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Introduction

The goal of *Pathways to Indigenous STEM (Ma:cidag wo:g STEM Wui),* a $2.5M NSF award, is to strengthen and transform the STEM program at Tohono O'odham Community College (TOCC) by improving instructional capacity, Indigenizing the science curriculum, and strengthening culturally responsive academic support for students. The *Man in the Maze Education (MiME) Model* developed at TOCC will serve as a culturally-based framework for curriculum development and program assessment and will provide an intentional and systematic approach to Indigenizing our curriculum and programs. By implementing a comprehensive approach to student success based on our *MiME Model*, our goal is to produce culturally competent, self-directed learners equipped to succeed in an increasingly complex and globalized society.

TOCC is the institution of higher education for the Tohono O'odham Nation (the Nation) and one of 38 tribally controlled colleges and universities (TCUs) in the United States. TOCC has 3 campuses in and near Sells, Arizona, the governing center of the Nation. Sells is located approximately 60 miles southwest of the nearest off-reservation population center in Tucson, Arizona. The Nation occupies the Tohono O'odham Reservation, geographically the second largest reservation in the United States and similar in size to the state of Connecticut. The reservation stretches 75 miles along the U.S.-Mexico border and is home to 15,000 of the Nation's 32,400 citizens (TOCC HLC report, 2015).

The Tohono O'odham *Himdag*, meaning "way of life", has survived over 500 years of European contact and is a strong motivating factor for strengthening tribal sovereignty, self-sufficiency, and self-determination. Before European contact, the Tohono O'odham (meaning "Desert People") were sovereign by way of their political, social, cultural, and religious structures and their cultural life-way, or *Himdag*. Tohono O'odham educational institutions historically were under the control of European missionaries, the United States government, or the Arizona State government and accordingly, pedagogy was established using the Western educational paradigm. For generations, Tohono O'odham leaders and elders dreamed of a college, locally controlled and operated. "Our dream fulfilled" (*Nia, oya g t-taccui am hab e-ju),* the aspiration of the Tohono O'odham elders and educators, became a reality in 1998 when TOCC was chartered and established by Legislative Council Resolution 98-01. The college welcomed its first class of students in the Spring semester of 2000.

TOCC enhances sovereignty, self-determination, and *Himdag* for the Nation and all its members. The authorizing resolution declares that "the college of learning manned by and for Tohono O'odham can best serve as a center for training and research in those disciplines that may define our past, present and future while preserving and teaching our history, language, culture, and tradition." Toward building its institutional efficacy to fulfill its tribal mandate, TOCC has successfully collaborated with other academic and non-academic institutions and has dedicated its modest financial, administrative, and personnel

resources to developing strategic interagency liaisons and partnerships that enhance the capacity and cost-effectiveness of all its academic programs and services.

Statement of Need and Strategic Basis for Project

Historically, Native American students are underrepresented at the undergraduate and graduate level in STEM disciplines (National Science Foundation, 2017). In addition, attrition rates for Native students in STEM are substantially higher relative to white and Asian-American STEM students (Hurtado et al., 2010). Native American students face obstacles in their undergraduate educational environment, including cultural and academic isolation, negative stereotypes, and low expectations, all of which contribute to lower levels of motivation and performance (Hurtado et al., 2014). To overcome these obstacles, culturally-based education is vitally important to increase the academic success of Native students; however, there has been little or no documented institution-wide, systematic efforts to create sustained changes in Native American serving educational institutions using this approach (Castagno & Brayboy, 2008).

Tribal education is an act of cultural restoration (Crazy Bull, 2010) and reconciliation through deconstructing and challenging the dominance of Western knowledge (Kanu, 2006; Wilson, 2004). Therefore, like all tribal colleges, TOCC has the mandate to preserve the language and *Himdag* of the Tohono O'odham as illustrated in the college's mission statement:

> *"As an accredited and land grant institution, TOCC's mission is to enhance our unique Tohono O'odham Himdag by strengthening individuals, families, and communities through holistic, quality higher education services. These services will include research opportunities and programs that address academic, life, and development skills."*

To fulfill this mission, the *Himdag* must be appropriately articulated with the curriculum. It is the goal of this project to create a comprehensive approach to integrating our curriculum into the *Himdag* that transforms our institution and creates a deep cultural context for our STEM degree programs. The proposed application of the *MiME Model* to our STEM programs, along with careful evaluation and documentation of its impact on learning and retention in STEM, will address the need for systematic and sustainable integration of our STEM curriculum into the *Himdag*.

