

Dual-Credit Engineering Program in Native American Serving School District: Best Practices and Findings

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Dual-Credit Engineering Program in Native American Serving School District: Best Practices and Findings (RTP, Diversity)

ABSTRACT

Early exposure to engineering is a valuable strategy to ignite interest, curiosity, and enthusiasm among students from a young age. Early exposure to engineering programs - such as after-school activities, career exploration events, guest speakers, and industry visits - can provide engineering concepts and hands-on experiences to help students develop a strong foundation and inspire the next generation of minority engineers, fostering a diverse and innovative workforce.

However, implementing most early exposure to engineering programs in the locations where Native American students reside is challenging. Many Native American communities are in remote or geographically isolated areas, making it difficult to access external resources and hold early exposure to engineering programs regularly. One program that stands out is dual-credit engineering, offering a promising opportunity to expose and reinforce engineering concepts to Native American students.

Navajo Technical University (NTU), a tribal university, partners with a Native American-serving school district, Gallup-McKinley County School (GMCS), to offer a dual-credit engineering program. In this program, 12th-grade students from GMCS take two NTU first-year engineering courses: ENGR 130 - Engineering Graphics (Engineering Design) in the fall semester and ENGR 103 - Introduction to Engineering (which involves a hands-on engineering project and a project report) in the spring semester.

To investigate the program and understand students' experiences, qualitative analysis of students' reports was conducted using thematic analysis via OpenChatGPT. The results revealed four themes: (1) Fundamental Processes, (2) Challenges in Execution, (3) Teamwork and Collaboration, and (4) Learning and Adaptation. These findings indicate the effectiveness of dual-credit engineering in engaging young Native Americans in engineering and align with ABET students' learning outcomes. The paper details the partnership, course specifics, challenges, and findings from students' perspectives.

1. Introduction

Native Americans are underrepresented in science, technology, engineering, and mathematics (STEM). Despite comprising nearly 2.9% of the population (United States Census, 2020), they represent only 0.25% of all engineering bachelor's degree recipients, 0.3% of the U.S. engineering workforce, and 0.07% of all engineering faculty [1, 2, 3, 4, 5]. Various barriers may contribute to this underrepresentation, including limited access to quality STEM education, lack of role models, and socioeconomic challenges [6, 7, 8].

NTU engineering faculty have also observed that students from local school districts entering engineering programs are often ill-equipped for engineering education. Engineering requires deep learning supported by critical thinking and self-testing skills. Faculty note that while Science, Technology, Engineering, and Math (STEM) have become essential to K-12 students' education, engineering remains underrepresented in K-12 STEM. Few K-12 teachers have had formal exposure to engineering concepts and practices, a reality more pronounced in underrepresented student-serving school districts.

Furthermore, after COVID-19, NTU experienced a significant decline in engineering enrollment. These issues prompted NTU to partner with GMCS to implement a dual-credit engineering program, bringing first-year engineering courses to the high school senior class.

NTU is one of the tribal colleges and universities (TCUs) in the United States and the only TCU with ABET-accredited engineering programs. TCUs are institutions chartered by tribes or tribal organizations that serve Native American students. NTU is situated in Crownpoint, a community within the Navajo Nation in northwestern New Mexico. The university strives to prepare students for engineering, information technology, and environmental science careers. GMCS is located in the western part of New Mexico, with a student population that is 90 percent Native American.

Several intervention efforts have been developed to target more Native Americans in engineering, such as creating TCUs, the American Indian Science and Engineering Society (AISES), and scholarships to support Native American students pursuing STEM degrees. Most intervention efforts target colleges to recruit and retain students in engineering programs. Little tailored effort is directed at promoting engineering among K-12 Native American students.

Early exposure to engineering programs (STEM workshops, field trips, guest speakers, extracurricular activities, etc.) has been indicated to positively affect minority students' interest in engineering [9, 10, 11, 12, 13]. However, the remote locations of Native American communities make it challenging to implement such programs [14]. There is little or no engineering industry nearby where students can have industry tours or conversations with engineers to learn about engineering. Native American-serving school districts hardly have teachers with an engineering background or engineering competency and skills to introduce engineering concepts and conduct hands-on engineering projects with students. Programs such as the FIRST Robotics Competition are not taking place due to the lack of teachers to mentor students for such programs.

NTU partners with GMCS to offer ENGR 130: Engineering Graphics in the fall semester and ENGR 103: Introduction to Engineering in the spring semester. This dual-credit engineering program (see Fig. 1) involves one NTU engineering faculty member, one NTU engineering teaching assistant, two high school teachers, and 12th-grade students. The classes occur at the high school campus (Gallup High School) during the third period (11:20 am - 12:15 pm). NTU engineering faculty and teaching assistant travel to Gallup High School to teach the classes, and while NTU faculty teach, the high school teachers are also present in the classroom.

