Responsive STEAM Activities

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Providing Science, Technology, Engineering, Art and Math (STEAM) culturally responsive out-of-classroom activities is one way of promoting more interest in Science Technology, Engineering, and Mathematics (STEM) studies and careers among indigenous students. The purpose of the study was to explore the impact, if any, of STEAM culturally responsive activities, embedded with Dakota/Lakota values and traditions, in a partnership between a mainstream college of engineering and a population of high school girls at a Federal Native American boarding high school. Researchers engaged in a qualitative methods exploratory place-based case study in a technical action partnership with indigenous persons, a study rooted in the situational perspective of critical theory and Native voice from the position of discovery, a diverse epistemological stance. For a majority of participants, results showed a movement in attitudes from negative to positive for STEM studies as a result of "being part of STEAM Girls." Mathematics remains problematical, since post-survey results demonstrate that a majority reported liking to study Science, Technology, and Engineering (STE) and believed that careers in those fields could make a real difference in their communities, but less so for Mathematics. The finding of enthusiastic feelings towards Mathematics is a particular concern considering its central role in Engineering and the overall STEM cluster. Results indicated increased interest in STE studies and careers. This study demonstrates a link between culturally relevant activities and increasing interest in STEM studies and STE careers in this situation at this place. Results suggest that indigenous relevancy of activities matters, even if not tribally specific.

Keywords female; pre-college; motivation; case study; arts

Introduction

Native Americans are severely under-represented in STEM fields (National Academies of Sciences, Engineering, and Medicine, 2016), and there is increasing interest in improving diversity. To explore under-representation of Native American girls in STEM fields, the South Dakota Space Grant Consortium (SDSGC) and the National Science Foundation's (NSF's) Pre-engineering Education Collaborative (PEEC), partially funded a program that partnered Flandreau Indian School (FIS) with a large northern plains university's Civil and Environmental Engineering Department. The program was called STEAM Girls (Science, Technology, Engineering, Art, and Mathematics Girls). Recent research by Microsoft Philanthropies (2017), including over 11,000 participants across Europe, indicates that girls and young women become interested in STEM at ages 11-12 and rapidly lose interest at ages 14-15, and many never recover interest. They recommend women role models and hands-on activities relevant to girls' lives, among other remedies.

In order to generally increase student success, the tribal college movement has long espoused building renewed respect for Native American culture and pride in traditional Native values through culturally responsive teaching and learning according to Boyer (2016).

However, caution is necessary in applying a one-size- fits-all mentality to culturally responsive teaching and learning for any group of persons outside the majority culture. For example, sometimes American Indian/Alaska Natives (AIANs) are simply included with "minorities" or "under-represented" groups when categorizing people of color in research, since Native American numbers are often very small in many research samples. Thus, they are sometimes inappropriately included when reaching conclusions about under-represented groups. To further complicate the situation, there are hundreds of tribes, and each is unique. Overgeneralizing and stereotyping may result (Morgan, 2009). With those cautions firmly in mind, we offer the following.

Native Americans hold cultural traditions as beloved ways that can be powerful motivators for their students when combined with other aspects of culturally responsive teaching and learning. Cultural identity is often embedded in their indigenous ways of life and learning (Author, et al., 2015b). For example, Oglala Lakota College (OLC), a tribal college on the Pine Ridge Reservation in South Dakota, includes a statement about cultural values as part of their Vision Statement for their Math, Science and Technology (MST) Department: "To provide constructivist-learning activities in science, technology, pre-engineering, and mathematics while incorporating traditional Lakota values." Furthermore, in a Philosophy Statement; the MST Department at OLC declared that their cultural traditions matter.

> *The Lakota have always held their land base to be sacred. The land is something that must be protected and managed wisely and effectively. . . . The Lakota perspective is a vital component of our natural science and natural resources programs. All students enrolled in these programs are required to take specific courses that incorporate traditional Lakota concepts concerning language, land, plants and animals. (Oglala Lakota College, 2017, n. p.)*

Pewewardy and Hammer (2003) and Morgan (2009) generally recommend culturally responsive teaching and learning practices with many Native American students. Astronaut J. B. Herrington (2014), a Native American, laments in his Ph.D. dissertation, a NASA-themed project among Native American students on the Duck Valley Reservation, that in hindsight he recommends including cultural relevancy, after the manner of anthropologist Jack Weatherford (1988). Herrington offered the following advice after the project ended.

> *Present historically relevant examples of Native Americans as natural scientists and engineers. Each student in this study commented that they were not exposed to culturally relevant examples of Native Americans and how their ancestors developed and demonstrated scientific and engineering concepts without the use of Western science or technology*. (Herrington, 2014, pp. 158-159)

Activities with accompanying messaging that promote STEM careers, that involve caring for communities and improving quality of life, tend to attract many Native Americans regardless of gender (Author, et al., 2015a; Smith, et al., 2014) and such activities tend to attract females more than males in the general population (Colvin, et al., 2013). In working with Native American students in South Dakota, many researchers have consistently reported increased interest in STEM studies among Native American students when lessons and projects include Native

American traditions, cultural values, or role models (Author, et al., 2014ab; Editor, et al., 2014; Editor, et al., 2016; Editor, 2016; Editor, et al., 2016)

The following are examples of recent culturally responsive teaching and learning in engineering in South Dakota and North Dakota in an NSF-sponsored program designed to bring engineering to Native Americans and Native Hawaiians, the Pre-Engineering Education Collaborative (PEEC). In South Dakota, Oglala Lakota College (OLC) instructor Editor (2016, 48-50) reported that he employs hands-on experiential learning pedagogy in the Math, Science, and Technology Department (that includes pre-engineering) at OLC. Editor reported that his teaching is place-based, student-directed, and centered on improving the quality of life and cultural preservation for persons living on the Pine Ridge Reservation governed by the Oglala Lakota Sioux Tribe.