Cajete (2005) posits that to achieve the ideals of tribal education, American Indian education should be founded on a shared cultural metaphor that embodies tribal epistemologies. LaFrance and Nicholls (2010) assert that evaluation processes that are robust enough to accommodate and value different "ways of knowing" must be based upon a cultural framework unique to each tribal community. Cajete (2005) encourages the use of cultural metaphors based on symbolic expressions because they reflect "the metaphysical, ecological and cultural constructs of a tribal epistemology" and "common understandings and shared foundations for traditional ways of learning." Additionally, modern research on brain-based learning suggests that information is most effectively and efficiently learned when presented in an overall framework (Bransford, 2000). This further strengthens the value of our proposed work to use a cultural metaphor as a metacognitive framework for transforming STEM education at TOCC.

In addition to cultural frameworks, culturally-relevant curricula should validate the culture and language of students and allow students to become co-constructors of knowledge (Belgarde, Mitchell, & Arquero, 2002). The culturally-relevant curriculum should also be infused with rich connections to students' cultural and linguistic backgrounds and be designed within family and community contexts. Therefore, this project seeks to implement culturally-infused, problem-based learning and transdisciplinary

approaches across our STEM courses. Transdisciplinary education goes beyond interdisciplinary content and includes the interactions between knowledge from academics and knowledge from community practitioners to promote a mutual learning process (Mitchell & Moore, 2015; Steiner & Posch, 2006). Furthermore, success in science is dependent on how well students can transcend the cultural borders between the disparate worldviews of their everyday life and science (Ezeife, 2003; Jegede & Aikenhead, 1996). Transdisciplinary education helps mediate these cultural border crossings and promote success in Native American students (Newberry & Trujillo, 2017).

Beyond efforts to Indigenize the science curriculum, one must also consider that Tohono O'odham students are Net Generation Learners who are digitally literate, connected social learners interested in immediate, relevant, and experiential learning (Oblinger, 2005). To engage 21st-century learners and create intentional, integrative thinkers who can solve problems from multiple information sources and perspectives (Clayton-Pedersen & O'Neill, 2005), it is important to apply innovative teaching strategies like problem-based learning, collaborative learning, and transdisciplinary curriculum. According to the American Association of Colleges and Universities (2002), the goal of education is to produce learners who can see connections between diverse information sources and are able to synthesize and analyze this information to make decisions and draw conclusions. Our STEM project will be constructed with the goal of producing culturally competent, intentional learners who are equipped to address the challenges faced by a complex, global society. The inclusion of traditional ecological knowledge (TEK) and social sciences in STEM curriculum will promote integrative, multi-contextual thinking and empower students to utilize their cultural knowledge and unique perspectives in problem-solving.

Overview of Project Plan

Based on priorities identified in the NSF TCUP STEM Pre-TI visioning process (see Table 1(b)), this project will focus on the following areas: (1) expand STEM curricular offerings in the Physical Sciences and the number of courses offered through online delivery, (2) apply the *MiME Model* to Indigenize the curriculum, increase rigor, and promote student success and retention, (3) promote professional preparedness of students through internships and research experiences, and (4) increase support for high school-TOCC and TOCC-University transitions. These focus areas are discussed in detail below, in the *Statement of Work* section.

Statement of Work

Goal 1: Expand the STEM Curriculum

TOCC's current STEM program consists of one Associate of Science in Life Sciences (ASLS) degree and one Associate of Applied Science degree. The ASLS degree emphasizes thorough preparation of students who plan to transfer to four-year colleges and universities after they graduate from TOCC. The ASLS degree includes concentrations in the areas of agriculture, natural resources, health and interdisciplinary studies. In addition, our STEM program includes a new Associate of Applied Science in Environmental Studies in Indigenous Borderlands, which examines environmental issues related to Indigenous border regions such as the Mexican-U.S. border. This degree draws on many of the same courses as the ASLS, with additional courses in Conservation Biology and Cultural Geography.