Fall Semester

- The teachers select students who have indicated an interest in the Dual Credit Engineering program.
- The teachers submit students' names to the school counselor.
- The school counselor provides students' details to the NTU dual coordinator, who registers them for ENGR 130—Engineering Graphics.
- Each student is given a laptop with installed SolidWorks software, which NTU supplies to GMCS.
- ENGR 130 – Engineering Graphics includes 16 weeks of lectures and at least 10 homework assignments that students submit via the NTU Blackboard portal.

Spring Semester

- Students who achieve good grades are registered for ENGR 103: Introduction to Engineering.
- ENGR 103: Introduction to Engineering involves design, manufacturing, building, and Arduino-based engineering processes.
- The project entails designing, fabricating, and assembling robotic vehicle parts.
- Students document their procedures and results and submit a final report.

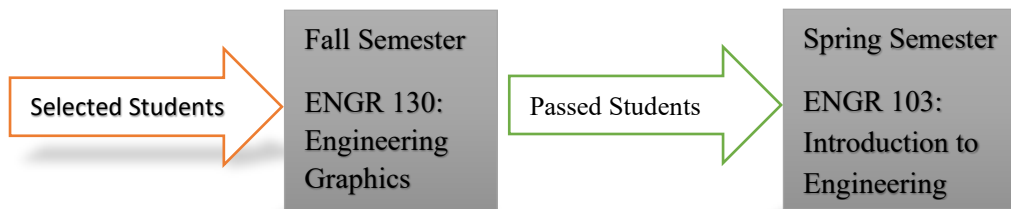


Figure 1. Schematic of NTU Dual-Credit Engineering

2. Literature Review

Engineering plays a central role in designing technologies, systems, and services that address human needs and desires. Diversity within engineering enriches innovations, as different cultures offer unique perspectives. Despite this, minority groups remain underrepresented in the U.S. engineering workforce. The demand for a diverse engineering workforce in the U.S. has grown, but the expected results have not been met. Particularly, the proportion of Native American students graduating with Science, Technology, Engineering, and Mathematics (STEM) degrees and entering the STEM workforce remains significantly low [4, 15, 16], with the situation being particularly acute in the engineering sector.

Federal agencies such as NSF, NASA, and DOE have allocated significant financial resources to increase Native American participation in engineering. Programs such as NSF TCUP, NNSA Tribal Engineering Program, NASA MUREP, and MAIANSE have supported Tribal Colleges and Universities (TCUs) and the enrollment of Native Americans in engineering programs.

Early exposure to engineering has been shown to be effective in increasing minority students' interest in engineering. However, some early exposure programs are challenging to implement, and commonly used

programs such as one-week summer workshops often lack engineering reinforcement and repeated exposure.

Research studies [17, 18, 19, 20] on dual-credit participation have demonstrated that students who take dual-credit courses perform well in their studies, graduate from high school at higher rates than their peers, require less first-semester remediation in college, and are more likely to obtain a college degree within four years. Dual-credit high school programs provide college access to students who may otherwise believe they cannot attend college.

Ferguson [21] found that dual-credit engineering courses can be a promising approach to diversifying the engineering workforce. The study indicated that such courses can increase the number of minority students who enter and graduate from engineering programs. Similarly, a study by the American Institutes for Research [22] found that dual-credit students were more likely to graduate from college and major in engineering than non-dual-credit students. Additionally, dual-credit engineering courses have been shown to increase the persistence of minority students in engineering majors [23, 24, 25].

Dual-credit programs, also known as dual enrollment or concurrent enrollment, emerged during the 1970s [18, 26, 27]. Initially developed for gifted and high-achieving students planning to attend college, these programs allow students to take college courses to build confidence, experience college expectations, and prepare for the transition to higher education.

NTU offers dual-credit engineering to promote engineering literacy, reinforce engineering concepts, and inspire confidence among young Native American students to enroll in engineering programs. NTU's dual-credit engineering incorporates hands-on projects, known as experiential learning, which have been shown to increase interest in pursuing sciences, improve self-efficacy and technical skills, and result in higher retention rates in engineering [26, 29, 30].

In New Mexico, every high school student interested in participating in the Dual Credit (D.C.) Program can enroll in college courses. This program provides access to academic, career, and technical education (CTE) courses that offer simultaneous credit toward high school graduation and a postsecondary degree or certificate.