In reflecting on PEEC's efforts to bring engineering to Native Americans and Native Hawaiians, Editor and others (2016) concluded that,

> *[c]reating and implementing projects with indigenous roots helps to increase interest in STEM and generates cultural pride that may improve student persistence, and it helps in recruitment. PEEC projects rooted in indigeneity increase encouragement form the community, family, and Elders, who help to keep PEEC students moving forward to reach their goals. (Editor, et al., 2016, p. 63).*

At tribal colleges in North Dakota, Editor and others (2016, 37-38) reported PEEC student persistence and increased interest in STEM studies when pairing lessons prepared by Native American cultural/spiritual teachers with STEM instructional units taught by tribal high school teachers and North Dakota State University faculty, the latter mostly engineers.

Conversely, Zaretta Hammond reported the view that culturally responsive teaching and learning does not *have to* [emphasis, the authors'] involve "racial background" in lesson content. In explaining her position, Hammond noted the following.

> *One of the biggest misconceptions about culturally responsive teaching is thinking you have to tie the lesson's content to African American or Latino students' racial background. The common belief is if you mention Africa, Mexico, or famous black and brown high achievers, it will spark students' attention. Then they will be motivated to participate.*
>
> *In reality, culturally responsive teaching is less about using racial pride as a motivator and more about mimicking students' cultural learning styles and tools. These are the strategies their moms, dads, grandmas, and other community folks use to teach them life skills and basic concepts long before they come to school and during out-of-school time. (Hammond, 2015, n. p.)*

Hammond recommended making lessons more culturally responsive as follows: "Gamify it." "Make it social." "Storify it" (Hammond, 2015, n. p.).

Another perspective on culturally responsive teaching and learning, but through parents' child rearing practices, is based on research by Sociologist Annette Lareau (2011). She reported the possibility of greater understanding of life's chances for a child based on categorization into social classes. In her research, she found that a child's life chances and likelihood for school success are increased by parental child rearing practices that are rooted in, and responsive to, the cultural values of the American middle class. Quite simply, the American education system is deeply culturally biased in favor of the middle class and not in favor of other classes that are struggling in poverty.

Lareau contrasts the "cultural logic" (2011, p. 237) of two systems of child rearing based on social class with less emphasis on race in predicting who succeeds in school, who gains diplomas, and who does not. One constitutes the intensely adult-organized and sometimes exhausting child rearing practices of middle class culture that she labeled "concerted cultivation." The other system, more hands-off, characterized by the poor and working classes' culture, she labeled "natural growth" (Lareau, 2011, pp. 1-2). Results indicated that they did. Lareau's research helps to explain the commonalities, based on social class, among professionals, regardless of racial identity. Thus, her findings have important implications in working with many Native American students since a highly disproportionate share of them are from families in poverty. Holding a college degree often creates upward social class mobility and increased income for such a family, as well as impacting the parent's child rearing practices in the direction of middle class values.

College degree holders often possess important "social capital and cultural capital," terms by which Bourdieu (1984, p. 114) generally meant the total social linkages and cultural preferences accumulated during an individual's upbringing that provide him or her with access to even more social and cultural capital, with increasing potential for more economic capital.

As an applied example of the theories of Bourdieu and Lareau, the following is an example of a Native American student seeking more "social and cultural capital" in order to negotiate graduate school. Editor is a PEEC Co-Principal Investigator and faculty member at OLC and is a Native American, enrolled on Rosebud Reservation, working on Pine Ridge Reservation, and living in Rapid City (off-reservation). Editor (2016) reflected about his past and present experience as a college student and his experiences operating in an educational system based and built on middle class values, off-reservation while he attended South Dakota School of Mines and Technology (SDSMT) in undergraduate and graduate engineering programs in Rapid City. He noted that he and his Native American classmates at SDSMT were curious, since he reported that,

> *. . . most Native American students are first generation college students, and they did not grow up in an environment where such topics were discussed or even mentioned* (Editor, 2016, 72),

an environment characteristic of poor class rather than middle class childrearing practices. Some of the questions that Editor asked non-Native SDSMT students out of curiosity included the following: "When do you study and for how long? What does our homework look like? Do you study with others? Do you do homework with others? Do you study on weekends?" (Editor,

2016, p. 72-73). How then do we impart information about how "the system" works, when it seems so obvious to most others on campuses?

In order for persons outside the middle class to gain advantage in a middle-class based system, they need to know the rules, whether it is non-reservation culture, campus culture, academia culture, Science culture, Technology culture, Engineering culture, or Mathematics culture, and an endless list of other macro- and micro-cultures. In the pilot study conducted by Author and others (2015a), designed to determine why more Native Americans do not take up engineering in South Dakota, a Native American student participant remarked that he and others needed to know more about how "the system" works if he were ever to select engineering studies, as follows.

> *Give students more information about it and about the opportunities. I would get graduates, who have a job in engineering to come in and express their experiences, whether they are native or non-native . . . . Students could get every little detail from dorm life to academics, summers, and how to pay for it. Let students know that there are different ways to accomplish those things, but how they persevered, without race being a part of it.* (Author, et al., 2015a, p. 27)

Background

The current project was originated by some Pre-engineering Education Collaborative (PEEC) leaders in South Dakota who often found it difficult to recruit Native American students into the PEEC NSF-funded program, specifically designed to bring engineering to Native Americans and Native Hawaiians. Frustrated with recruiting problems, some PEEC leaders turned to their previously referenced "Why don't more" study (Author, et al., 2015a). One of the conclusions of that research was that interest in engineering needed to occur in the K-12 system, not after students arrived on college campuses, and another was that Mathematics is perceived as a barrier to engineering studies because of inadequate K-12 preparation, in agreement with reflections reported by Editor (2016). In surveying the resources available to the leaders of the current project, they decided to try one of the recommendations of the "Why don't more" study, by engaging in culturally relevant teaching and learning at the high school level, although they broadened the topic to STEM rather than only engineering in the hope of gaining more participation and more input about perceptions of Mathematics.