Physical Science Curriculum

The results of our planning process revealed a notable gap in physical sciences. To address this, we propose to create an Associate of Science degree in Physical Science (ASPS) that will provide students with the academic basis to pursue a university degree in Physics, Astronomy, Computer Science, or Engineering. The ASPS program, especially Astronomy, will capitalize on the research and educational opportunities offered by our proximity to world-class research telescopes atop nearby Kitt Peak, our long-standing partnership with NOAO, and the reservation's naturally dark skies. This project includes funds to hire two new full-time faculty members: (1) a physicist or astronomer preferably with a background in culturally-responsive curriculum development to develop the ASPS program, and (2) a chemist having a background in science education to teach chemistry both at TOCC and via dual enrollment with Baboquivari High School. This grant will support adjunct faculty to teach elective courses within the ASPS degree. TOCC has committed to continued support of the ASPS program, including providing ongoing funding for the two full-time faculty members, at the completion of this project. There are project funds available for lab supplies and library resources to support this new program. The ASPS program will be designed using the *MiME Model* described in Goal 2. As part of a collaborative agreement with NOAO, Dr. Stephen Pompea will commit 5-10% of his time as a senior science education advisor for the development of a robust, innovative, and student-centered ASPS curriculum.

Distance Education

This project will expand our STEM course offerings in a variety of delivery formats ranging from web-enhanced to hybrid to fully online. The goal of Year 1 will be STEM faculty development in online teaching through the completion of the Quality Matters (QM) online certificate program. The QM online certificate includes training in online course design, learning theory, assessment, and institutional policies. The process of web-enhancing all STEM courses will begin during Year 1 using TOCC's existing Canvas Learning Management System. In Year 2, two fully online classes will be developed by two STEM faculty, who will each choose a course to build online. Using grant funds, an adjunct will be hired to teach one of their courses in the fall semester so that each of the two STEM faculty will have a reduced course load to develop the online course. The new STEM online courses will be taught during the following spring semester. This will continue for the following three years until there are a total of six fully online classes. During Years 2-5, STEM faculty will each choose two other courses to develop as hybrid courses with a commitment to completing six hybrid courses at the end of five years. In addition, all STEM courses will be web-enhanced and include online course supplements by the end of Year 5.

Goal 2: Apply the Man in the Maze Education (MiME) Model

We plan to Indigenize and transform our STEM curriculum by applying the *MiME Model* to our curriculum development and assessment approaches. This will include developing culturally sustaining curriculum through Indigenous education strategies such as the adoption of holistic transdisciplinary teaching approaches, increased emphasis on student-centered and problem-based learning, and through teaching-learning communities. The *MiME Model* will provide a framework for our learning communities and ongoing culturally responsive support for our students throughout their educational journey at TOCC.

We have already initiated this work through the development of the *MiME Model* (Newberry et al., 2016) and the application of PBL to selected STEM courses. This project will allow us to continue this work at the program level and to incorporate its use across all our STEM offerings. This project will support a

cultural mentor Camillus Lopez who co-developed the *MiME Model* with STEM faculty. As a cultural mentor for this project, he will be involved in every aspect of applying the *MiME Model* at TOCC and will work with students, faculty, and administrators to ensure its culturally appropriate and comprehensive application.

Overview of the Man in the Maze Education (MiME) Model

The *MiME Model* is framed on the wisdom regarding personal transformation and learning inherent in the cultural symbol, *The Man in the Maze* (Figure 3). For the Tohono O'odham, the *Man in the Maze* symbol is rich in meaning at multiple layers and is reflective of one's journey toward both inner and outer knowledge through life. *The MiME Model* serves as a powerful symbol for a holistic educational journey founded on the *Himdag*. The *Man in the Maze* represents a person's journey through life and reaching for one's dreams. According to this symbol, the life path leads a person to four encounters with the dark spot in the center of the maze: Birth, Puberty, Responsibility, and Acceptance to the completion of a life. The dark spot in the center symbolizes the four major life sacraments that every person must pass through to complete the journey. Each time a person moves to the center of the maze during major life transitions, there is time for reflection, evaluation, and transformation before moving onward to the next phase of the life journey.