NTU and GMCS seized the opportunity to launch a Dual-Credit engineering program. Research [31, 32, 33] has shown that in courses where high school teachers teach college courses in high school, better learning outcomes are achieved compared to other means of implementation. However, Native American-serving school districts often lack teachers with an engineering background or the competency and skills needed to introduce engineering concepts and conduct hands-on engineering projects with students.

3. Methods

3.1 Study Design

In this study, NTU faculty serve as the instructors for the dual-credit engineering courses, which are conducted at the high school campus. All instructional and support materials are provided by NTU, including SolidWorks SEK, filaments, robotics vehicle parts, electronics, Arduino basics, and sensors.

During the fall semester, students are enrolled in ENGR130 Engineering Graphics. This course consists of 16 weeks of lectures and includes at least ten homework assignments, which students submit via the NTU Blackboard portal.

Fall Semester: ENGR130- Engineering Graphics contents (Table 1) are as follows:

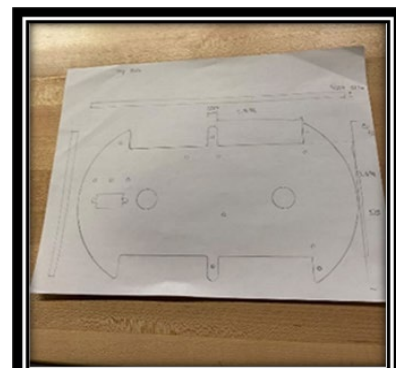
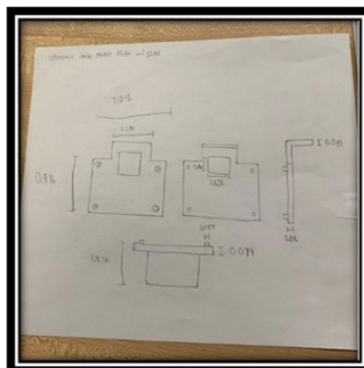
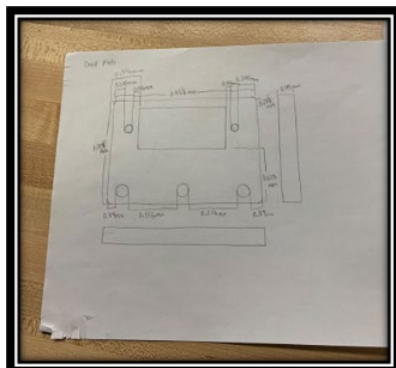
Table 1: ENGR130 Engineering Graphics		
Week	Class Topics	Due Date
Week 1	Introduction to computer-aided design Pictorials and Sketching	
Week 2	Overview of SOLIDWORKS and the User Interface	Homework 1
Week 3	Parametric Modeling Fundamentals	
Week 4	Constructive Solid Geometry Concepts	Homework 2
Week 5	Feature Design Tree	
Week 6	Geometric Relations Fundamentals	Homework 3
Week 7	Geometric Construction Tools	
Week 8	Orthographic Projections and Multiview Constructions	Homework 4
Week 9	Parent/Child Relationships and the BORN Technique	
Week 10	Feature Design Tree Geometric Construction Tools	Homework 5
Week 11	Orthographic Projections and Multiview Constructions	Homework 6
Week 12	Swept, Lofted, and Additional Features	Homework 7
Week 13	Symmetrical Features in Designs	
Week 14	Reference Geometry and Auxiliary Views	Homework 8
Week 15	Introduction to 3D Printing & Threads and Fasteners	Homework 9
Week 16	Advanced 3D Construction Tools	Homework 10

