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Mentored Research in a Tribal College Setting: The Northern Cheyenne Case

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The current study, which focuses on mentored research experiences of freshmen and sophomores at the tribal college of the Northern Cheyenne Nation, responds to the call by Ovink and Veazey (2011) for additional study of effective strategies for providing both mentoring and research experiences for minority undergraduates. We use qualitative data—interviews and observations—to explore the meanings rural tribal college students give to their mentored research experiences and the impact on their academic plans. Findings show that effective mentors develop trust and support for student learning and their personal goals. The data also suggest that successful mentoring strategies facilitate learning by doing and relating to the student's worldview and context. Additionally, non-native instructors who engage in authentic, caring interactions with students can successfully mentor native students in a supportive tribal college context. Tribal college students indicate that, similar to many American Indian university students, they want to return to their reservation communities following completion of college. However, tribal college students bring these interests into their academic plans as freshmen and sophomores. We conclude that appropriate mentoring relationships and relevant research experiences empower tribal college students to pursue their academic goals both in and outside their community as well as prepare to return.

Introduction

Mentored research is the centerpiece of an approach to minority student retention and completion in science. While some may question the usefulness of undergraduate research experiences, this approach finds support in recent studies concerned with effective strategies for promoting minority college student retention and completion (Jones, Barlow & Villarejo, 2010). What sets the research presented here apart, however, is its focus on mentored research for rural freshman and sophomore students attending Chief Dull Knife College (CDKC), the tribal college of the Northern Cheyenne Nation in southeastern Montana.[1] This research responds to the call by Ovink and Veazey (2011) for additional study of effective strategies for providing both mentoring and research experiences for minority undergraduate students. According to Kim (2011), American Indian

This paper is dedicated to the memory of Robert Madsen, Science Instructor and mentor at Chief Dull Knife College.

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[1] The Northern Cheyenne Nation is one of Montana's seven reservations that are home to thirteen tribes whose land area is larger than the state of Maryland. These reservations each have their own tribal college (about 20% of the nation's total) whose missions include providing postsecondary education for students who have low rates of high school completion and college enrollment; only 17% attend college (versus 62% overall). Even fewer pursue graduate studies. In STEM fields they make up less than 1% of graduate students (University of Montana Bridges program information).

undergraduate enrollment in higher education increased by about 30% between fall 1998 and fall 2008. However, degree completion among American Indians ages 25-29 was 17% compared to 22% among the next age group, 30 and older. Overall enrollment among American Indians was the lowest (23%) for all racial and ethnic groups in 2009.

Much of the research on retention of minority students, especially in science, technology, engineering and math (STEM) fields, includes few American Indian students (or only those attending mainstream colleges and universities). Therefore, the relevance of retention approaches identified in other minority STEM programs (cf. Jones, et al., 2004), such as supplemental instruction, mentoring and research experience, is unclear in its relevance for students attending rural, tribal colleges. An assessment of a project funded by the Tribal Colleges and Universities Program (TCUP) of the National Science Foundation at CDKC, however, provides an opportunity to examine the effectiveness of two central elements identified by Ovink and Veazey (2011), mentoring and undergraduate research, among tribal college student participants from 2007-12. The specific research questions include the following: What meanings did rural tribal college students give to their experiences with mentored research? What effects did these experiences have on student attitudes and feelings (e.g., anxiety and confidence) toward learning science, future plans, and their identity as students? What mentoring strategies contributed to the student experiences and their impacts? Can non-natives successfully mentor native students? And finally, what are the key elements of the rural tribal college context that support student retention in STEM?

While prior research (Hermes, 2005) involving the teaching strategies of non-native instructors in American Indian secondary schools suggests that non-native teachers can be effective in teaching native students, their role in rural tribal colleges has not been examined. Of particular interest in this study is the effectiveness of non-native tribal college instructors in the mentored research process. Factors that contribute to American Indian retention and success in college (Engle & Tinto, 2008; Jackson, Smith & Hill, 2003; Wright & Tierney, 1992) occur on several levels: individual, institutional and community/societal (Jensen, 2011). Following Ovink and Veazey's (2011) approach, this paper explores some key institutional elements (e.g., programs that develop cultural capital) and social relationships that support student retention in STEM fields in a rural tribal college where most students are minority, first generation college students. Many of these students are also from low-income families and, therefore, face additional challenges. Tribal college students are similar to other two-year college students who are preparing for transfer to four-year programs. However, tribal colleges are unique in their missions to support the preservation of local traditional language and culture (Cole, 2006). Thus, mentored research experiences, found to be important means for students to realize academic success (Jones et al., 2010), must also provide meaningful STEM experiences to students who are closely tied to their rural, reservation communities.

The importance of mentoring and supportive relationships with faculty, staff, friends and family has been identified in recent research for both secondary and college students and especially for first generation and minority students (Engle and Tinto, 2008; Gaddis, 2012; PrettyPaint, 2009;). For American Indian students, however, mentoring represents a type of traditional native pedagogy (Cajete, 1999; Huffman, 2001, 2011; White Shield, 2004) that has particular meaning. This exploration of the meaning of mentored research in a tribal college setting has implications for recent discussions (cf. Corbett, 2009; Faircloth, 2009) of Corbett's *Learning to Leave* (2007). Pointing to indigenous communities as important sites for "re-visioning" rural education, this case study shows how increased local control may provide opportunities for students to learn both science and cultural knowledge that they can then use to strengthen their community.

Literature Review

American Indian Students in Higher Education

Although college student enrollment among American Indians has doubled over the last 25 years (Shotton Oosahwe & Cintron, 2007; Freeman & Fox, 2005), only 18% of the American Indians between the ages of 18 to 24 are enrolled in college, compared to 42% of Whites, 60% of Asian/Pacific Islanders, and 32% of African Americans (Freeman & Fox, 2005). Furthermore, despite the increase in enrollment, the 2006-07 Consortium for Student Retention Data Exchange (CSRDE) Retention Report (discussed in NCELA, 2011) indicated that for first-time, full-time freshman, the six-year graduation rate ranged from 65.2% for Asians and 59.4% for Whites while Native American students had the lowest graduation rate at 38.4%.