In applying this cultural metaphor to the process of learning, each journey through the maze and into the center represents a level of learning that ends in an assessment or evaluation and reflection on learning. Each successive journey leads to deeper discovery. The first journey represents knowledge gathering and each successive journey gathers more knowledge, with the final journey delving more deeply into the problem or subject area. Since each journey represents a succession in one's life and mastery of a higher level of learning, each journey is assigned a level of learning based on Bloom's taxonomy (Figure 3).

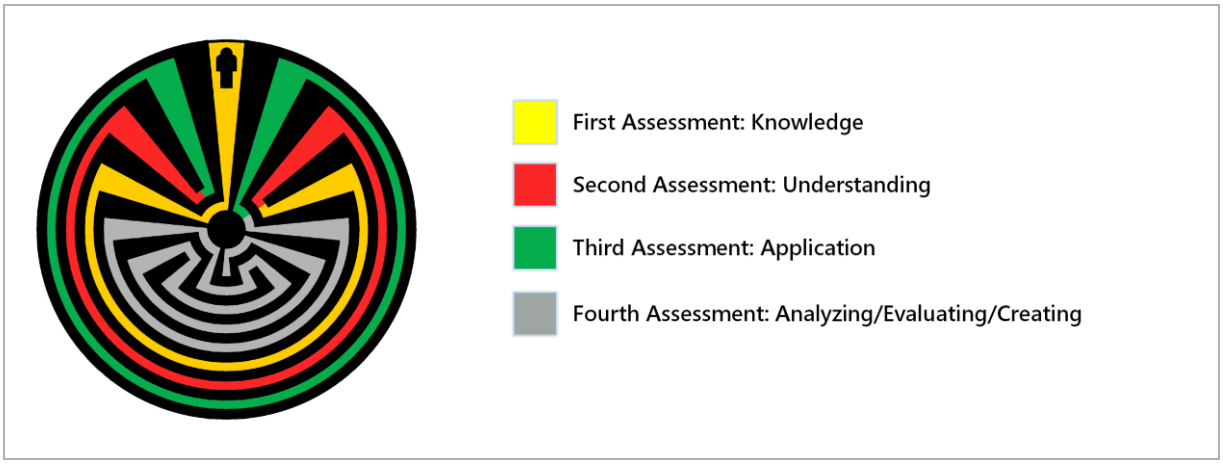

Figure 3. Indigenous education model derived from The Man in the Maze.

Our *MiME* model is unique in that it incorporates a focus on student empowerment through self-actualization and incorporates goals of identity, personal transformation and giving back to the community. This model addresses the whole student as well as the relationship of the student with self, others, and community -- all important elements of Indigenous education (Cajete, 2005). According to Deloria (1999), Indigenous education must acknowledge that "life is a unity" and must be founded on the "unified experience of being a human being." This model also incorporates elements of the highly successful Family Education Model (HeavyRunner & DeCelles, 2002) that asserts that retention programs must affirm and strengthen families' cultural, racial, and linguistic identities and enhance their ability to

function in a multicultural society. In addition, according to the Family Education Model, retention programs must include elders, be embedded in their communities and contribute to the community building process. Below, we outline how we will incorporate the *MiME Model* into our STEM students' educational journey at TOCC.

Program-level Assessment and Student Retention

This project will provide the support to apply the *MiME Model* across our science degree programs. A detailed explanation of this project and model is provided in Newberry et al (2016), but a brief synopsis follows. The *MiME Model* applied to the program level assessment model is based on three levels: the curriculum, student learning, and the student self-evaluation throughout the program (Table 2). Each level—curriculum, learning, and student self-evaluation –- has four journeys corresponding to the four journeys in the *Man in the Maze* (Figure 3).

The first journey is the introductory level and occurs during the first semester of the 2-year ASLS program. The curriculum during the first-semester journey is designed at the introductory level and the assessment of program level outcomes (PLOs), using Bloom's taxonomy, is at the knowledge level. During the first semester, the student sets personal goals for learning and self-development. The second semester, or journey, focuses on reinforcing PLOs and culminates in an assessment at the understanding level, including a second student self-assessment. The third journey relates to finding one's life purpose and taking on responsibilities; therefore, the third semester or journey continues to reinforce the PLOs through the application of knowledge. The final journey incorporates learning and assessment at the analysis, evaluation and/or synthesis level. From a cultural perspective, important components are the creation of something of value using acquired knowledge and sharing this value with the community. This journey culminates in a celebration that includes a presentation of capstone course projects to the community. The student self-assessment will include a reflection on accomplishments and lessons learned.