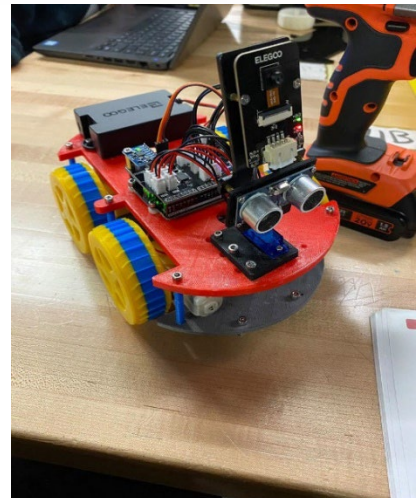
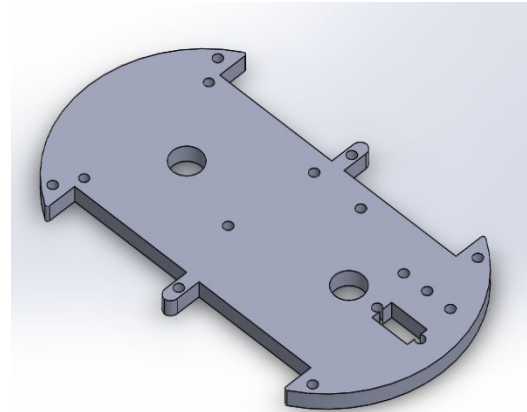
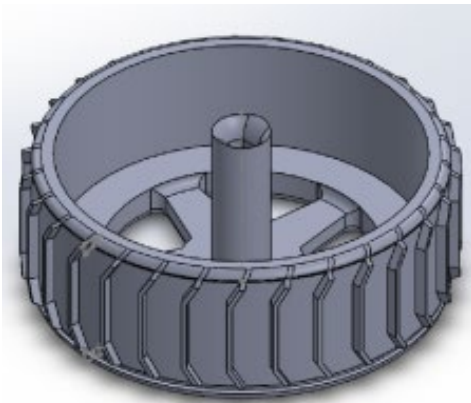
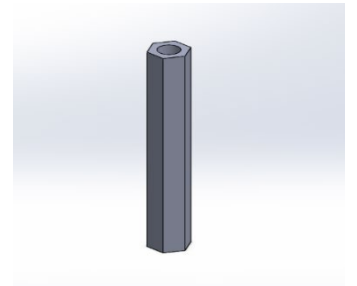
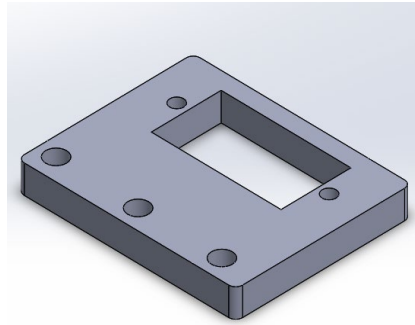
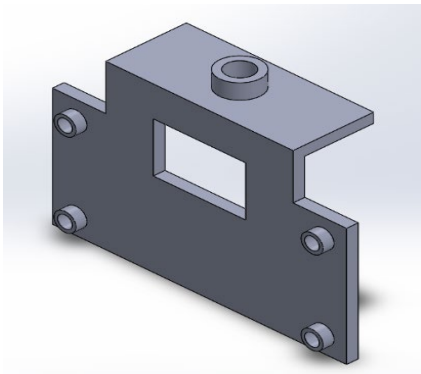
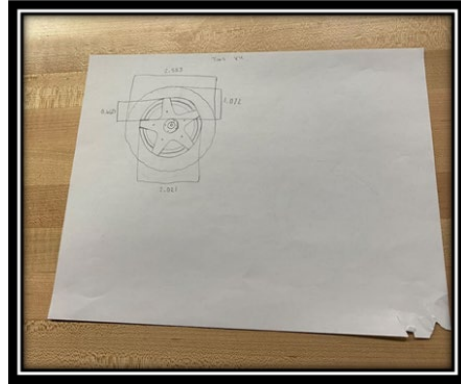
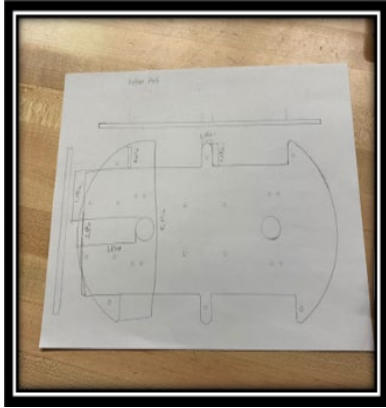
Spring Semester: ENGR 103 – Introduction to Engineering involves hands-on projects and Arduino-based projects. Students were divided into teams of 3-4 and provided with project guidelines, including milestones, due dates, and deliverables.

Table 2. Introduction to Engineering		
Milestone	Deliverable	Due Date
Milestone 1	<p>1 . Team</p> <ul style="list-style-type: none"> ○ Students form teams of 3-4 ○ All robotic vehicle parts: chassis, wheel, sensor holders, dead plate blocks, cylinder screws, electronics, batteries, and sensors are provided to each team. ○ Each team does a rough sketch of robotic vehicle parts except electronics, batteries, screws, and sensors <p>1 plain white paper for each part. Each team must sketch all the parts. Once the team completes the rough draft, they need to present it. What needs to be presented- their rough draft of what the team has done; each student in the team will take a turn to speak about each work and process, etc.</p>	Week 2

