Results from the Implementation of Culturally-relevant Engineering Design Curriculum for the Navajo Nation and Future Directions

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Courtney Betoney is from Ganado, Arizona and is studying Mechanical Engineering Systems at Arizona State University. Since January 2014, Courtney has been an undergraduate researcher for Engineering Design Across Navajo Culture, Community, and Society. She has enjoyed the opportunity to collaborate within the engineering community and now hopes to continue towards a graduate degree for Mechanical Engineering.

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Ieshya Anderson is Naakétł'áhí (Tohono O'odham), born for Tł'ááshchí'í. Her cheii is Naakétł'áhí and her nálí is Tódích'íi'nii. Ieshya graduated from Arizona State University, Ira A. Fulton Schools of Engineering with a Bachelor of Science in Engineering, emphasis in electrical systems. She is pursuing her PhD in Engineering Education Systems and Design at Arizona State University. Ieshya also continues to work with Dr. Shawn Jordan to develop engineering design curricula for middle school students on the Navajo reservation and facilitates Dr. Jordan's STEAM Machines^{TM} outreach camps across the Navajo Nation with the ambition to expand to Tohono O'odham Nation.

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Executive Summary: Results from the implementation of culturally-relevant engineering design curriculum for the Navajo Nation and future directions

The purpose of this ongoing research is to study the intersection of Navajo culture and engineering design and use the results to develop culturally-relevant engineering design curriculum for middle schools in the Navajo Nation (Jordan, 2015). A design-based research approach (Design-Based Research Collective, 2003) is being used to develop curriculum and instruments, test curriculum, analyze data, and modify curriculum, repeating the process several times for continuous improvement.

Pilot 1: 2017 School Year

An initial curriculum pilot was conducted in 2017, where four curriculum modules were tested: (1) Introduction to Engineering Design, (2) Solution Dissection, (3) Distance Between the Sacred Mountains: A Lesson in Scale and Proportion, and (4) The Great Animal Escape: Portable Livestock Corral Design Project. Descriptions of these curriculum modules are in (Jordan et al., 2017). The curriculum was piloted with 59 students and two teachers across two middle schools on the Navajo Nation. Pilot results showed that students:

1. Had a better understanding of what engineers do
2. Knew what they needed to learn to become an engineer
3. Are aware of how their Navajo values and teachings can be used to better solve engineering problems
4. Are aware how the engineering process relates to the way that the students think as Navajo
5. Are aware how engineering can provide solutions for future generations of Navajo
6. See how their experiences growing up in the Navajo Nation would be helpful to them as engineers.

The primary concern expressed by students was that engineering requires too much paperwork, and therefore they were less interested in pursuing engineering as a career.

Current Progress: Pilot 2: 2018 School Year

In this design-based research study, results from the first pilot were used to create improved versions of the existing curriculum modules and to inform the development of several new curriculum modules that were piloted in spring 2018. The modules are:

1. *Future Chapter Presidents.* In this lesson, students invent their futures while learning about Navajo governmental mechanisms by learning about and running for Chapter President within their classrooms.

2. *Identifying a Project Goal and Creating a Prototype*. In this lesson, students take their Chapter President campaign ideas, identify a problem in the community that could be solved using engineering design, define constraints and criteria, brainstorm ideas, select a solution, and create a cardboard prototype of a solution to the problem.

3. *Introduction to the Engineering Profession*. In this lesson, students are introduced to the profession of engineering through the people who are engineers. Stories of Navajo engineers and the impact they make are shared, and students are asked to reflect on their

own motivations as they explore potential career pathways.

4. *Solving a Problem with the Scientific Method and the Diné Engineering Design Process.* In this lesson, students learn about and explain differences between the scientific method and the engineering design process, and then conduct hypothetical investigations using the different methods.

5. *Size of the Sacred Mountains: A Lesson in Scale and Proportion*. In this lesson, students learn the definition of scale, ratio, and proportion, and apply these concepts to calculating the distance between the sacred mountains and their hometown.

6. *Engineering Design Process Solution Dissection*. In this lesson, students step through an example engineering design process solution of different types of Navajo pottery.

7. *The Great Animal Escape: Portable Livestock Corral Design Project*. In this lesson, students design, build, and test scale models of portable livestock corrals using the engineering design process.

8. *Cultural Geometry of the Hogan*. In this lesson, students use knowledge of the Navajo Hogan (a traditional home) and apply geometry to calculate the area and volume of the octagon-shaped structure. They will also build a scale model of a Hogan that will be used in the last two lessons.

9. *Hogan Heat Transfer*. In this lesson, students learn about different types of heat transfer and apply their knowledge to test different types of insulation added to a scale model of a Hogan built in lesson 8.

10. *Bringing Electricity to the Remote Hogan: An Introduction to Photovoltaic System Design*. In this lesson, students will learn how to add solar power to their scale model Hogans. They will first learn about basic series and parallel circuits using paper circuits, and then learn how to measure voltage using a digital multimeter. Then, they will learn about the parts of a solar energy system and finally design and build a solar system for their scale model hogans that charges batteries and lights an LED.

Next Steps

Following the 2018 curriculum pilot, the curriculum will continue to be improved and additional curriculum modules will be added to build an even more robust culturally-relevant engineering design curriculum

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