The impact of poor secondary schooling experiences can be seen in the fact that about half of American Indian students drop out of high school (Faircloth & Tippeconic, 2010; Ward, 2005). Even with sufficient preparation for college, the college experience can be difficult for minority students who may feel that peers and professors are constantly searching for indications of their "inferiority" (Steele, 1992). Reasons for attrition among American Indian students are both academic and socio-cultural (Ballantine, 2001; Ewen, 1997). One prevailing explanation of higher attrition among minority students noted student resistance to "White" education due to negative cultural views of education or lack of individual motivation. However, the research findings indicate little if any statistical difference between American Indian and White students in their motivations and attitudes toward education (Lin, 1985). Institutional efforts to provide opportunities for academic engagement have been found to positively influence retention among both dominant group and minority students (Jones, Barlow & Villarejo, 2010; Townsend & Wilson, 2009). For both groups, participation in research promoted academic involvement and supported improvements in performance. Support from external sources also increases persistence in higher education; family and social support from community and higher education staff are particularly important to the persistence of Native American students (PrettyPaint, 2009).

Huffman (2001) proposed that persistence among American Indian students occurs when a student reaches a Transculturation Threshold, which represents the ability of students to effectively reconcile the native and dominant cultures encountered in the higher education setting. In his 2011 article, Huffman notes that his findings support the work of other researchers (e.g., Guillory, 2008; White Shield, 2004) who found that traditional cultural practices and relationships to family and community helped native students obtain college degrees and motivated them to return to their home communities. Huffman's and other studies have suggested alternatives to Tinto's (1975) approach that was criticized for its emphasis on assimilation. Taking more exploratory and interpretive approaches, these studies have incorporated the social and cultural contexts of American Indian education, focused on understanding the individual experience of American Indian college students, and explored factors that successfully promote persistence and academic achievement (Dehyle, 1992; Hoover & Jacobs, 1992; Wright & Tierney, 1991).

Rendón, Jalomo, and Nora (2004) suggest that inclusive strategies by institutions are also important to student integration to college life. However, Kuh and Love (2004) assert that students should not need to leave their sense of identity at home when pursuing an education. Tierney's (2004) model emphasizes the importance of the cultural capital that students can use to overcome barriers to retention. He also suggests that higher education institutions need to "validate Indigenous capital, epistemologies" (also, see Pidgeon, 2009, p. 353). Additional studies support the incorporation of cultural identity and cultural capital (Benham, 2006) and show how both cultural and social capital affect retention (Astin, 1993; Berger, 2000; Teranishi, Behringer, Grey & Parker, 2004; Wells, 2008). Ovink and Veazey (2011), in particular, demonstrate that when higher education institutions enhance the cultural capital beneficial to minority students, these students are more able to navigate academic settings and achieve academic success in STEM fields. These authors also indicate the importance of research opportunities in which students can use and practice what they have learned and assert their own views.[2]

Adding to these studies, Hermes' research (2005) extends understanding of the social elements of American Indian schooling by examining the practices of successful teachers of native students in American Indian schools. Specifically, she asserts that while the "cultural discontinuity" approach to explaining educational failure among American Indian students is relevant, it fails to include the social structural factors that critical theorists emphasize. Further, she finds that effective teachers establish relationships with their students and often recognize the social issues and challenges their students face. Hermes' research findings indicate that both native and non-native teachers can be effective, which is consistent with recent studies of mentoring indicating that racial similarity between the mentor and student is not required for positive effects (Gaddis, 2012). As Abrams, Taylor & Guo (2013) suggest, although non-native teachers may not be able to teach indigenous knowledge, they can play an important supportive role and even create a "hybrid space" in which native students can explore both mainstream and indigenous knowledge. This research suggests that social capital—the mentor relationship, in particular—is more important than shared social class or culture.

Central to understanding the mentor-student relationship is the concept of moral relations, i.e., the relation of the moral self to the other, as conceptualized by Levinas (Knapp, 2000). In this view the responsibility of an individual to "be *for* the other" emerges in his/her encounters with others and, therefore, is not based on the social rules of existing institutions or the expectations of reciprocation. Acting on this responsibility to the other requires "that the actor interpret the conditions and needs of the other and respond accordingly" (Knapp, 2000, p. 196). Greater familiarity with and knowledge of the individual in need may help to ensure that the action taken to meet the needs of the other will be more likely to bring meaningful benefits (Knapp, 2000). Thus, as Knapp points out, the mentors' genuine, caring acts are even more important than specific needs they might discover.

Science, Technology, Engineering and Math (STEM) Education

A recent report by the American Indian Higher Education Consortium (AIHEC, 2012) indicates tribal colleges

[2] Social capital refers to the social connections through which important norms, trust and information can be shared across generations or among family or other group members. While all groups have social capital, the types of cultural capital needed for success in dominant institutions are typically inherent to elite groups, but can be acquired by other class groups through mobilizing social capital (Ovink & Veazey, 2011).

saw enrollment gains in STEM fields in 2009-10 (7%) compared to 2003-04 (5%), due largely to the development of degree programs and emphases in these areas at tribal colleges. However, these statistics may underestimate interest in STEM because a large proportion of students obtaining associate's degrees do not declare a major or emphasis. Using earlier data for mainstream institutions, Babco (2005) reported that in 2002 Native Americans completed 12.9% of STEM-related degrees, indicating that Native Americans were just as likely as other under-represented groups to earn STEM degrees. Among the possible deterrents to greater STEM interest is the poor academic preparation by native students living in rural and poor areas. Anderson and Kim (2006) report that STEM degree completion among under-represented minority students is related to both economic factors and preparation for college. Thus, a range of strategies is needed, such as enhancing academic preparation, identifying students that need support once they enroll in college, and ensuring full-time attendance—factors that should support graduation in all fields.

Challenges that American Indian students face in the STEM areas include discouragement from pursuing math (Bonous-Hammarth, 2000; Cheek, 1984; Kerbo, 1981; Nelson-Barber & Estrin, 1995). As in earlier decades, low academic expectations for American Indian students continue to be problematic today (Deyhle & Swisher, 1997). Parsons, Adler & Kaczala (1982) found that students whose parents believed math was difficult passed this belief on to their children. Additionally, studies of instructor attitudes and teaching methods (e.g., Wenglinsky, 2002; Williams, 1988) show that instructor preparation affects classroom activities, student achievement and anxiety levels. Turner's research (discussed in Perina, 2002) indicates that students were afraid to ask for help when math instructors displayed even a slightly negative attitude about the student's abilities.