Milestone 2	<p>2. Dimensioning and Tolerance After sketching their design, the team measures the robotic vehicle's parts with detailed information- holes, locations, radius, etc. Use the following items. Ruler Digital calipers Once the team completes the rough draft, they must present it. Each student in the group takes turns speaking about each piece of work.</p>	Week 4
Milestone 3	Learn Coding with basic Arduino projects- Arduino download, Blinking LED, Blink 3 LED, Piezo buzzer	Week 5
Milestone 4	Design the vehicle parts in Solidworks Each team designs all parts in Solidworks with defined dimensions.	Week 6
Milestones 5	Research for part manufacturing. Each team researches a 3D printer, what parts are in a 3d printer, and about your school printer information for dimension and tolerance.	Week 8
Milestones 6	Parts Manufacturing Each team prints all their designed parts and takes pictures of parts and documents.	Week 10
Milestone 7	Learn Coding with Arduino projects- Photoresistor, Digital Dice	Week 11
Milestones 8	Building of their robotic vehicle: Assembly of 3D printed- parts with battery, screws, Arduino Uno, expansion board, ultrasonic sensor, and motor.	Week 12
Milestones 9	Verify Arduino codes and upload into the assembled robotic vehicle	Week 13
Milestones 10	Final technical report	Week 15

Students works are shown below:





3.2 Participants

The participants in this study were high school students enrolled in a Native American-serving school district. The Dual-Credit Engineering program began in 2021 and has been running for three consecutive years: 2021, 2022, and 2023. A total of 78 students and 3 teachers participated in the program during this time period.

Each team of students submits a project report at the end of the spring semester as part of the program requirements.

3.3 Data Collection Instrument(s)

For this study, a total of 10 reports were randomly selected from the participants' submissions. These reports were analyzed using Open ChatGPT to explore the students' experiences in the Dual-Credit Engineering program.

Open ChatGPT was utilized to conduct a thematic analysis of the reports. Each report was inputted into Open ChatGPT, which generated codes based on its content. These codes were then combined to form overall themes across all 10 reports.

The procedure for thematic analysis with Open ChatGPT is depicted in Figure 2. Instructions were provided to the Open ChatGPT to conduct qualitative coding, specifically initial coding (also known as open coding), on the students' reports. The text provided to the Open ChatGPT for analysis consisted of student reports, and detailed and descriptive codes were generated based on the content of the reports.

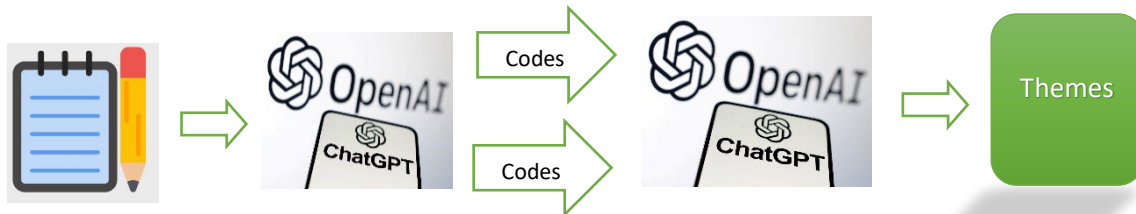


Figure 2. Procedure for Thematic Analysis with Open ChatGPT

The instruction ("prompts") is given to the Open ChatGPT as follows for the analysis of students' reports:

You are a researcher, I will now upload a high student report, and you will do what is called qualitative coding, specifically initial coding also known as open coding. The text is a student report. I want the codes to be detailed and descriptive. I want to apply codes to sentences or parts of sentences and later when you develop a list of codes, I want to be able to tell me what sentence or parts of a sentence these codes were applied to. In other words, when I ask you to provide example quotes for the codes that you create, I would like you to be able to do it. Here is the text to be coded:

Some of the students' reports of Open ChatGPT analysis as provided in the Appendix

3.4 Data Analysis Procedure(s)

The data analysis is conducted using thematic analysis, a highly flexible and widely used method for identifying, analyzing, and interpreting patterns of meaning (referred to as 'themes') within qualitative data.

Katz et al. [31] successfully labeled student comments using ChatGPT when a label taxonomy was provided. Building upon this approach, the thematic analysis in this study utilizes Open ChatGPT to generate themes from the coded data.

After the initial coding process, where codes were generated from the students' reports, all codes were inputted into Open ChatGPT for theme generation.

The following questions were parts of “Prompts” to lead to learning about students’ experiences in engineering and determine if some of ABET Criterion 3 are achieved in the program.

- Understand the student's experiences with engineering courses and hands-on projects.?
- Explain how participating students gain engineering knowledge in the project.
- How does the project affect the students' ability to function in the engineering team, and how did the program affect the students' confidence in doing engineering?