STEAM Girls Program

The current project was known as STEAM Girls (Science, Technology, Engineering, Art, and Math Girls) after the current STEAM movement that advocates combining STEM plus Art (Maeda, 2013; Bequette and Bequette, 2012). In this case, we emphasized Dakota/Lakota traditional arts and crafts, mostly focused on crafts.

We explored the research question of whether or not certain indigenous and culturally relevant experiential learning activities that combined STEM with Native arts and crafts might increase interest in STEM studies and careers among Native American high school girls. We also included bus trips to selected locations to help the STEAM Girls to build social and cultural

capital. The PI and Co-PIs were assisted by five Native American women students from a large northern plains university (two graduate students and three undergraduate students) and some of their relatives.

The group met monthly (Table 1) from noon to 4:00 pm from October 2015 to April 2016 at the FIS Tea Room with kitchen facilities and tables, or at grassy shaded areas on the FIS campus, or during a bus trips. We took a bus trip and tour of the Center for Earth Resources Observation and Science (EROS), a United States Geological Survey (USGS) facility near Baltic, SD; and three bus trips and tours to STEM and Art facilities at a large northern plains university. Flandreau Indian School administrators and their science teacher selected dates and meeting times.

The two most dominant themes for activities at the FIS campus included Native plants, and glass making because of the central importance of Native fruits and glass beads in traditional Native American life in South Dakota, and because key project leaders had expertise in those topics. We identified characteristics of traditionally used Native fruits and plants, made and ate tribal foods, collected Native plants and prepared herbarium-style plant vouchers, established a Flandreau Indian School (FIS) herbarium, and related the plant activities to NASA's Visible Earth website and plant groundcover from space. We made wild rose petal perfume. On Earth Day, STEAM Girls, project leaders, FIS employees, and volunteers planted over 100 traditional Native plants on the FIS campus as a resource for their herbarium, with each STEAM Girl tagging a plant with her name to personalize the experience and create a legacy experience (Fig. 1).

Within the glass making theme, we explored glass manufacturing techniques, considered liquid glass-like properties in sugar-based candy through hands-on work, analyzed glass beads and historic beadwork designs, and introduced a system of laying out beadwork patterns using a spreadsheet (Fig. 2). We made traditional Lakota/Dakota glass beadwork and porcupine quillwork using brain-tanned hides, rawhide, sinew, Giant Canada Goose feathers, ermine pelts, box turtle shells, horse hair, and many other authentic materials (Fig. 3).

At project's end, project leaders produced a booklet, available at a large northern plains university's on-line repository, of some STEAM Girls activities (Author, et al., 2016b), particularly Dakota/Lakota plant recipes for traditional foods, as well as warnings about cyanogenic glycoside toxicity in some plants. The booklet also includes instructions for assembling a small still for plant based perfume making. As a separate product, project leaders prepared eight pages of patterns and instructions for authentic, traditional Dakota/Lakota beadwork and quillwork and distributed those to the STEAM Girls, some of whom had little prior experience in such activities.

Table 1. Summaries of STEAM Girls Meetings.

1. October 28, 2015; 1-5 pm We collected completed pre-surveys. We explained the purpose of the STEAM Girl program: Do certain activities increase interest in STEM studies and careers? We explained that the activities would be relevant to indigenous cultures, particularly Lakota/Dakota. We explained

that the first STEM practitioners in this hemisphere were Native Americans who operated through trial and error and through centuries of intimate knowledge of their ecosystems. At FIS, we introduced the newly proposed herbarium and its purpose, along with its metal cabinet and supplies, and we made plant vouchers from local Native plants that project leaders had collected in summer and fall when the plants were in bloom or had set fruit. We made fry bread and served it with wild plum jelly. We explored and identified Native trees and shrubs on the periphery of this heavily wooded FIS campus that includes a small wetlands, where we encountered a dozen wild turkeys.

2. November 18, 2015; 1-5 pm
At FIS, we continued to develop the school's herbarium, cooked bison and Giant Canada Goose with *wasna* (Native fruit pudding) including chokecherry sauce, and we served traditional foods with Native plant fruits (plums, rosehips, wild grapes, and elderberries). We planted wild rose roots and seeds from wild plums, elderberries, rosehips, and wild grapes. We collected milkweeds and cattails on the FIS campus and painted dried milkweed stems and pods to make bouquets. We released wind-born seeds from existing cattails at FIS. We assembled traditional Dakota/Lakota recipes using native fruits and other plant parts, and we began assembling a booklet of some of our activities that we planned to distribute at project's end.

3. December 2, 2105; 1-5 pm
We took a bus trip to a large northern plains university. The first event was a traditional meal of bison, fry bread, and Native plant jellies, and *wasna* (plum pudding) with help from two of the interns' mother and grandmother at a campus Native American center. Native American students from a large northern plains university attended the meal and each talked about their life experiences on campus and answered questions from the STEAM Girls. We visited a campus museum at a large northern plains university where the campus herbarium curator explained the purpose and importance of herbaria and why Native plant study is important. We toured the campus herbarium with the curator who emphasized Native plants and their vouchers. We toured the campus art museum, where guides emphasized a Native American art exhibit.

4. December 9, 2015; 1-5 pm
At FIS, we showed a rare green turtle PowerPoint illustrating a project at Oglala Lakota College (OLC), Pine Ridge Reservation, and we explained how OLC students and faculty are working to conserve turtle habitat. We examined common box turtle shells and made them available to the girls to make traditional dance rattles. We discussed the upcoming visit to EROS that would feature ground cover imagery from space. We presented a history of the glass trade bead and beaded floral versus geometric designs among the Dakota/Lakota. We explained how beadwork designs could be created in a spreadsheet (Fig. 1). We distributed beadwork patterns and individual kits, and we began the art/craft projects.

