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ENHANCING STEM EDUCATION IN INDIGENOUS SERVING SCHOOLS USING CULTURALLY RESPONSIVE PEDAGOGY

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Abstract

The DINÉ project (Diné Institute for Navajo Nation Educators) was designed to engage teachers of Indigenous students in a rich, content-focused, long-term professional development program, honoring their cultural expertise to design culturally responsive STEM learning experiences. A different cohort of teachers worked with content expert university faculty over an 8-month period during each of the past four years to gain content mastery, develop grade/subject specific STEM instructional units, and learn to become effective pedagogues bringing in cultural relevance to the STEM subject matter. During the 8-month period (March – November), teachers had monthly group meetings with the university faculty and a 2-week intense summer residency at the university. By the end of the 8-month program, teachers would have created ONE instructional unit (1 – 3 weeks duration) on the STEM topic area in which they engaged with the university faculty member and relevant for use in their own classroom. The unit employed culturally relevant pedagogy learned during the program and was taught in their designated classroom before the end of the 8-month program period. The program culminates each year with a show-case and open house in December during which the teachers displayed and presented their units along with samples of work their students did within the unit.
This paper describes program impact on teachers' ability in STEM curriculum development (high quality instructional units), instructional practice, and incorporation of culturally responsive approaches to STEM education. The impact was investigated using the SCOOP Notebook protocol; an internally developed and validated questionnaire to assess elements of culturally responsive practices specific to the Indigenous context; and focus group interviews of faculty facilitators and teacher leaders in the program. Results indicate positive impact of the program on each area investigated (curriculum development, instructional practice, and culturally responsive pedagogy), indicating the effectiveness of the professional development program and the content-rich learning model it employs, which is based on the Yale National Institute© (YNI) model of K-12 in-service teacher professional development.

Keywords: *Indigenous education, STEM education, culturally responsive pedagogy, teacher professional development.*

1. Introduction

Whether it is science, math, or reading scores; high school graduation rates; access to advance coursework; enrollment in post-secondary schools; or post-baccalaureate degree attainment; there are multiple persistent educational gaps between Indigenous youth and their peers in the United States (Faircloth & Tippeconnic, 2010; Claren, 2017; Brayboy et al., 2012; Field, 2017). Factors contributing to these student outcomes include high mobility rates of teachers in schools serving Native youth, minimal access to curricular and professional development resources, and lower levels of advanced training than their teacher colleagues elsewhere. Indigenous youth deserve access to the best educational opportunities available. Although educational attainment is impacted by a complex set of factors, teacher quality is one of the most impactful school-based factors that influences student learning and attainment. Thus, improving teacher quality is an important strategy for increasing the educational attainment of those most adversely impacted by the persistent achievement gaps in our nation's schools. Furthermore, our nation's

K-12 teacher shortage is even more acute in our rural Indigenous communities. An important strategy for addressing these crises is to improve teacher quality and retention.

The DINÉ project (Diné Institute for Navajo Nation Educators) was designed to do just that by engaging teachers in a rich, content-focused, long-term professional development program that honored their cultural expertise and challenged them to improve their instruction in a culturally responsive manner. In working over an 8-month period with university faculty who are content experts, teachers in schools serving Native youth gained the opportunity to develop as instructional leaders and learn to become effective pedagogues. With a focus on STEM Education, our team investigated the impact of this professional development by way of the following research questions: 1) To what extent and in what ways does the DINÉ professional development program impact teachers' curriculum development abilities and instructional practices in Native-serving schools? 2) To what extent and in what ways does the DINÉ professional development program impact teachers' ability to incorporate culturally responsive approaches in STEM curriculum development and instructional practice?

2. Model & theory of change

The DINÉ project is modeled after the Yale National Institute© (YNI) for K-12 in-service teacher professional development, which was initially developed through a partnership between Yale University and the New Haven public school system. It has been used in that community for 40 years, and in several other urban communities across the nation for over a decade. The YNI approach has undergone external evaluation efforts, leading to the development of the *theory of change* presented in Figure 1. Importantly, data from various local YNI Teachers Institutes suggest that teacher retention is improved, and that teachers report higher efficacy in content knowledge mastery (Kisker, 2011, 2015). This theory of change provided the foundational starting point for our efforts in the DINÉ project. However, the YNI model's applicability to rural Indigenous contexts, its impact on teacher practice, and on incorporation of culturally responsive pedagogy has never been investigated. These are important components of professional development that the DINÉ project was designed to explore.