Open ChatGPT was provided with “Prompts” for themes generation as follows

The following is a list of codes that were created when qualitatively coding the content of students' projects. The purpose of the students is to understand their experiences with engineering courses and hands-on projects.? Explain how participating students gain engineering knowledge in the project. How does the project affect the students' ability to function in the engineering team, how did the program affect the students' confidence to do engineering?

Looking at the following codes, please try to identify four main themes and then allocate the codes to these respective themes to is to understand their experiences with engineering studies and projects.

Open ChatGPT Results as follows:

Theme 1: Fundamental Processes (F.P.)

SKT - Sketching Process

TUM - Measurement Tools

TDP - 3D Printing Process

BMP - Blueprint Measurement Process

Theme 2: Challenges in Execution (C.E.)

CAS - Assembly Challenges

IMP - Incorrect Measurements and Printing Issues

CBT - Challenges in Blueprint Transfer

Theme 3: Teamwork and Collaboration (T.C.)

TMC - Team Collaboration

FBP - Focus on Platforms and Blueprint

Theme 4: Learning and Adaptation (L.A.)

PFP - Parts Fixing Process

LAP - Learning Process in Assembly

IAS - Improvisation in Assembly

TRT - Robot Car Testing

4. Results

The qualitative analysis of the reports yielded four significant themes:

1. Fundamental Processes: This theme encompasses the fundamental engineering processes involved in the project. It includes codes related to sketching, measurement tools, 3D printing, and blueprint measurement. Students acquire foundational knowledge in conception, design, fabrication, and building engineering processes.

2. Challenges in Execution: This theme focuses on challenges encountered during project execution. It involves codes related to assembly challenges, incorrect measurements and printing issues, and challenges in blueprint transfer. Students develop problem-solving skills and gain experience overcoming obstacles and solving engineering challenges.

3. Teamwork and Collaboration: This theme highlights the importance of teamwork and collaboration in engineering projects. It includes codes related to team collaboration and a focus on platforms and blueprints. Students develop skills in working together and understanding project objectives.

4. Learning and Adaptation: This theme emphasizes the project's learning and adaptive aspects. It includes codes related to the parts fixing process, the learning process in assembly, improvisation in assembly, and robot car testing. Students acquire knowledge through hands-on experience and acquire new knowledge and skills to solve challenges.

These themes provide insights into the students' experiences participating in the Dual-Credit Engineering program and underscore the multifaceted nature of their learning journey.

5. Discussion

5.1 Interpretation

The identified themes provide a structured overview of the students' experiences in the Dual-Credit Engineering program, encompassing fundamental engineering processes, challenges in execution, teamwork and collaboration, and learning and adaptation aspects. These themes indicate that students are gaining engineering knowledge, skills, and the persistence needed to succeed in engineering programs. Moreover, the findings align with ABET students' learning outcomes, particularly in terms of engineering design, teamwork, and lifelong learning skills.

5.2 Compare and Contrast

As the majority of Native Americans are first-generation college students, NTU's dual-credit engineering program offers critical exposure to the expectations of an engineering program to 12th-grade Native American students. Research[32,33] indicates that first-generation students often face unique challenges in pursuing STEM careers. Dual-credit programs, anchored on transition and expectancy-value theories, aim to smooth the academic and social transition from high school to college, enhance students'

expectations of success in engineering classes, and increase the perceived value of pursuing higher education.

The program's incorporation of engaging and active learning positively impacts young students' interest in pursuing engineering careers. The challenges encountered in the execution theme demonstrate that dual-credit engineering prepares Native American students for the rigorous academic environment of engineering programs by fostering problem-solving skills and overcoming obstacles. This increased readiness can contribute to their success in college engineering courses. Studies [34, 35, 28] indicate that dual credit programs offer high school students the chance to participate in more challenging coursework than in high school.

Similarly, the learning and adaptation theme indicates students' opportunities to complete dual-credit engineering courses and gain valuable learning experiences. Early adaptation to challenging coursework can positively impact students' college aspirations. This aligns with the commonly cited reasons for creating dual enrollment programs, facilitating a smoother transition between high school and college. [36, 37]

5.3 Implications for Practitioners

Dual-credit engineering courses are powerful tools for closing the gap in engineering education for Native American students. By investing in resources, promoting collaboration, and fostering culturally inclusive learning environments, practitioners can unlock the potential of dual-credit programs and empower more Native American students to pursue rewarding careers in engineering. Native American-serving school districts should actively seek partnerships with higher education institutions to incorporate engineering courses into their dual-enrollment programs.