5. January 27, 2016; 1-5 pm
We took second bus trip to a large northern plains university. On the large northern plains university campus, an engineering professor provided a hands-on lesson comparing some properties of liquid glass and bead manufacturing to sugar syrup in candy making. We toured the athletic complex and their score board, emphasizing that the athletic score board company

founders were professors from the large northern plains university's College of Engineering. We again toured the campus history museum where some of the STEAM Girls had asked to spend more time since their earlier visit was brief.

6. February 17, 2016; 1-5 pm
We took a third bus trip to a large northern plains university headed by the project's Native American women student interns. The College of Nursing provided a welcoming meal during our tour and activities. The large northern plains university's dairy plant provided ice cream while we toured their manufacturing facility.

7. February 24, 2016; 1-5 pm
At FIS, we continued working on beadwork and porcupine quillwork arts and crafts projects. We presented a short PowerPoint, Road Ditch Flowers from Pine Ridge Reservation, providing common names for each plant. The girls selected the species of trees, bushes, and other Native plants that we later ordered from the local county Conservation District to refurbish the FIS landscape on Earth Day in April and to provide a resource for the new herbarium at FIS.

8. March 9, 2016; 1-5 pm
We took a bus trip to EROS, with guides emphasizing ground cover plant imagery from space. The EROS guides explained what types of college degrees are necessary to work there. We distributed booklets and posters about regional plant identification so that each girl owned personal guides in order to continue to learn field identification of plants.

9 March 30, 2016; 1-5 pm
At FIS, we completed arts and crafts beadwork/quillwork projects. We produced more plant vouchers and assessed what is already in the FIS herbarium and how to continue in the future. We posted information at FIS to use to promote the Earth Day planting event as a way of inviting more FIS students, staff, and volunteers to help.

10. April 22, 2016 1-5 pm
At FIS, we conducted an Earth Day event where the STEAM Girls installed native shrubs, trees, and other plants. We planted 100 native plants alongside an existing shelterbelt on the FIS campus to refurbish this selected area to serve the herbarium in the future. We shared fry bread and native plant jelly. The STEAM Girls completed post-surveys and participated in a post-focus group.

Figure 1. At the FIS campus, STEAM Girls, along with SDSU project leaders and FIS staff installed Native plants that remain important within Dakota/Lakota culture. The plants will provide a resource for the new FIS herbarium, as well as fruit for making traditional foods. Each STEAM Girl tagged a plant with her name as a legacy experience. The most favored plants were chokecherries and plums.

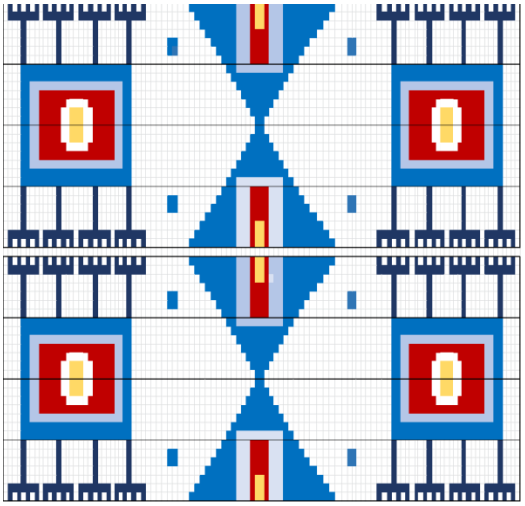

Figure 2. This is a traditional Dakota/Lakota lazystitch beadwork design created in a spreadsheet by reducing rectangular cells to squares and selecting colors. It is an example of

creating interest in learning to use spreadsheets through culturally responsive teaching. Historically, such designs were borrowed from wool Caucasus rugs brought to the area by white settlers in the 1870s and 1880s.

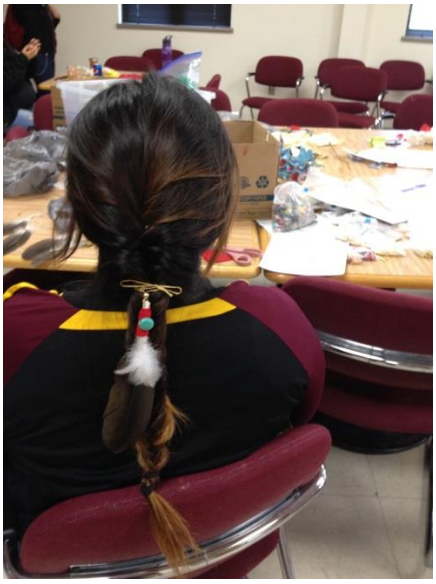

Figure 3. This Giant Canada goose feather hair ornament was made by one of the STEAM Girls. They also produced wing feather dance fans, turtle shell dance rattles, and strike-a-light bags made from brain-tanned hides. Handling traditional Native arts and crafts materials increased their STEM connections by creating awareness that Native Americans were the first STEM practitioners in their homelands.

Purpose

The purpose of the project was to explore the research question of whether or not certain culturally relevant experiential learning activities combining Native arts and crafts with STEM, could potentially increase interest in STEM studies and careers among high school girls at Flandreau Indian School (FIS). Through this exploratory case study, as the term was used by Case and Light (2011, p. 191-192), we gathered and reported student responses after engaging in those activities. There was no particular intent to teach standards or theoretical concepts within STEM fields. To do so would put the cart before the horse. Research by Author and others (2015a) found that first there must be interest in such fields or most Native American students would not select STEM majors, as is currently the case.