The attempts to understand student experiences with alienation from the STEM subjects, such as math, have also sparked research on effective educational methods and learning models. Effective instruction strategies for American Indian students include active experimentation, apprenticeships, and methods that emphasize reflective rather than impulsive action, cooperation rather than competition, and visual-spatial and interactive learning as opposed to verbal or lecture based learning (More, 1989; Wilson, 1998; Swisher & Deyhle, 1989; Van Hamme, 1995). Additionally, strategies effective for math learning have included group instruction and peer mentoring (Hooker, 2010; Larimore & McClellan, 2005; Lundberg, 2007; Schmidtke, 2010). Finally, culturally grounded instructional approaches and problems have been found to facilitate and strengthen learning (Huffman, 2001; Larimore & McClellan, 2005).

Asserting that the Western approach to teaching science alienates American Indian students from local community settings and cultural traditions, Cajete (1994; Cajete 1999, quoted and cited in Cheyfitz, 2009), a native educator, recommends teaching through observation and imitation and then trial and error in order to achieve a more holistic understanding of natural phenomena. Other researchers also support including traditional native perspectives in instruction on the natural world, which may be incorporated into the research process by native students themselves (Abams et al., 2013; Band & Medin, 2010; Hermes, 2005; Pierotti & Wildcat, 2000). Consistent with this approach is recent attention to the "funds of knowledge" (or "native capital") (Moll, Amanti, Neff & González, 2005) that students bring into school settings, which includes social and cultural practices, worldviews, values, and traditions that native students learn in their families and communities. This type of capital is distinct from "cultural capital," or forms of knowledge associated with participation in mainstream institutions, such as education, and that support upward mobility into the middle and upper class. In contrast, "native capital" (Ward, 2005) is associated with belonging to and participating in the cultural and social life of local native communities and tribal nations. Importantly, recent research suggests that incorporating such cultural knowledge is associated with the positive identities and experiences of native students involved in science research activities (Larimore & McClellan, 2005; Miller 2010; Okagaki et al., 2009; Tran, 2011). Such experiences also counteract the erosion of traditional culture and identity through assimilationist schooling practices (Faircloth, 2009; Fenelon & LeBeau, 2006).

Recent work by Tran (2011) is particularly instructive in suggesting how students manage tensions in their identities and reconstruct what it means to be a scientist and a minority student. Specifically, students in this study redefined science to include social justice goals, such as improving conditions for communities of color, and transforming science into a vehicle for social change, thus, forging new forms of academic science and social identities. This strategy generally confirms the findings of Carlone and Johnson (2007) that minority women would pursue, among others, a science identity trajectory towards being an "altruistic scientist." Tran's study (2011) also shows that students found additional sources of encouragement, support, and validation from friends, family members, and home communities. In order to continue in their academic disciplines, students depended on out-of-class sources of support, especially when they felt that their science identities were not validated in class or in the lab. Finally, supporting the research of Hurtado, Eagan, Tran, Newman, Chang & Velasco (2011) on Black science student development, Tran (2011) called for more research "to identify aspects of supportive environments and the strategies that departments and institutions have effectively employed to validate and recognize the science identities of students from diverse backgrounds"

(p. 8). Such research will help to show the range of factors that may be effective in such settings as tribal colleges. Figure 1 summarizes the findings from research in mainstream colleges and universities that focus largely on improving student performance and retention.

University and Tribal College Settings

While Huffman and others have focused on American Indian student experiences in mainstream university settings, little research has examined STEM retention and completion in the 37 tribal colleges and universities that serve native communities today (AIHEC, 2012). These colleges are described by Stein (1999), as “small tenacious institutions of higher education that serve the smallest and poorest minority group in the United States (American Indians) under difficult and challenging circumstances” while being “under-funded, overworked, and viewed by the rest of American higher education with some wonder at their ability not only to survive, but to survive with panache” (p. 259). They assist American Indian students, who come to college under-prepared and who may have previously felt unable to relate to the educational process, by building closer relationships with school faculty, easing the pressures of education, and preparing them for transition to a four-year institution (AIHEC, 2008). Despite the challenges they face, tribal college students have significantly higher rates of academic persistence after studying at a tribal college (Pavel, Skinner, Farris, Cahalan, Tippeconnic & Stein, 1998; Wenzlaff & Biewer, 1996). Tribal college missions support learning local native history and culture as well as pursuing academic goals. Thus, these settings might be considered excellent representatives of effective rural “place-based education” (Greenwood, 2009) as well as sites for exploring other sources of knowledge (Faircloth, 2009).

The Research Population

Chief Dull Knife College Students

For students attending Chief Dull Knife College (CDKC), retention and completion are affected by many factors, including the lack of transportation to campus (CDKC does not have dormitories), and inadequate access to computers and internet services. The majority of CDKC students are from families with incomes below the poverty level.[3] Many are primary caregivers to children and cannot

[3] The Northern Cheyenne Nation, located in southeastern Montana, includes about 6,000 members, approximately 4,500 of whom live on the reservation. Nearly 40% of Cheyenne families have incomes below the poverty level (U.S. Bureau of Census 2000), an important point in light of today’s gas prices and the