Tribal Colleges and Universities (TCUs) are vital in offering higher education and culturally relevant learning environments for Native American students. TCUs should seize every opportunity to introduce engineering programs and develop dual-credit engineering partnerships with local school districts. Such programs can significantly impact steering young Native Americans towards engineering careers.

6. Conclusion

6.1 Respond to Research Question / Objective

The effectiveness of the Dual-Credit Engineering program was assessed through several key questions:

- How do participating students gain engineering knowledge in the project?

Participating students reported a sense of accomplishment, indicating that the program effectively promotes their self-efficacy and provides exposure to the challenges and rewards of engineering. This experience helps Native American students develop the perseverance and grit necessary to overcome challenges in engineering programs.

- How does the project affect the students' ability to function in engineering teams?

The program fosters student collaboration and teamwork, as indicated by their engagement in group projects and interactions with high school teachers. This collaborative environment enhances students' ability to work effectively in engineering teams.

- How did the program affect the students' confidence to engage in engineering?

Students' increased enrollment and positive word-of-mouth promotion of the program suggest that they perceive value in the Dual-Credit Engineering program. This increased confidence and enthusiasm for engineering among Native American students can have long-term benefits for their educational and career pathways.

The program's success is evidenced by the increasing student enrollment over the years, attributed to improved organization, effective recruitment, and positive student experiences.

6.2 Emphasize Takeaway

The university must purchase all instructional materials for the program and have them ready before the program begins. Classes take place at high school to provide a stable learning environment, as students do not have to be bussed to the university campus, and the presence of high school teachers is mandatory.

The high school teachers in the program are gaining engineering knowledge and skills to the extent that they assist students during classes. This is akin to teacher professional development advocated by Lin et al. [38] for infusing the engineering design process into K-12 STEM project-based learning.

The unique challenges faced by Native American communities, including geographical remoteness and limited access to engineering resources and expertise, underscore the importance of sustained and meaningful exposure to engineering programs. One-off workshops do not provide the necessary engineering literacy and motivation to significantly increase Native American enrollment in engineering.

Tribal Colleges and Universities (TCUs) present an opportunity to address these challenges through dual-credit engineering programs. These programs can introduce and reinforce engineering concepts to young Native Americans, ultimately increasing their representation in engineering fields.

6.3 Limitations and Future Research

This study is subject to certain limitations. The analysis was based on a limited sample of 10 student teams' reports, which may not fully capture the breadth of experiences across all participants. Future research should include a larger sample size encompassing reports from all three years of the program to provide a more comprehensive understanding of student experiences.

Additionally, the study would benefit from validation through replication at multiple TCUs offering dual-credit engineering programs to ensure the reliability and repeatability of findings. Future research should also explore the program's weaknesses from the students' perspective and utilize prompts to identify opportunities for continuous improvement.

Acknowledgments

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Appendix

REPORT #1 ChatGPT Output.

Let's create detailed and descriptive codes for the qualitative coding of the student report:

1. Measurement Challenges in Solid Works:

- Code: MCS
- Description: Describes challenges faced in measuring circles in Solid Works due to limitations in measuring from the center.

2. Top Plate Challenges:

- Code: TPC
- Description: Highlights challenges in creating the top plate, including incorrect measurements and small screw holes.

3. Inconsistency in Screw Hole Sizes:

- Code: ISH
- Description: Refers to problems arising from inconsistent sizes of screw holes and the need to use a drill to adjust.

4. Communication Issues Affecting Parts Alignment:

- Code: CIA
- Description: Discusses the inconsistency between the top and bottom plate due to communication issues within the team.

5. Remeasuring for Bottom Plate:

- Code: RMB
- Description: Describes the need to remeasure and adjust the bottom plate for accuracy.

6. Difficulty in Bottom Plate Assembly:

- Code: DBA
- Description: Explains difficulties faced in assembling the bottom plate, involving drilling and reconstruction.

7. Consistency and Mistakes as Learning:

- Code: CAL
- Description: Reflects on the importance of consistency, learning from mistakes, and the overall positive experience.

8. Servo Mount Plate Challenges:

- Code: SMC

- Description: Mentions challenges faced in designing the Servo Mount Plate, including issues with screw hole measurements.

9. Smooth Process for Robot Wheels:

- Code: SWP
- Description: Describes a smooth process in creating the wheels with minimal problems affecting fitment or function.

10. Aluminum Block Challenges:

- Code: ABC
- Description: Discusses challenges in measuring the curve and threading screws in the Aluminum block.