Methodology and Theoretical Orientations

Project leaders selected Dakota/Lakota-related culturally responsive activities with which they were familiar and had expertise Participating SDSU faculty, professional staff, student helpers, and volunteer helpers mirrored the ethnic diversity of the STEAM Girls school population, a strategy reported as successful in promoting STEM among other non-majority student populations (Kendricks, et al., 2013). The depth and breadth of the activities was increased or

decreased based on the ebb and flow of the interest levels of the participating FIS high school girl students and the project's Native American interns, from a large northern plains university, and their relatives, who were volunteer helpers. Thereby, we increased "Native voice" (Editor, et al., 2016, p. 21) in appealing to "technical action" research methodology as the term is used by Case and Light (2011, p. 197, after Carr and Kemmis, 1986).

The methodology and theoretical foundations for the research generally follow the terminology as defined by Case and Light (2011), Crotty (1998), Koro-Ljungberg and Douglas (2008), and Lincoln and Guba (1985), and Cousin, 2009. The resulting scaffolding (Fig. 1), helps to expose and to clarify the selection of techniques, method, methodology, theoretical perspectives, and epistemological stance for the research, all having their implicit biases, strengths, and weaknesses.

The tools or techniques used to gather evaluation data included a post-survey and a post-focus group of students. Within the post-survey, items 1-8 were questions requiring responses from 1-5 on a Likert scale from which we extracted majority and non-majority opinions. The post-survey also included open-ended statements 9-16 requiring written replies. An after-project focus group included discussion statements requiring one-sentence responses about attitudes towards the project activities, as well as attitudes towards STEM studies and careers, with notes recorded by the project director and SDSU student interns. We then conducted thematic analysis of the data for statements 9-16 and the focus group.

The method was qualitative. The methodology was case study with aspects of technical action research (Case & Light, 2011). The theoretical perspective included aspects of Paulo Friere's (1970 and 1976) critical pedagogy movement and liberation theology, particularly his books *Pedagogy of the Oppressed* and *Education as the Practice of Freedom*. Freire espouses cooperation and unity among oppressed, colonized populations in order to free themselves through education using their own local solutions.

Detractors sometimes refer to studies such as ours as "deficit-based" (Harper, 2010), where researchers are charged with treating participants as though there were something missing from the group studied, and that whatever is missing needs to be added in order for participants to succeed. Deficit-based studies are criticized for ignoring or failing to adequately acknowledge the realities of institutional barriers as major impediments to the educational success of under-represented minorities. We acknowledge a primary institutional barrier in this study: that the American education system is based on middle-class values, but changing that system is beyond the scope of this study. Through Native voice, we examine how the oppressed may participate in their own liberation, through self-empowerment and local educational solutions: culturally relevant teaching and learning. There is, indeed, something missing that might be added to increase school success: Freire called it a "pedagogy of the oppressed."

Other theoretical perspectives that underpin the research included Paul Bourdieu's (1984) Annette Lareau's (2011) Sociological theories that shed light on the process by which persons acquire "social capital and cultural capital," preferences and linkages that may increase, for example, success in gaining educational credentials, enabling an increase in personal economic capital and an increase in upward social mobility. An example of such social and cultural capital theory research aimed at improving educational outcomes of under-represented minorities, although not Native Americans, includes a study by Ovink and Veazey (2011).

The relevant "situational perspective" (seeking to understand a particular situation) was "critical theory," that is often inductive and dialectical in reasoning (as the terms are used by Koro-Ljungberg & Douglas, 2008). "Critical theory" as defined by Case and Light (2011, 189; after Koro-Ljungberg & Douglas, 2008) "is explicitly directed towards critique of social inequities and power relationships with the ultimate goal of facilitating social change." Aspects of critical theory that inform the research include "critical pedagogy of place" as it relates to place-based and land-based pedagogies where curricula do not often integrate alternative world-views as compared to Westernized views (Tuck, et al., 2014), in this particular case we focused on indigenous populations' views through Native voice.

The epistemological (philosophy of knowledge or theory of knowing) basis of the research is *a posteriori* knowledge, gained through experience from a position of discovery and exploration. Thereby, the researcher does not seek statistical generalizability drawn from the data, but rather, the validity of a study may be relevant to the research of others or only generalizable within the research study, itself (Lincoln & Guba, 1985).