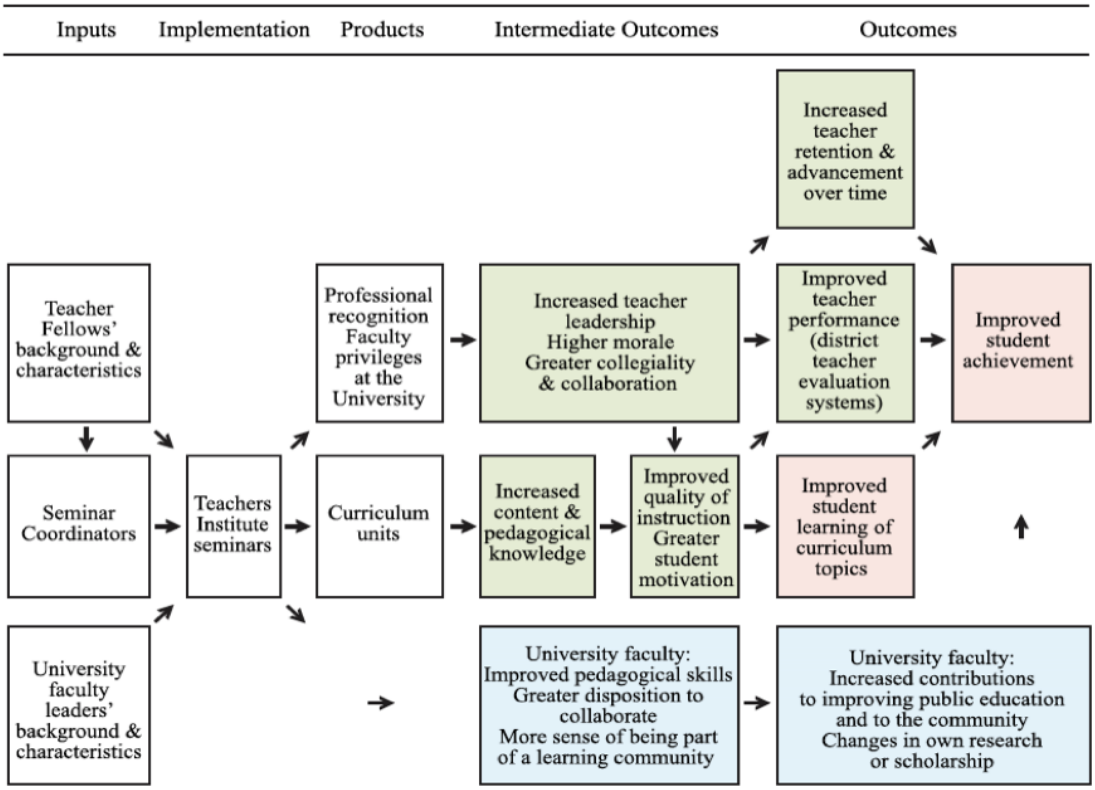
The DINÉ project embodies many elements of effective teacher professional development. It focuses on content knowledge, is long- term, engages active learning strategies, and is aligned to local and state standards (Archibald et al., 2011; Benilower, Heck, & Weiss, 2007; Kisker, 2015; Penuel, 2015; Penuel et al., 2009; Penuel et al., 2007). High teacher turnover is a barrier to maximizing the impacts of PD (Shear & Penuel, 2010), and teacher turnover is especially significant across Indian Country. But we also know that collaborative approaches are particularly suited for Indigenous contexts (Cronin & Ostergren, 2007; McCarty et al., 1997; Parker & White, 2015), and that culturally responsive curriculum produces more engagement and learning (Castagno & Brayboy, 2008). While the DINÉ project involves teachers of all grade levels and subject areas, this presentation will focus on project impact on instruction in STEM disciplines, which is the NSF funded part of this project.

3. Design / procedure

3.1. Methodological approach

Project impact on participating teachers with regard to the research questions, identified in the *Introduction* section above, was investigated using a mixed-methods approach employing a collective case study (or multiple case design) and informed by Critical Indigenous Research Methodologies (CIRM). While quantitative and qualitative data were collected from individual teachers, the cohort of teachers in each of the three years of the project (2019, 2020, 2021) was considered a "case" and comparison of teacher data across yearly cohorts formed the collective case study/multiple case design (Creswell & Creswell, 2018; Creswell & Poth, 2017). Given that this project and research occurs in Indigenous-serving schools, with teachers who mostly identify as Indigenous, the principles of CIRM were an important element in the research design. These principles include fore-fronting the inherent sovereignty and self-determination of tribal nations, honoring and building on relationships within and between researchers and community members, and pursuing research questions that will advance community needs and interests (Brayboy et al., 2012; Smith, 1999; Wilson 2008).

Figure 1. Theory of Change for Teacher Institutes.