11. Unique Challenges in Separation Pillars:

- Code: UPC
- Description: Highlights unique challenges in designing and printing separation pillars, including precision issues with screw holes.

12. Final Build Challenges:

- Code: FBC
- Description: Summarizes challenges in the final build, including parts misalignment, screw fitting issues, and breakage.

List of Codes:

- MCS - Measurement Challenges in Solid Works
- TPC - Top Plate Challenges
- ISH - Inconsistency in Screw Hole Sizes
- CIA - Communication Issues Affecting Parts Alignment
- RMB - Remeasuring for Bottom Plate
- DBA - Difficulty in Bottom Plate Assembly
- CAL - Consistency and Mistakes as Learning
- SMC - Servo Mount Plate Challenges
- SWP - Smooth Process for Robot Wheels
- ABC - Aluminum Block Challenges
- UPC - Unique Challenges in Separation Pillars
- FBC - Final Build Challenges

These codes cover various aspects of the student report, addressing challenges in measurements, communication, assembly, and the overall learning experience. Feel free to ask for example quotes or any additional information related to these codes!

REPORT #2 ChatGPT Output.

Sure, let's start the qualitative coding (open coding) process. I'll provide detailed and descriptive codes for various parts of the text.

1. Sketching and Measurement Process:

- Code: SKT
- Example Quote: "For the rough sketching we copied out the drawing and that's how we sketched it out then we found out the measurement."

2. Tools Used for Measurement:

- Code: TUM
- Example Quote: "The tools we used to make the measurement is called a caliper, paper for the sketching, pencil for drawing the rough sketch also for the measurement, ruler for measuring the length and the wide of the parts we need to make the robot..."

3. Challenges in Assembly:

- Code: CAS
- Example Quote: "It's hard to put the parts together because once we mess up a part, we got to reprint it and it might take longer to do..."

4. Time Taken for Project:

- Code: TTP
- Example Quote: "Me personally it took almost 3 weeks to do because we had to fix the parts..."

5. Team Collaboration:

- Code: TMC
- Example Quote: "I'm glad I had a team that will help each other and define problems."

6. Blueprint and Solid Works:

- Code: BSW
- Example Quote: "When we started a new lesson on assembling the robot, there was multiple problems we had to overcome. Our focus was to sketch platforms, and later use the blueprint to create a similar model on Solid Works."

7. Incorrect Measurements:

- Code: IMT
- Example Quote: "The biggest mistake we faced was the incorrect measurements we printed on the 3D printer. Our platform that holds the main electronic system was slightly smaller than the other platform that goes on top."

8. Part Breakage and Fixes:

- Code: PBF
- Example Quote: "As you can see, there are some parts that we broke to try to fix our robot but we still have the time to make our right parts to make our robot."

9. **3D Printing Process:**

- Code: TDP
- Example Quote: "What we did to make our parts is we use our computers and a 3D printer to make it for the computer we use an app called Solid works and we built our part there to make our robot then once we had our part done we had to use a flash drive to put the part on there so we can be able to print it out."

10. **Learning Process:**

- Code: LPR
- Example Quote: "When we first started assembling the robot, it took a while to get used to where every wire goes and to learn what every wire does."

11. **Improvisation in Assembly:**

- Code: IAS
- Example Quote: "The plates that we created did not fit together. So, we had to improvise and drill some extra holes so the plates so that every component could fit together."

12. **Testing the Robot:**

- Code: TRT
- Example Quote: "Once we put all the parts we made together feels like an accomplishment because it was a struggle to build all the individual parts so that the robot car won't have any flaws and issues."

13. **Blueprint Measurement Process:**

- Code: BMP
- Example Quote: "The first thing we did was use the actual piece from the box and trace it onto a clear sheet of paper. After that, the team used a caliper to measure the distance from the holes to the side."

14. **Challenges in Blueprint Transfer:**

- Code: CBT
- Example Quote: "Despite this, we had to learn how to transfer the measurements from the actual robot part to the sketch so that we could print out our version of the robot part from a 3D print machine."

List of Codes:

- SKT - Sketching Process
- TUM - Measurement Tools

- CAS - Assembly Challenges
- TTP - Project Timeframe
- TMC - Team Collaboration
- FBP - Focus on Platforms and Blueprint
- IMP - Incorrect Measurements and Printing Issues
- PFP - Parts Fixing Process
- TDP - 3D Printing Process
- LAP - Learning Process in Assembly
- IAS - Improvisation in Assembly
- TRT - Robot Car Testing
- BMP - Blueprint Measurement Process
- CBT - Challenges in Blueprint Transfer