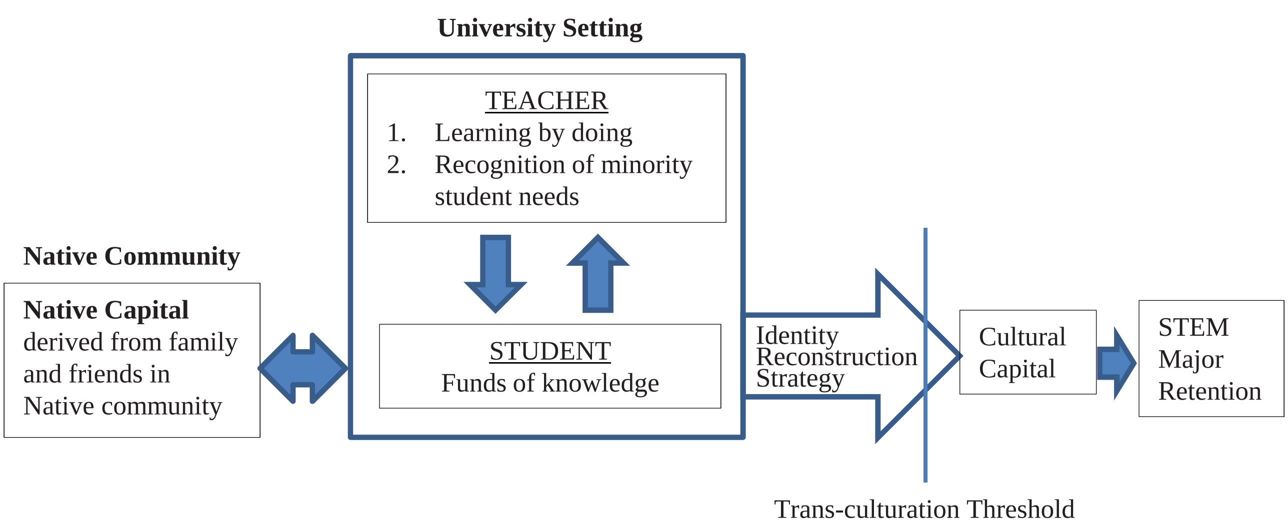

Figure 1. Overview of literature on minority student university experience with STEM.

attend classes without childcare assistance. CDKC Enrollment Survey data (Ward & Jones, 2012) for recent years show that almost 60% of the students have one or more children, about a third report they need babysitting daily, and a similar percentage reports problems with obtaining childcare. Recent CDKC Student Retention Survey data (Ward & Jones, 2012) also suggest that many students have problems with time management, test-taking skills, computer access, and study skills. Students need more than just access to academic opportunities; they need direct experience in communities of learners, culturally sensitive mentoring and social support.

As a community-based, tribally controlled college and land-grant institution located on the Northern Cheyenne Indian Reservation, CDKC's open-admission policy offers to the Cheyenne Nation and their neighbors in the region opportunities for liberal arts and career education. Originally chartered in 1975 by tribal ordinance, the college offers Associate of Arts and Associate of Applied Science programs, and certificates in several areas. CDKC's enrollment averages between two and three hundred students per semester, about 90% of whom are American Indian. Placement tests for CDKC students indicate a substantial need for remedial instruction: almost 90% test below the level of skill needed to enroll in College Algebra. In Communication Arts, more than 40% of students test below the college level. Because students must complete several developmental skills classes, they typically take several semesters to complete their freshman year and at least three years to graduate.[4]

Overview of TCUP and Science Course Enrollment

One of the primary purposes of the CDKC TCUP program was to improve tribal college student interest in science leading to higher student achievement in science. In addition to developing and improving the science curriculum, other TCUP project objectives were to create opportunities for student participation in science research activities and provide mentoring experiences that support successful science course completion as well as transfer to four-year programs and selection of science majors.

Data on CDKC science courses offered indicate a general increase in rates of enrollment and completion among CDKC students over the last ten years. Academic year enrollment for CDKC science classes increased from 124 students in 2007-08 to 259 students in 2011-12. Academic year completion rates for science courses have ranged from a high of 72% (2008-09) to a low of 55% (2009-10). The ten-year completion average for CDKC science courses is 69%.

Improvements in students' science experiences began with collaborative research projects with partners at the University of Montana (UM) and Montana State University (MSU) Bozeman. In the late 1990s, the UM Bridges to Baccalaureate program recruited students from CDKC and other tribal colleges to spend eight weeks each summer participating in research projects mentored by UM faculty. In 1998, a CDKC science instructor began collaboration with three UM faculty members on a study of thermoregulation and air movements in honeybee colonies that provided research opportunities for CDKC students and UM and CDKC science faculty over nine years.

Recognizing the important benefits of CDKC students' participation in mentored research at the University of Montana, CDKC administrators also noted the limitations of this approach: research opportunities were available only to students who were able to move to Missoula for the summer; and student interest in the science topics was limited. In response, the CDKC president encouraged science faculty to seek support for collaborative projects that would be more accessible and relevant to Northern Cheyenne students. Thus, projects like TCUP allowed them to conduct research with local interest and make research opportunities available to all students. The TCUP project funded the first full academic-year research and supported the creation of a research lab at CKDC.

In 2007, a new multi-year collaborative project began that involved investigating use of zeolite[5] to create low-cost water filters. Other research projects, conducted by CDKC faculty and students with UM faculty, addressed local interests: assessing water quality in the Tongue River; documenting original homesteads, the Northern Cheyenne powwow, and the impact of 2012 wildfire damage using tethered blimp and GPS/GIS technology; and examining the concentration of West Nile Virus on the reservation. An MSU project involved CDKC faculty and students in agricultural studies in Mali, Africa.

Research Approach, Methods and Data Sources

An exploratory case study approach was used to address the research questions concerning the meanings students gave to their experiences with mentored research, the effects of these experiences on student attitudes and feelings

remoteness of the Cheyenne reservation (about a hundred miles from an urban center).

[4] Only about half of high school students attend college shortly after they graduate, and the high school dropout rate ranges from 40-60% among local K-12 schools (Ward, 2005). The recent CDKC graduation rate is less than 20% (Ward & Jones, 2012) and about 14% of adults have college degrees (U.S. Census Bureau, 2006-10 American Community Survey), compared to 17% in Montana and more than 15% in the US (Ward & Jones, 2012).

[5] Zeolite is any of a large group of minerals consisting of hydrated aluminosilicates of sodium, potassium, calcium, and barium. They can be readily dehydrated and rehydrated, and are used as cation exchangers and molecular sieves (http://www.oxforddictionaries.com/us/definition/american_english/zeolite).

toward learning science, future plans, and their identity as students, the faculty mentoring strategies and their impacts, and the key elements of the context that support student retention in STEM. The Indigenous Evaluation Framework (AIHEC, 2008), which informed the methodology, focuses on involving all parties interested in the program evaluation and using data collected at each stage of the program to provide meaningful feedback. Similar to the recommendations of Abrams et al. (2013) the research team facilitated a participatory process that produced relevant, high quality data needed to answer the assessment questions. Of particular importance in this approach is *telling the story* of a program in a way that accurately represents the interests, values, and views of indigenous communities. It is compatible with grounded theory techniques and utilization-focused evaluation (Corbin & Strauss, 2007; Patton, 2008) as well as recommendations of Abrams et al. (2013) for research on indigenous math and science teaching.