This is a holistic model of education because it accounts for the whole student as well as the relationship of the student with self, others, and community. The aims and goals of one's journey toward the true-self include strengthening identity, personal transformation, and giving back to the community.

Table 2. Program level application of the Man in the Maze Education Model.

Journey	Curriculum	Learning	True Self
First journey	Introduction of PLOs	Assessment at Knowledge Level (I)	Student self-assessment 1: Identify goals, timeline, and obstacles.
Second journey	Reinforcement of PLOs	Assessment of Understanding (R1)	Student self-assessment 2: Honest check-in and re-evaluation.
Third journey	Reinforcement of PLOs	Assessment for Application of Knowledge (R2)	Student self-assessment 3: Honest check-in and re-evaluation.
Fourth journey	Create something of value using knowledge gained and shared with community	Assessment for PLOs (A): analysis, evaluation, and synthesis.	Student self-assessment 4: Celebration of knowledge and completion of the journey; reflection on service to the community.

Journey 1: *Ma:cidag Wo:g* STEM (MWS) Learning Community and First-Year Experience

The *Ma:cidag Wo:g* STEM (*MWS*) first-year experience will include enrollment in a block course consisting of a STEM Pathways course and an introductory interdisciplinary science course. The 1-credit STEM Pathways course will introduce students to the *MiME Model* and give an overview of career pathways in STEM fields. In this course, the students will conduct their first self-evaluation and set their learning goals for their upcoming two-year program. Our cultural mentor Camillus Lopez will serve as a mentor for students, provide training for the *Man in the Maze* cultural metaphor, and facilitate the process of applying the metaphor to their academic studies at TOCC.

All new science majors will be required to take the interdisciplinary science course Environmental Biology in which the students will be introduced to TEK and learn basic scientific concepts using transdisciplinary approaches to education. This course is an ideal candidate for the incorporation of transdisciplinary approaches because it encompasses social science, ecology, environmental health, chemistry, physics, geology, and policy, law, and economics.

This work will draw on the foundations that were developed by TOCC's recent SWNL project (see Statement of Need) which sought to improve math and science instruction through interdisciplinary, high context learning. These thematic units were offered as part of an SWNL semester where math, science and Tohono O'odham culture classes met jointly to form a learning community to explore biodiversity, water resources, and climate change. Each unit incorporated a field trip to a culturally significant location, environmental sampling and lab work, and formal and informal lectures on math, science, and Tohono O'odham history and culture. This project will expand these thematic units to incorporate physical science and a health unit by the project's PI in collaboration with the cultural mentor and STEM faculty.

After completion of the *Ma:cidog Wo:g* first-year experience, a student is eligible to earn the designation Ma:cidag Wo:g (*MWS*) STEM Scholar. An *MWS* scholar is a student who successfully completes the First-Year Experience core curriculum, maintains at least a 3.0 cumulative GPA and displays the *T-So:son* (TOCC core values). Funds will be designated to compensate the *MWS* scholars at a rate of $1,000 per academic year for the top 5 students. The *MWS* scholars will be selected by a team of STEM faculty, PIs and co-PIs, and the cultural mentor. *MWS* STEM scholars are expected to maintain good academic standing throughout their degree program. They will be expected to serve as ambassadors for the STEM program at TOCC and participate in community and K-12 outreach to maintain their position as an *MWS* scholar.

Journeys 2 and 3: Indigenizing STEM Curriculum

Semesters 2 and 3 will focus on the reinforcement of PLOs through the application of Indigenous approaches to teaching, such as the incorporation of problem-based learning, service learning, and community-based action research, as well as transdisciplinary approaches. This draws on the work of Newberry et al. (2016) which piloted the use of the *MiME Model* to create culturally-based PBL units in selected STEM courses. The PBL units were infused with the unifying theme of sustainability and *T-So:son* (TOCC core values) to align our curriculum with the college's mission of strengthening the *Himdag*. This project will expand this approach across our STEM offerings The TOCC cultural mentor will provide ongoing mentoring for the students in their 2nd and 3rd self-evaluations.