3.2. Instruments and analysis approach

For examining the impact on STEM instructional design and delivery, each instructional unit developed by participating teachers was analyzed using the SCOOP Notebook protocol (Martínez, et al., 2012). For examining teachers' ability to incorporate culturally responsive pedagogy, specific to the Indigenous context, in STEM instruction, the project developed and validated a new protocol titled *Culturally Responsive Assessment of Indigenous Schooling* (CRAIS Tool; Joseph *et al*, 2022, in review; Castagno *et al*, 2021). Each teacher's instructional unit was analyzed using this questionnaire to assess the extent of culturally responsive instruction. Both the SCOOP Notebook protocol and the CRAIS tool yielded quantitative data. Additionally, corroborating qualitative data were collected via individual interviews of faculty facilitating the professional development "courses" each year, and focus group interviews of the teacher leaders of these courses each year.

Each of the 11 domains (10 specific domains and one "overall" category) of the SCOOP Notebook Protocol are scored on a 5-point scale, with specific descriptors for each point on the scale provided by the developers of the SCOOP Notebook Protocol.

The CRAIS Tool contains 23 items classified into 5 thematic clusters. The scoring scale for each of these items is a 7-point scale (-3, -2, -1, 0, 1, 2, 3) plus a 'Not Applicable' option. There are descriptors for each point of the scale to guide the rater in determining the score for each item on the tool.

4. Analyses and findings

The two primary analysis instruments used in this study include the SCOOP Notebook Protocol and the CRAIS Tool. The primary source of data were the instructional units written by each individual teacher in the program each year, which they also taught during late Fall or early Spring in their classes. Corroborative data were also collected via interviews as described in the last section. Due to space limitation, only the analyses of written instructional units designed by the teachers, which were the primary source of data, are presented here.

Both the SCOOP and CRAIS instruments were used to analyze the instructional unit written by each teacher, each year. Each instructional unit was assigned randomly to three members of the project team for analyzing by the SCOOP and CRAIS instruments. Thus, each instructional unit received three scores on each domain of the SCOOP Notebook Protocol and each item of the CRAIS tool. These three scores were averaged into one score for each domain of the SCOOP Notebook Protocol and each item of

the CRAIS tool. These single scores on each instructional unit were further averaged to yield an overall composite score on the SCOOP Notebook protocol and another overall composite score on the CRAIS tool. Thus, for example, the instructional unit of a specific teacher may end up with a 2.5 composite SCOOP Notebook score and a 2.5 composite CRAIS score. Also, these composite scores of all teachers within a yearly cohort are averaged to get a year-specific composite score for the purpose of comparison between yearly cohorts to look for "trends" or progression of project impact on teachers' instructional quality.

Since a different set of "courses" are offered each year, several teachers have participated in the program each year and written a different instructional unit each year. Thus, another line of analysis being pursued is the comparison of their scores from one year to the next. This line of analysis provides information about how multi-year participation in the program impacts teachers' overall STEM instructional quality and their facility with incorporating culturally responsive pedagogy in STEM instruction.

Scores on individual SCOOP Notebook domains and individual CRAIS items are also averaged across all teachers within a yearly cohort. The resulting scores help identify which SCOOP Notebook domain/s and which CRAIS item/s received high scores and which ones received low scores. The project activities and mentoring from faculty facilitators and teacher leaders are then adjusted to try to improve on the low scoring areas for the next year.

Finally, the SCOOP Notebook scores and the CRAIS scores of each specific teacher are compared to find any relationship between a teacher's general STEM instructional quality and their ability to incorporate culturally responsive pedagogy in STEM instruction. The question being examined here is whether or not there is a positive correlation between general STEM instructional quality and the ability to incorporate culturally responsive pedagogy.

Given the relatively small number of teachers participating in each course, each year (<15), only descriptive statistics are used in order to find trends or progression, rather than inferential statistics to claim statistical significance of the results of these analyses. Some sample summary results are presented in Tables 1 and 2 below.

Table 1. Composite CRAIS scores by years.

2019			**2020**			**2021**		
All Teachers in the Program (n = 19)	Teachers in the Science Course (n = 13)	No Math Course offered	All Teachers in the Program (n = 22)	No Science Course offered	Teachers in the Math Course (n = 7)	All Teachers in the Program (n = 22)	Teachers in the Science Course (n = 10)	Teachers in the Math Course (n = 5)
1.8169	1.8094		1.8395		1.5191	1.5064	1.4945	1.5004

Table 2. Composite SCOOP Notebook scores by years.

2019		**2020**		**2021**	
Teachers in the Science Course (n = 13)	No Math Course offered	No Science Course offered	Teachers in the Math Course (n = 7)	Teachers in the Science Course (n = 10)	Teachers in the Math Course (n = 5)
2.284			3.8586	3.610	3.855

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