The research team included one native and two non-native researchers who have many years of experience working with CDKC faculty and students on STEM program assessments, such as TCUP. Several non-native sociology graduate students also assisted with some assessment tasks. The extended period of the assessment (12 years) allowed the evaluation team to develop the relationships, trust and communication with stakeholders needed for effective research on indigenous education (Abrams et al., 2013).

The analysis presented uses the qualitative data collected (observations and individual and group interviews) to explore student experiences with the STEM program changes and new activities developed through the TCUP project. Interviews were conducted with all fifty-one student interns and paraprofessionals a minimum of twice a year as well as all science instructors involved each year of the project. Interviews with participants typically ranged from thirty to sixty minutes. Additionally, three focus groups were conducted with thirty TCUP student and paraprofessional alumni in 2013. Focus group interviews ranged in length from sixty to ninety minutes. Topics for student interviews included attitudes toward learning science, experiences with the science program and related resources, sources of support for schooling, interactions with peers, family and instructors that influence school experiences, the meaning of the mentored research experiences for their lives, and aspirations for future schooling. Interviews were conducted at the tribal college. The purpose of the research was presented to students and they were invited to participate in confidential interviews; participation was voluntary. Pseudonyms were assigned, and research team members transcribed and coded the interviews for patterns and themes.

The process of coding data followed the approaches recommended by Corbin and Strauss (2007) and Patton (2008) for ongoing interrogation of the data by team members in order to identify concepts and patterns as well as themes that needed further investigation through additional data collection. All team members contributed to coding and data analysis each year. A process of comparing coding and interpretations provided cross checking of results that yielded more nuanced understandings of the data and helped to ensure the validity of research findings. Triangulation of data sources included comparing qualitative with quantitative analyses prepared for annual reports and discussions with the CDKC faculty and staff. Annual data analyses from 2004 to 2013 were important for identifying the continuity and changes in student and faculty experiences with the mentored research program.

Research Findings: Students' Mentored Research Experiences

During the past ten academic years, fifty-one students have participated as student interns or paraprofessionals in two CDKC TCUP projects. Most of the students participated in the project during multiple academic years and were selected by the TCUP research director with assistance from CDKC math and science faculty. When asked how they first learned about the program, the TCUP interns indicated that they had learned about TCUP through CDKC faculty and TCUP staff, but also from other students who expressed positive experiences in TCUP and other STEM programs. As the primary mentor for CDKC students over a twenty year period, the TCUP research director involved students in scientific research projects that gave the interns experience working in a lab, exposed them to collaborators and science labs at partner universities, and ultimately increased the interns' confidence and skills as transfer students.

Mentoring provided by the TCUP research director and university collaborators was a key component of the TCUP internship experience. The mentoring relationship had important meanings to a number of students who referred to the TCUP Research Director not only as an instructor and science mentor but also as a "father" who had helped them learn important life skills. Similarly, one of the TCUP paraprofessionals explained her relationship with her mentor, the CDKC IT Director.

> This job keeps me close to home while my daughter is tiny, and I'm learning a lot. [The CDKC IT Director] is so cool, and any question I have, he'll help me walk through it, give me examples, and cut me loose. It's been a real learning experience. It's also been helpful to be here while I am working on my degree, because [my mentor] has helped me with all of the IT aspects of my coursework. [He] is a boss, teacher, and guidance counselor, all in one. (Student 29)

The TCUP Research Director trained each student individually as he or she entered the ongoing research projects. Interviews with TCUP interns indicated that prior to their involvement in TCUP and related projects, none of the CDKC students believed that they were capable of majoring in a STEM field, much less able to conduct scientific research alongside university faculty members. Largely as a result of the one-on-one instruction, students' perceptions of themselves, their abilities, and their futures changed. The interns began to see that not only could they complete science courses and do research, they could finish two-year degrees, transfer to four-year schools, and complete bachelor's degrees. All of the students discussed ways of incorporating science and research into their future careers, and some began to consider science, engineering, and technology majors and the possibility of graduate school.

The process of TCUP interns building long-term relationships with CDKC and UM faculty benefitted students in another key way. When asked about their interactions with CKDC math and science faculty, CDKC students repeatedly reported that they wanted their instructors to "know them" as individuals and "believe" in their capability to perform well in their courses. Once the students felt that their instructors had invested in them, they had a difficult time "letting their instructors down" by not completing their assignments. For the Northern Cheyenne a strong cultural tradition involves inter-generational mentoring by which members of older generations pass along important knowledge and skills, guidance and support to younger generations. For many TCUP students, mentoring by CDKC and UM faculty felt culturally familiar and facilitated an environment in which students with primarily negative educational experiences were allowed to reverse that trend and see themselves in a new light – as successful students.

The UM collaborators visited CDKC to work with the TCUP interns nearly every semester of the project and communicated almost weekly through a Polycom connection. One of the UM collaborators commented on the interns' progress.

> I think we've definitely made some progress. I've been trying to give students an idea of the big picture, and I think that has helped them have a better understanding of what they are doing, and now they are asking their own questions and are starting to think like scientists. Once they had an understanding of the big picture, then they were interested in the details. (Faculty Member 3)

Meaning and Impact of Student Mentored Research Experiences

In the interviews TCUP interns discussed the meaning of their research experience to them and their families and the effect it had on their future plans. Students also addressed what the experience meant to them as Northern Cheyenne students and the potential impact of their experience on their community.

The interview data reinforced the importance of understanding the context of the tribal college and the challenges that many of its students face. A substantial proportion of the student interns were parents and were working as TCUP interns, in part, to support their families. A majority of the students, prior to their working as TCUP interns, had a history of repeated negative experiences with math and science and began their research experience with very little confidence in their ability to do scientific research. Several of the TCUP interns were high school dropouts who later received their GED certification. A few of the TCUP interns had previous experiences with drugs, violence, incarceration, and gang activity. While several of the interns had considered nursing majors, virtually none of the TCUP interns had envisioned participating in scientific research prior to their involvement in science enrichment activities provided by CDKC.