To prepare faculty to incorporate these teaching strategies in their courses, this project will sponsor professional development in Indigenous education and develop a Maci:dag Wo:g STEM (MWS) Faculty Learning Community (FLC) to support this transformation in teaching. A Faculty Learning Community (FLC) is defined as a cross-disciplinary faculty group that conducts in-depth, ongoing, scholarly, and

systematic discussions within a common area of inquiry. FLC members develop and implement projects requiring them to apply and test new ideas and information about student learning.

The MWS FLC program will begin in May 2019 with a one-week workshop. This will be followed during the academic year by ongoing mentorship and support via monthly meetings. It will culminate in April 2020 with a showcase of accomplishments and will continue through Year 5 of the grant. In January 2019, we will conduct a needs assessment of faculty professional development and provide follow-on training during the May workshops. In addition to topics requested by the faculty, each year will have a focus or theme as follows:

Year 1: (May 2019-April 2020): Indigenous Education/Integrative, Transdisciplinary Learning

Year 2: (May 2020-April 2021): Problem-based Learning

Year 3: (May 2021-April 2022): CBPR/Action Research

Year 4: (May 2022-April 2023): Service Learning

As described in the proposal, FLC workshops will be conducted by educational consultants and experts in indigenous education. Dr. Octaviana Trujillo will serve as Indigenous education mentor for this project. She will provide faculty development workshops in Indigenous education, ongoing mentoring by participating in monthly MW FLC meetings in person or via videoconferencing, and will help identify and recruit expert consultants in indigenous education for the workshops held each May. Community members will also be invited to participate and provide input. Dr. Stephen Pompea of National Optical Astronomy Observatory (NOAO) will serve as an educational consultant through our agreement with NOAO to commit 5--10% of his time to this project (see grant letters of collaboration). Our educational consultants and the Cultural Mentor for this project will provide ongoing mentorship during the academic year by participating in the monthly FLC meetings in person or via video conferencing.

STEM faculty participating in the professional development workshop will receive a stipend upon completion of the 1-week summer workshop and production of a detailed curriculum proposal to implement in at least one of their courses the following year. TOCC faculty are required to incorporate T-So:son (core values) in their classes as part of job expectations and, therefore, faculty will be able to include workshop attendance and curriculum development in their annual faculty evaluation. TOCC faculty annual evaluations are strengthened by incorporating innovative teaching techniques and new approaches to learning, especially through constructive implementation of technology. Other faculty rewards include academic-year professional support from peers and educational consultants and the intrinsic reward of improving teaching effectiveness. In addition, our dissemination plan provides faculty opportunities to publish their innovative work and receive grant support for traveling to academic conferences.

The MW FLC will focus primarily on improving instructional practices and cultural competence. TOCC's strategic plan includes expanding the presence of online education opportunities, so we anticipate there will be on-going college-wide support and professional development for faculty delivering online courses in addition to the online Quality Matters Certification for science faculty in Year 1 of this project. Monthly MWS FLC meetings can provide additional peer support for faculty in developing and teaching online courses.

Journey 4: *Ma:cidog Wo:g STEM* Capstone Experience

Each of our science degree programs culminates in a Service Learning capstone course and a Research capstone course to assess the PLOs at the analysis, evaluation and/or synthesis level. These courses will be redesigned to ensure that the students' projects create value to give back to the community and to incorporate a celebration of learning. In addition, the students will have an opportunity to look back over their programs of study, reflect on their journey and set new goals, with the support of the cultural mentor and STEM faculty advisor, for their next educational or professional journey. This will also serve to help the student to transition to the university or workplace.

Goal 3: Enhance Professional Preparedness

Careers and Internships

We will hold an annual STEM career fair to connect students with internships in local and regional agencies that provide opportunities for professional development. The STEM Career fair will build on relationships that were initiated or strengthened through our visioning sessions. We will leverage our partnerships UA, ASU and NAU, federally funded agencies such as NOAO and NRCS, regional agencies such as the NPS and ASDM, and the Nation's departments to provide mentoring, research and internship opportunities for TOCC students.

Tohono Field Studies Center

We plan to use TOCC's rich, natural desert setting to create the Tohono ("desert") Field Studies (TFS) Center. The TFS Center will include natural desert experimental areas adjacent to our campuses, an astronomical observatory, a desert plant nature trail, an herbarium and natural history collection, and a public education exhibit area. It will provide exciting opportunities for STEM education and course-based research for TOCC students as well as opportunities for community and K-12 outreach. Since land is central to the cultural identity of the Tohono O'odham, these place-based educational experiences will serve to engage and promote interest in the natural sciences.