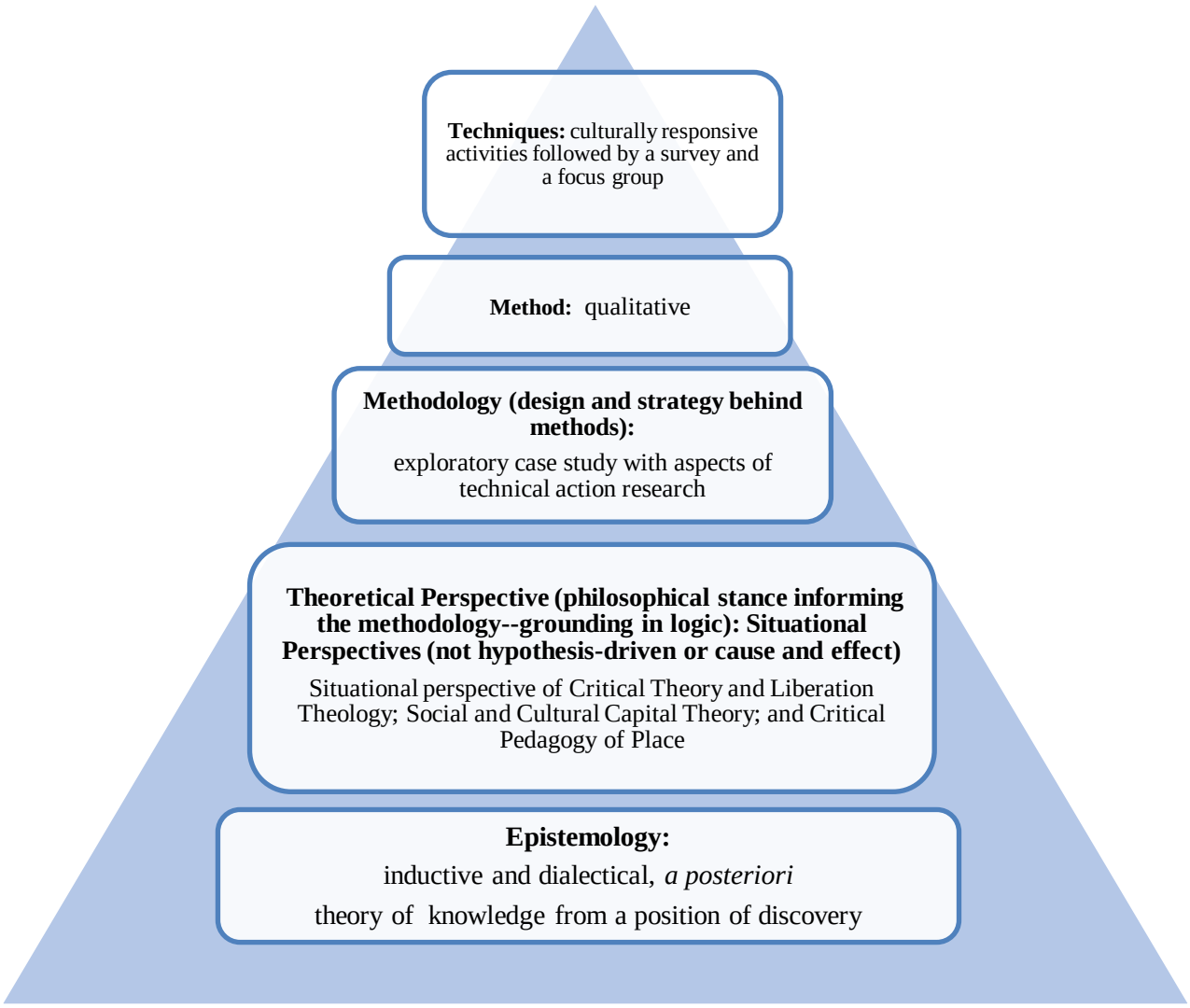

Figure 1. Research design scaffolding for the study (terminology after Case & Light, 2011; Crotty, 1998; Koro-Ljungberg & Douglas, 2008; Lincoln & Guba, 1985; and Cousin, 2009).

Data Collection

We had originally planned to work with an identical cohort of 30 high school girls (grades 9 through 12), selected by Flandreau Indian School (FIS) at each monthly meeting from October 2015 through April 2016, as explained in the Limitations of the Study Section of this paper. As it turned out, we were not able to work with the identical cohort of girls at each meeting. There was, however, a core group of about 10 girls who usually attended, although an average meeting included about 20 girls. Of the 10 STEAM Girls' monthly meetings, the 17 girls who participated in the post-survey at the final meeting reported that the number of meetings they attended ranged from 2 to 10 with a mean of 6, a median of 6, and a mode of 5.

Post-survey

Project staff from a large northern plains university and their student interns administered a post-survey to 17 FIS STEAM Girl participants at the last project meeting on April 22, 2016, Earth Day. They were asked to rank statements on a Likert scale for items 1-8 of the post-survey (Table 2) that focused on their like or dislike of STEM studies and their perceived value or lack of value in their earning STEM degrees that could help their communities. We included the statement about the perceived helpfulness to their communities, since research by Smith and others (2014) and by Author and others (2015a) indicates that it is of primary importance as a motivator for many Native American students. Since participation was voluntary, only 13 of the 17 participants completed items 9 through 16 of the post-survey (Table 3) that included open ended statements about STEM, in an "I used to think, but now I think" format to elicit responses.

Table 2. Post-survey questions included these that asked for Likert scale ratings 1 (strongly disagree) to 5 (strongly agree) responses.

1. I like to study subjects involving science.
2. I think that I could make a real difference in my home community if I majored in science in college and earned a degree.
3. I like to study subjects involving technology.
4. I think that I could make a real difference in my home community if I majored in technology in college and earned a degree.
5. I like to study subjects involving engineering.
6. I think that I could make a real difference in my home community if I majored in engineering in college and earned a degree.
7. I like to study subjects involving mathematics.
8. I think that I could make a real difference in my home community if I majored in mathematics in college and earned a degree.

Table 3. Post-survey open-ended statements included these in order to elicit short written responses.

9. Before being part of STEAM Girls, I used to think that science was . . . .
10. Now I think that science is . . . .
11. Before being part of STEAM Girls, I used to think that technology was . . . .
12. Now I think that technology is . . . .

13. Before being part of STEAM Girls, I used to think that engineering was . . . .

14. Now I think that engineering is . . . .

15. Before being part of STEAM Girls, I used to think that mathematics was . . . .

16. Now I think that mathematics is . . . .

Post-focus group

At the same final STEAM Girls meeting at FIS, after a few hours of planting bushes and trees that are traditionally important in Dakota/Lakota culture, 12 STEAM Girls had a picnic on blankets in the shade. While eating home-made fry bread with plum jelly, 7 of them voluntarily participated in a post-focus group led and documented through notetaking by staff from a large northern plains university and Native American graduate and undergraduate students with the following questions as prompts.

1. What did you think of the STEAM Girls activities?
2. What activities should we increase?
3. What were your favorite parts of the STEAM activities?

Findings and Analysis

Post-survey (Table 2)

For post-survey questions 1-8 in Table 2, the majority of participants (n=17) responded in the case of Science, Technology, and Engineering (STE), that they agreed or strongly agreed that they liked to study each of those subjects and that they thought they could make a real difference in their home communities with a college degree in any of the STE fields. In contrast, less than a majority reported those attitudes towards Mathematics. Such results confirm some other reports of Native American students' opinions about Mathematics (Author, et al., 2015a; Editor, 2016; Editor, et al., 2016), indicating that Mathematics is seen as a barrier to engineering studies, partly due to inadequate preparation for college-level Mathematics in K-12 in tribal schools. Even though survey participants indicated favorable attitudes towards STE studies and indicated that they believed that they could make a difference for their communities with a degree in STE fields, there is lack of understanding of the key role that Mathematics plays in gaining STE knowledge and credentials.