One of the clear benefits of TCUP involvement in scientific research was the impact on students' academic performance. All but one of the TCUP interns required remedial instruction in math prior to enrolling in a college-level math course. Despite this fact, all of the TCUP interns successfully completed upper-level science research methods courses, co-instructed by University of Montana and CDKC faculty. Arguably, the most meaningful gain of the TCUP internship experience was the shift in students' view of themselves from a deficit perspective to one in which they were able to recognize their academic strengths. For many students, the experience of working on the TCUP research changed how they saw their individual capabilities and what they had the potential to become in the future. The following interview quotes represent a prominent theme in the comments of TCUP interns about how their experiences with mentored research changed their lives – both in terms of knowledge and self-confidence.

> I was always wondering what life could have been, and this has opened my eyes to what I could become. I was sitting there all those years, working construction and wondering if I'd ever be able to make anything out of my life, if I'd ever be able to go back to school and see what I could do, and then this project came along and it changed everything. (Student 33)

> Well, the effect of TCUP really is that it has given me a lot of confidence. When I got here I had a GED, and I was a sophomore drop out. On paper, I looked like a retarded person cuz I had been shot, gang-related, sold drugs, should be in prison, and

> had a sophomore education…and I started believing that about myself. But everyone here really didn't know who I was cuz I hadn't been on the rez so they didn't know me. They couldn't gossip about me. They didn't know my name or who I was. They gave me an equal chance. I thought, "If I can do this, what can I not do?" (Student 32)

TCUP internships gave CDKC students the opportunities to develop their academic capabilities in a supportive setting. The TCUP Research Director created an environment in which TCUP interns were allowed to discuss their vulnerabilities, to admit that their previous experiences in math and science had left them questioning their ability to succeed academically, and pursue interests they viewed as impossible to achieve. In this new setting, students transformed the view of themselves from construction workers, custodians, and dropouts to future nurses, engineers, and environmental scientists. Several interns described their newly constructed future plans and how they would use their science skills to strengthen their community:

> I want to go into something environmental. I'm thinking about around here, because this is our chunk of space, because I know we are starting to have problems. Last year for Native American week I went to New Jersey and on our way back we were flying over an area somewhere over near Glacier, and we could see how the pine bark beetle had decimated sections of forest…If we got that here we'd be in trouble. We wouldn't even be able to go and get firewood. I have a wood-burning stove in my house and that's how we heat the house for the winter. As you go along in these projects you build bridges. You start to be seen as someone who can come back and help with these things. (Student 36)

> I never, ever thought I'd have a college education. I worked 20 years in construction. Before I took this job, it had been 7 years since I had picked up a textbook...during all that time working construction my brain was still functioning. My Grandma always said that you're going to make your money with your brain or your back, and you're going to have to figure out what it's going to be. So this is a job, but it's also a ladder. That's why I like working with [the TCUP Research Director]; he wants you to get your education. He likes to think and teach you as well. (Student 35)

Other students discussed plans to use the skills they learned from their mentored research experiences to work on specific issues or problems for their community.

> I want to go into Chemical and Environmental Engineering with a minor in mathematics…I want to help out with resolving environmental issues that deal with chemicals and try to neutralize them. I also want to come back to the reservation and do that here because one of my big goals is to try to fix up everyone's houses and install solar panels. (Student 43)

> We need to help the mother earth…I lead a spiritual life…We need that for our next generations. I worked for [an electric utilities company]. You see the smoke and all. I know what's in it…So I feel being able to work in the private sector with a science degree does help ensure that the standards are followed and resources are protected. (Student 40)

A student involved with the MSU project in Mali focused on the medicinal uses of plants. This experience was the impetus for her to explore, learn and preserve traditional Cheyenne knowledge on this subject.

> We hardly use our plants here for healing. [In Mali] it's all plants because they don't have the clinic. They…live off the land, like heart and soul. Here it is fading…It's only certain ladies that know the benefits and use it. I would like to do that here. I have a plant book now and I am practicing it. (Student 24)

Student responses show that their mentored research experiences gave them a sense of their own worth, increased their confidence, helped them to think critically, and motivated them to both learn and create new knowledge that they could use and give back to the community. These experiences reflect the students' development of the types of cultural capital that are important to their future academic pursuits *and* that are meaningful in their own cultural and social context. Thus, by providing mentored research opportunities, CDKC "re-visioned" science education (Faircloth, 2009) to include learning and research opportunities in which students could develop science skills as well as explore the use of both traditional and other sources of knowledge.

Successful Teaching and Mentoring

In addition to attaching meaning to their research experiences, students also frequently discussed the positive impact of their interactions with their non-native science mentor. The positive impact on the students supports previous research suggesting that non-native instructors can effectively teach American Indian students (Hermes, 2005). Quotes from the interview data for several students provide insight into how the science instructors successfully mentored CDKC students.

> [The science instructor] came along and this was so much fun. He got me enthused about going to school. He was always really, really encouraging. He was always very polite, he always tried to make questions in a way that you could understand. You could talk to him about anything. (Student 44)

> All of my good memories from being here at school are wrapped up in [my mentor]….He took us to conferences, gave us opportunity, and when he took us places, he wanted to make sure that everyone got to meet *us*. Really, meet us? He was so proud of us, and would sit there and talk to everyone about us and what we're doing. He came along during a hard time for me and showed me another way. (Student 44)

> [TCUP] gave me a definite direction as to where I would like to go. I haven't done enough science; when I started college here I didn't even think about it, but I did so well in my science classes that [the science instructor] approached me, asked me if I wanted to be an intern and that just opened my eyes to how much science is a part of this world. You think science is just a guy in a suit working in lab, but science is much more than that. It's all around us. (Student 36)

> What I got out of TCUP is it helped me build my confidence, especially in a predominantly Caucasian world. In the sciences, [there are] a lot of Caucasian people and then you realize that you are not that different when it comes to intellect or knowledge. (Student 33)

Several points in these student comments illustrate cross-cultural teaching. First, in relating her good memories at school to her mentor, the student affirms that successful teaching means transmitting information in a way that the student can retain, and those moments are shared with a teacher who is non-native. Successful teaching was also viewed as being able to ask questions in a way that the students could understand, i.e., from within the student's worldview and range of experiences. Furthermore, the mentor was successful in cross-cultural teaching because he was perceived as *approachable*. Finally, the instructor was successful because he did not limit the experience to learning by hearing information, but he focused on *learning by doing and learning by observing*. The student mentioned that the instructor took her to conferences where she could present (learning by doing), and where she could observe others. In short, this instructor was successful because he taught people rather than lessons, he facilitated learning by observing and doing, and he was open to the students' perspectives.