The TFS Center will serve as an outdoor lab for students to engage in hands-on learning and course-based research. The TFS Center will provide a natural laboratory for the exploration of topics such as the chemistry of soils, water relations of plants, phenology, biodiversity, rainfall patterns, energy balance in natural ecosystems, and properties of variable stars. The natural experimental areas will also serve as long-term ecological research sites for the monitoring and study of natural desert ecosystems, thereby providing students with opportunities to engage in real-world learning experiences in field measurements, mapping, and quantitative analysis of data. Through NASA sponsorship, TOCC recently purchased an herbarium cabinet and supplies, and a telescope and CCD camera providing a nucleus for the TFS Center.

The TFS Center will work synergistically with our educational initiatives to incorporate TEK into our courses. TEK is "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 2008), and is an important part of the *Himdag*. The TFS Center will build on TOCC's membership with the Indigenous Phenology Network (IPN) in the production and preservation of TEK. The IPN is a grassroots organization whose participants are interested in understanding changes to seasonality and timing of life cycle events, and in forecasting impacts to lands and species of importance to Native peoples. The group focuses on building relationships, ensuring benefits to Indigenous communities, and integrating Indigenous and Western

knowledge systems. The IPN's work is guided by the Relational Doctrine, a set of principles founded on the concept that all things are interconnected, which is in alignment with TOCC's mission and the *Himdag*.

The TFS Center will provide opportunities for exciting STEM outreach to the community and K-12 schools through a public educational exhibit area, outreach events, and web-based resources. TOCC's American Indian Science and Engineering Society (AISES) chapter has partnered with NOAO to host a bi-annual stargazing event open to the community. The development of a permanent astronomical observatory will enhance this event and give the public an opportunity to experience deep sky observing. TOCC currently has a guided walking path that will be further developed by the TFS Center activities, along with additional natural history exhibits.

The TFS Center will be developed by the STEM faculty and a TFS Curator to be hired under this grant. Three student researchers will assist in the development of the collections and web-based resources. Our cultural mentor will ensure appropriate use of the *Himdag* by the TFS Center. In addition, STEM students will be involved in the ongoing measurements, mapping, and development web-based and public educational displays.

Student Research

This project is committed to increasing research experiences for students as an essential and transformative element for their academic preparation and success. We will institutionalize undergraduate research by requiring a Research Methods course in the Associate of Science degrees, with a focus on Community-based Participatory Research. We will also create an elective 1-3 credit hour course in Independent Study and Research.

Beginning in Year 1, two student research assistants will be hired in support of developing the Tohono Field Studies (TFS) Center and will participate in research related to the TFS Center. In Year 2, three additional student research assistants will be supported: one for the Life Sciences program, one for Physics/Astronomy, and one for Chemistry. These students must have previously completed the Research Methods class to then serve as Research Mentors for students taking the Research Methods class.

The Tohono Field Studies Center will be instrumental in providing research opportunities for students. Co-PIs Newberry and Quijada will develop the Center as a facility for field research by faculty and students and as an inquiry-based component of STEM courses. The Co-PI's will coordinate and facilitate student research by proposing projects and collaborative initiatives with other institutions. Within this dynamic intellectual environment and locally rich natural environment, student curiosity and acquisition of scientific skills are expected to flourish.

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Goal 4: Support for Transitions from High School to TOCC to University

To ensure increased Nation member involvement in the STEM disciplines, it is important to attract pre-college students into STEM higher education programs. Potential students need to become aware of career opportunities in the STEM fields, to be interested in STEM, and to be ready to succeed in their preferred program of study. Students leaving TOCC and entering the university need to receive financial, academic and emotional support for transitioning to life outside of the Nation and to study at the university level. A critical aspect of our project is to provide support for students during their transitions from high school to TOCC and from TOCC to universities. These transitional phases are essential elements of our pathway to increase student enrollment and graduation.