Post-survey (Table 3)

For post-survey questions 9-16 in Table 3, only 13 (n=13) of 17 girls responded, since participation was voluntary. Questions were open-ended beginning with the phrase, "Before being part of STEAM Girls, I used to think; now I think . . ." for the four individual disciplines within STEM. More than half of respondents reported a change in attitude from previously negative to now positive for Science (8 of 13), Technology (8 if 13), Engineering (7 of 13), and Mathematics (8 of 13). None reported a movement in attitude to a view that was more negative

for each STEM discipline than previously. Specifically, 61.5 per cent attributed a change in attitude for all four individual STEM disciplines from negative to positive based on participating in STEAM Girls activities.

Post-focus group

Seven (n=7) STEAM Girls noted what they liked, what should be increased, and how they felt about the program in an after project focus group. Major themes included the following. Respondents indicated a high degree of overall interest in the activities, particularly those that related to tribal culture and hands-on learning; expressed a desire for more contact with SDSU and more activities in the future; and indicated increased interest in STEM studies and careers.

The following statements, example of Native voice, were collected by staff from a large northern plains university and interns who compared notes and reached consensus after the focus group. They divided STEAM Girl responses into the following themes achieved through color coding: interesting, cultural pride, engagement with a large northern plains university, STEM studies and careers, and hope that activities can continue.

Interesting

- I thought the STEAM Girls activities were interesting.
- They were different from anything I have ever done before.
- I liked that each lesson was different each time
- I liked it when we spread those [traditional] seeds out.
- I like it when we painted the dry milkweed pods as dried flowers.
- I liked what we did today [planting traditional bushes and trees] a lot. It is something I have always wanted to do.

Cultural pride

- I would look at the plants that we used to eat back then and plant more of them.
- Some of my favorite parts included the cooking, and making food was fun. It is more cool to make traditional foods, but it was fun just to learn to do stuff.
- I liked cooking traditional foods, jelly and *wojapi* [a fruit pudding].
- It would be cool to learn about other cultures, like where other people came from. My best friend is Apache, and I did not know anything about how sacred pollen is for them.
- The beadwork lessons were interesting. It is really cool to find out how other tribes do things.
- We would rather plant the kinds of plants we grew up around. In my area, that would be chokecherry trees and plum trees. It is important.
- We loved learning about what the students from a large northern plains university were learning about at the traditional dinner at the large northern plains university.
- It would be cool to have someone who teaches American Indian Studies to tell us more about what Native Americans used to plant and things like that – someone like Dr. Anonymous from the university herbarium.

- It would be cool to show student success stories from Native American students who majored in STEM.
- I plan on loving my job and not dreading it. When I am older, I want to do something I love doing.
- I think it would be helpful to major in STEM and then I could go and do STEAM Girl stuff like this to help explain these things to other people to help the profession.
- Engineers build stuff like architects do.
- My grandpa used to make the blueprints of our roads, and he shaped how they are now.
- There are engineers right now trying to put a pipeline through my rez [reservation].
- Going to the Native American center helped because we learned from people who are experiencing campus life and have knowledge about it.
- Grandmas know a lot, and they can teach you, if they want to.
- This women's society idea would be really cool, especially hearing what the elders (*uncis*, grandmothers in Lakota) have to say. That would get a lot more girls involved, too. Having even more staff would be cool, too.

SDSU engagement

- The ice cream manufacturing tour [at a large northern plains university] was pretty cool. We had a walking tour there. We explored what they do, and they told us some of the students were creating their own flavors.
- I liked going to a large northern plains university and meeting all of the other students. You guys are cool.
- We should have more students at a large northern plains university get involved. We had two or three students, but they could not always make it. It is still cool because we got to learn about their experiences.
- I liked visiting the College of Nursing at the large northern plains university and putting needles in fake arms as the activity there.
- Bring more interns from a large northern plains university so we can hear more student stories.

STEM studies and careers

- I liked it when we went to the athletic field and learned more about the scoreboard and engineering [at a large northern plains university].
- Those engineering lessons with Dr. Author were really cool. I never knew that candy was made like that.
- I live right next to a river, and it is going to make me think a lot about the plants and how we can learn more about them.
- I was interested in STEM before, but these lessons reinforce my idea.
- I really liked the STEM activities, and I was not thinking of STEM at all, before.
- Taking a class for science now, this has helped reinforce the STEM stuff.
- Back at home, all of our plants look different to me now. Even our sage does not look the same.
- I think [that majoring] in natural resources would be really cool.

Hope that activities can continue

- I hope this will be here next year.
- I was exposed to a lot of things in this program, but there was not enough time to learn it.
- We should do more trips, like the one to EROS, and more exploration of other programs.
- And we should avoid basketball season
- We should meet more often, twice a month, during our science classes.
- We could do a field trip on a Saturday or Sunday.
- I hope we can do more of this next year. Are you coming back then?

Discussion

Overall, there is scant literature on culturally responsive teaching and learning activities to increase STEM interest among Native Americans, especially studies limited to girls. In our study, we found that such an approach is worthwhile, in agreement with recommendations by the overall tribal college movement and Editor (2016), the Oglala Lakota College MST Department, Pewewardy and Hammer (2003), Morgan (2009), Herrington (2014), Weatherford (1988), Author, et al. (2015a), Author, et al., (2014), Editor (2016), and others.

Our study indicates that culturally responsive (Dakota/Lakota) STEAM activities increased interest in STEM studies and careers in this situation among high school girls at FIS, a Federal Native American boarding school, although STE were viewed more positively than Mathematics. Results indicated that women role models and hands-on culturally-focused teaching and learning help to increase STEM interest, particularly important within the age group of high school girls, since Microsoft Philanthropies (2017) research reported that interest in STEM tends to decrease in European girls at ages 14-15 and may not change in later years.