Two students describe the impact of their experiences with their mentor that captures what many students reported.

> … Getting involved with [the instructor] was a fluke. I didn't really have a job when I asked him about these projects two summers ago. I told him "I show up everyday. I have good grades, but I'm not a science major," and he took me on. Science was not my thing, but it just so happens, it's probably where I belonged all along and [the instructor] could see that. He had faith in me and nurtured my schooling. Then after [a trip to] Kentucky when I decided that I really wanted to do science, I went to him and said, "I don't know what I am going to need to do, but I'll listen to you." From then on, if [the instructor] thought it was important, then I'd do it, and until the time I had a further grasp on what I needed to do, he'd make those decisions for me. It made me feel good to have him take that role for me and lead me by the hand. (Student 40)

> This is what [the science mentor] taught me: *you study in a field to become who you are.* You start making contacts, and if you work really hard, eventually people will start coming to you as a person that can help them. Then people won't care about your criminal background. You will have these biology and chemistry skills that are valuable, and they will come…and want you to use them. (Student 40)

> He taught me how to be an adult in a lot of ways. He taught me to take care of myself. I had to grow up. I was learning life skills and communication skills. I learned how to rely on myself for stuff. I mean [the mentor] taught me more than just what it was to be a good scientist - ask questions, find the facts, form a hypothesis, and do the research. That's scientific stuff, but what about life situations? So, I think he taught me…to be where I was…I wish I could do it again and again and again. That's a big, big part of my life right there. (Student 9)

Similar to the previous student interviews quoted, these students described successful mentoring in terms of their relationship to the mentor: the instructor "nurtured" or supported the students' learning, rather than simply managing it. Additionally, the student found meaning in the mentor's advice, "You study in a field to become who you are." These strategies supported the principle of relating to or caring for the "other" discussed by Knapp (2000). The students' experiences with their faculty mentors show that successful cross-cultural mentoring is possible even when teachers do not have extensive knowledge of their students' culture, but rather they are good teachers who allow the students to guide them in the way in which the students want to be taught. The mentor's role as facilitator supported active learning and research roles for students.

The TCUP interns also discussed their role and contribution to the science research projects as Northern Cheyenne students at CDKC.

> What comes to mind for me, you know, going to all the places, all these different projects is I am a representative of the Northern Cheyenne people. They ask me what tribe are you from. To me it is important to put out a positive image, a positive thing about who we are as a people because a lot of times white people they don't really know; they think we are all related. He's Sioux, he's a Crow over there, and that we all speak the same language. I think it is important that I am Northern Cheyenne. So…when they remember my interaction with them, they will say, "I know a Native American, he's Northern Cheyenne." (Student 36)

When asked about what they bring to their studies and research as native students, interns suggested that they bring a unique perspective and interests.

> Looking back and the way I think now, I can think two ways now. It is kind of weird because you have the Western science and the native science; conglomerate those two worlds together. It takes a lot of time and experience, a lot of thought and practice too to do that. That's pretty much what I thought I brought to the labs and stuff like that. (Student 33)

> There's a lot of opportunities in science…Native American science as a different approach would be very unique but very challenging as well. (Student 33)

These student comments reveal, consistent with Tran's findings (2011), that the mentoring at CDKC allowed students to reconstruct what it means to be a "scientist" on the Northern Cheyenne reservation. For CDKC students, mentoring experiences transformed science from a concept used by the outside (white) world to a tool or process that could be used by the Northern Cheyenne to explore, help protect and preserve their community. Moreover, as one student explained, his science research experience allowed him to "put out a positive image, positive things about who we are as a people" because he felt that "a lot of times white people don't really know" (Student 36). Thus, mentoring in STEM fields became not only a vehicle for students to create new academic and social identities as scientists (Tran, 2011), but also a platform for them to transmit their Northern Cheyenne identity to the outside world.

Science Intern Research Presentations

Further evidence of the active role of students is represented in the opportunities TCUP students had to present their research at regional and national meetings - another key strategy for student development designed by the CDKC TCUP program. For example, TCUP interns presented their research at the 2009 National Science Foundation Joint Annual Meeting (JAM) in Washington, D.C., the 2010 Montana Space Grant Consortium Student Research Symposium, and the 2008 California State Beekeepers Conference. Two TCUP interns had the opportunity to present at the Montana Space Grant Consortium's Annual Student Research Symposium in Bozeman, Montana in April 2010. One TCUP intern created a presentation that detailed his experiences working with a CDKC math instructor during summer 2009 on a GPS/GIS program. His presentation on noxious weed detection was awarded the best student presentation.

In addition to support from CDKC science faculty mentors, the TCUP program hired a writing instructor to help the TCUP students prepare their results for poster presentations. This additional form of support was important to the TCUP interns who were initially intimidated by the prospect of creating a poster presentation. A TCUP intern explains how writing was a major obstacle in preparing a poster.

> The writing was what was the biggest obstacle. To do this, there is a different way of thinking; it's not emotion-based, and it's all scientific language. When I worked with them, my mentors, it changed my ideas. It was therapeutic. Everyone was helpful, and now I'm going to be able to present at a bee conference in Lake Tahoe in November. (Student 33)

As a result of their positive experiences with their poster presentations, the TCUP interns welcomed additional opportunities to disseminate their research in academic settings.

Discussion and Conclusions

The findings of this rural case study suggest that mentored research activities supported by the TCUP program provided essential learning opportunities and academic preparation for students' education beyond the two-year associates degree. Specifically, the findings showed that the mentored research opportunities: (1) had positive impacts for these tribal college students, (2) involved meaningful mentoring strategies by both native and non-native mentors, and (3) utilized organizational resources that supported the mentored research. Student involvement in instructor-led mentored research projects as well as independent and student-led research activities improved student performance and confidence in math and science, improved course retention and completion, and resulted in more students planning to pursue four-year degrees. More CDKC students have transferred to four-year programs than any time in the 35-year history of the college, and more students have chosen science-related fields as well (Ward & Jones, 2012). Finally, TCUP project participants reported that their research experiences held special meaning for them and their families. Importantly, they believed their experiences are relevant to their future education and career interests and in helping them to find ways that they can make important contributions to their community.