Summer Bridge Program

The Summer Bridge Program will serve as a vehicle to introduce high school students to TOCC and opportunities in STEM careers and to strengthen their academic skills. The Summer Bridge programs will incorporate transdisciplinary, culturally-relevant educational approaches and introduce students to the exciting science program at TOCC that includes hands-on, student-centered educational approaches and the culturally-based *MiME Model*. The Summer Bridge Program will be taught by a team of 1 science faculty, 1 math faculty, 1 cultural faculty member and 1 high school teacher who, with the assistance of the cultural mentor, will offer a 2-week culture-based, transdisciplinary summer bridge program. A 2-credit class will be developed for students enrolled in the Summer Bridge Program.

Summer Science Institute

The Summer Science Institute will serve as a vehicle for STEM enrichment and to help prepare students for the university by strengthening their knowledge of scientific content, ability to engage in scientific inquiry and exposure to techniques and technologies used in both the field and laboratory. Some proposed areas of focus for the Summer Science Institute are observational astronomy, field geology, GIS computing, image processing and ethnobotany. In 2017, TOCC piloted a NASA Arizona Space Grant sponsored Summer Science Institute with a focus on astronomy, image processing, and astronomical tools. Nearly all student participants subsequently enrolled in our Astronomy class this fall. It is our intent to build on this momentum by continuing to offer a Summer Science Institute annually. The Summer Science Institute will be led by a team of 1 science faculty, 1 expert science consultant, and cultural faculty member, Philip Miguel. The expert science consultant will have expertise in an area outside of the TOCC faculty and will allow the students to have in-depth exposure to other fields. The Institute will extend approximately 6 weeks and include 40 hours of student contact time. Six students will be invited to participate through a competitive process and will each receive $800 upon completion of the Institute.

Native STEM Exchange

This project will sponsor an annual 3-day statewide Native STEM Exchange with the university and tribal college faculty and advisors across the state to share ideas and resources for Native student success at the university level. Through this institute, university faculty and advisors will gain first-hand experience of a tribal college and learn about Indigenous educational strategies that are used by tribal colleges. Tribal college faculty will learn about trends at the university level and about resources that can help our students transitioning to the university. The Native STEM Exchange will support the creation of 2+2 articulation programs that address not only the academic needs of the students but also provide access to resources to ensure that their financial and social needs are being met.

Intellectual Merit

A dominant theme emerging from decolonizing theory is that the goal of Indigenous education should be "to heal and transcend the effects of colonization" (Cajete, 2000, p. 181) and that Indigenous education must address the issue of decolonization directly. This proposal seeks to implement strategies to decolonize STEM education by understanding and explicitly addressing this issue in students' learning experiences by incorporating cultural symbols in STEM pedagogy. To make STEM learning meaningful and transformative for students, this project includes the incorporation of elements of Indigenous sovereignty, identity, and worldviews as part of the STEM learning experience. This project will explore systematic ways to increase student success in STEM programs through the application of an Indigenous education framework and innovative pedagogical approaches which can serve as a model for other underrepresented students and minority-serving institutions.

This project's support for innovative and transformative approaches to STEM education for Native students through the application of the *MiME Model* will contribute to the growing body of knowledge of a more holistic academic experience for Native students. Although the *MiME Model* is culturally specific to TOCC, the concept represented by the model for integrating STEM into a traditional cultural knowledge base may be applied across other TCUs and minority-serving academic institutions.

Broader Impact

This proposal seeks to enhance the participation and interest of Tohono O'odham students in STEM disciplines by expanding our STEM course offerings and incorporating a cultural symbol and tribal core values to Indigenize education in science and technology. Tohono O'odham students graduating from TOCC with an Associate of Science degree will have a strong sense of identity and culture to bring to the classroom, enhancing the sense of diversity at universities.

This proposal will assist more Tohono O'odham students to achieve postsecondary education and to be successful in their continuing university education, or as part of the local and national labor forces. This STEM program is uniquely adapted to the needs of our students and will contribute to the development of a core of TOCC graduates qualified to provide expertise in the STEM fields to their Nation. The project will strengthen collaborations among educational institutions, the STEM research community, and the Nation for this common purpose. TOCC students will employ their culturally-based STEM education, skills and a diverse set of perspectives to problem-solving that is critical for our modern society. Diverse professionals not only benefit their own communities, but also benefit society as a whole with their culture-based knowledge, motivation, and skills that bring unique perspectives to problem-solving that are critical in today's global society.