We found that culturally responsive, indigenous, teaching and learning activities were important motivators, even among FIS girls whose tribes were at opposite ends of the United States; indigeneity mattered. While Hammond (2015) reported that culturally responsive teaching and learning does not have to include "racial background" in lesson content, our study found that it helps.

With the intention of increasing "cultural capital" and "social capital," based on insights from Bourdieu (1984) and Lareau (2011), one of the purposes of the bus trips for the STEAM Girls was to allow them to ask questions about how "the system" works. The four bus trips were not meant to result in the participants' suddenly catching up with middle class students who had a head start, but, rather, providing a glimpse into how they could make the system work for them. The bus trips allowed STEAM Girls to see that others, with whom they might identify, e.g. SDSU Native American student interns, successfully making the system work for them at a large northern plains university. The bus trips helped the STEAM Girls to understand what it takes to go to college, and the credentials it takes to work as professionals conducting activities such as those that they observed at EROS. The STEAM Girls asked numerous questions of interns from a large northern plains university and tour guides throughout the trips, as they increased their "cultural and social capital": Where do I live on campus; how much does it cost; how do I get the

money to pay for college, how much would I need to study; how long do students attend; what are the different types of degrees; which classes do I take; how do I select a major; and what kinds of jobs are available after college; where would I live after college; how much money would I make after college; and could I get a job on a reservation after college since unemployment is high there?

Limitations of the Study

The original plan was to meet with the same group of 30 interested girls as a cohort selected by FIS. While it was beyond the control of STEAM Girls project leaders, we worked with a different group of FIS high school girls at each meeting, ranging from 11 to 25 participants with an average attendance of 20 for all of the 10 monthly STEAM Girls meetings, although a core group of the same girls formed the majority at each meeting. We, thereby, modified the project in the interests of technical action research which includes doing projects with rather than to participants (Cousin, 2009, p. 151) and in the interests of Native voice. There is so little research on culturally responsive STEAM teaching and learning among Native American high school girls, that project leaders gratefully accepted the FIS operational rules, including in-depth Federal background checks for project leaders and student interns from the large northern plains university who requested admittance to the FIS campus.

Furthermore, the original plan had been to include a pre-survey in order to have a comparison group before we conducted STEAM Girls activities, but that plan was abandoned for reasons that follow. A non-voluntary pre-survey was administered to 36 FIS students by an FIS employee, and thus the leadership team from a large northern plains university eliminated the pre-surveys from the study as per the University's IRB protocol in keeping with our written statements distributed to participating students and to FIS administration that they did not have to engage in any activities at any time without penalty.

It is likely that the focus group of STEAM Girls respondents were too polite to be critical of the activities in such a face to face, non-anonymous setting. The STEAM Girls indicated often that they wanted Native American women students from a large northern plains university to return to FIS and continue the activities, and they were likely reluctant to be critical in order to keep the project going. We extracted and analyzed data without full access to participant information such as tribal affiliation and other circumstances because of their status as under-age in a marginalized and vulnerable population. While parents, or school officials acting in the role of parents, provided written permissions or refusals for participation, activities and photos, the STEAM Girls students signed assent forms and voluntarily participated without penalty for discontinuing at any time for any reason without penalty.

Our activities favored Science and Engineering with less Technology and Mathematics, although leaders emphasized the interdependency of STEM throughout. Those project leaders with the most time to devote to the project have Ph.D. backgrounds in Science (and post-doctorate in Engineering Education) or Engineering along with unique expertise in Dakota/Lakota arts, crafts, and cultural traditions. A third project leader has a Ph.D. in Anthropology and is an enrolled tribal member in South Dakota with life-long experience in Native American culture in South Dakota. In responding to surveys and the focus group, STEAM Girls may not have been aware

of technical distinctions between Science, Technology, Engineering, or Mathematics disciplines. Since this is exploratory research, we do not claim its generalizability, although we recommend testing it at other places. The National Center for Educational Statistics (2008) cautions researchers about over-generalizing in studies concerning Native Americans with small samples and self-identified racial or ethnic affiliations. Our exploratory research involves complex relationships with many alternative variables that are not examined.

Conclusions, Implications, and Future Work

Results indicated that culturally relevant and responsive STEM teaching and learning combined with Native arts and crafts, increased interest in STEM studies and careers for Native American high school girls in this situation at this place, although Mathematics remains somewhat problematical. We found that women role models and hands-on learning also increased interest in STEM, especially when the women role models were Native American college students. Our results indicate that small steps in the journey to bring equitable representation in STEM to Native American girls, may be to (1) first create interest, especially in the population of high school girls through tribal culturally responsive teaching and learning; (2) generally increase their cultural and social capital through visits to STEAM resources such as universities, science centers, arts and crafts centers, and museums; (3) include Native voice so that activities are done with Native Americans, not to them; and (4) provide consistent culturally responsive teaching and learning exposure, rather than one-time projects such as ours.

The long-standing problem of under-representation of Native Americans in STEM careers requires more exploratory research aimed at discovery in order to reach a point of testing in-depth hypotheses and forming in-depth research questions after the manner of Smith and others (2014). However, each piece of the exploratory and discovery process, such as the current study, adds to the puzzle in order to bring into focus, successful practices in bringing STEM education to Native American girls at particular places. We further recommend that champions of STEAM integrate this culturally responsive teaching and learning approach into other tribally-related schools as after-school activities to discover the impact on STEM interest, if any, in those places.

We recommend future research into ways to improve Mathematics preparation in grades K-12 on and near reservations. Such future research should also include exploring our confirmation of findings that Mathematics is not viewed as positively as Science, Technology, and Engineering (STE), and that Mathematics is not perceived as being as likely as STE to "make a real difference in students' home communities if students majored in Mathematics in college and earned a degree," especially in light of the centrality of Mathematics to the STEM complex.

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