The TCUP program included a number of the resources identified in retention models as important for student success: academic advising, faculty support, tutoring, encouragement by family members, involvement by community elders and access to cultural events and activities (the tribal college context) (PrettyPaint, 2009; Tierney, 2004). Most importantly, the findings affirm that through connecting mentored research opportunities to local community interests, CDKC faculty created the type of culturally responsive curriculum that Abrams et al. (2013) highlights as an important tool for engaging indigenous learners of math and science. Additionally, the mentored research experience involved trust and a caring relationship (Knapp, 2000) through which instructors provided one-on-one instruction and assistance that met the students' needs. For the science instructors at CDKC this meant understanding more about the students personally as well as their abilities and needs. As Hermes (2005) suggests, the instructor became an "ally" in meeting new learning challenges.

The data on students' experiences with mentored research projects show that student academic goals improved when learning involved both observation and doing. Furthermore, students learned best in a supportive socio-cultural context. In contrast to approaches suggesting that "cultural discontinuity" between instructors and students contributes to student failure, this study supports Hermes' (2005) research findings that *more* was involved than culturally sensitive pedagogy. In fact, the effectiveness of non-native instructors involved developing appropriate mentoring relationships that included both trust and collaboration. Non-native teachers were most effective in sharing their math and science knowledge when they recognized the students and understood their learning goals and needs. In short, effectively teaching tribal college students did not require that mentors had extensive knowledge of the students' culture as much as it required that they recognized the students as persons who brought their own cultural identities and resources, i.e., funds of knowledge or native capital (Gonzalez, Moll & Amanti, 2005; Moll et al., 1992; Ward, 2005) to their studies, and they supported their students' learning (Ladson-Billings, 1995). In this way, mentors encouraged students both to learn new knowledge and to see the value and relevance of their own worldview, interests and beliefs. The research process became increasingly collaborative when there were exchanges of ideas and cultural knowledge and the research was relevant to the students' home community. In fact, these findings suggest that CDKC faculty and students were able to create a type of "hybrid space" for learning that Abrams et al. (2013) describes. This space allowed CDKC students to explore both western science and indigenous knowledge and begin to develop their capabilities as native scientists.

The findings of this case study support the instructional approach suggested by Fenelon and LeBeau (2006), Pierotti and Wildcat (2000), and Abrams et al. (2013) that makes native students' interests central to teaching and learning. Additionally, the caring relationship between the mentor and student is culturally consistent with the roles of elders in this community to offer guidance and assistance to members of younger generations (Ward, 2005). As Figure 2 illustrates, this case study shows that the mentored research experiences facilitated students' re-construction of their identities as successful Northern Cheyenne students and scientists (Tran, 2011). This process then allowed the students to pursue independent and collaborative research that they identified as meaningful and to make plans beyond their two-year degrees.

This case study also supports Hall and Fenelon's (2009) assertion that tribal colleges can be important sites of resistance by supporting and contributing to tribal culture and society. The views expressed by the students indicate that like American Indian students in university settings, these rural tribal college students want to return to their communities following graduation (Huffman, 2011; Guillory, 2008). The difference in this case, however, is that tribal college students bring these goals into their academic plans and experiences as freshmen and sophomores. Through the mentored research process these rural, tribal college students experience place-based education in which, in the words of Greenwood (2009), they are “learning in connection with others and with the land” (p. 5) in ways that honor their community, their past and present. Such experiences enable and empower them to learn within their community *and* give them the tools to pursue their goals and dreams both in and outside the community. Thus, the mentored research program represents a type of learning in this rural education setting that bridges native and non-native contexts (Faircloth, 2009), allowing students to establish their own “place” in the process of learning and creating new knowledge.

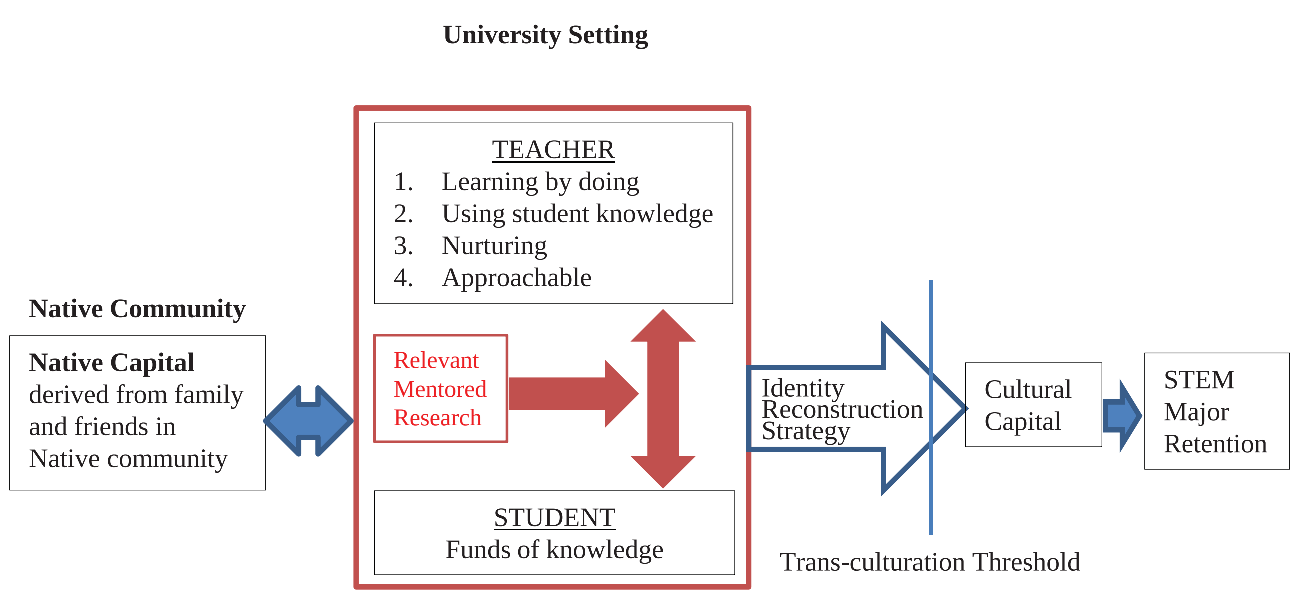

Figure 2. Contributions from study of Tribal College student mentored STEM research experience.

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