Science, Technology, Engineering, and Mathematics (STEM) Project-based Learning Education: A New Mexico Case Study for Equity and Inclusion

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ABSTRACT

This research was designed to understand and address STEM education solutions for both rural and urban school systems. The focus on mathematics achievement, project-based learning (PBL) student experiences, and high school counselor perspectives, coupled with STEM education organization personnel's perceptions showcases the educational differences that underrepresented New Mexico (NM) students must work to overcome throughout their educational careers. The study identified and analyzed NM-based public school programming that engages and supports high school students in STEM educational pathways. It allowed for the examination of how PBL practices, laced with intentional cultural connections through STEM education, may or may not work to equalize access and opportunity for underrepresented minority students. Overall, this study reveals, categorizes, and proposes national solutions for educational challenges within the shifting digital economy. Challenges that underrepresented minority high school students undergo regarding equity, inclusion, and sustainable trajectories in STEM and STEM-related career fields are identified and highlighted.

KEYWORDS: STEM Education, STEM, Project-based Learning, PBL, New Mexico, Public School, Underrepresented Minority Students, High School Counselor, STEM Personnel.

1 INTRODUCTION

The students of NM are unique in their demographics. As a collective, they consist of underrepresented minority students with large numbers living in rural and low socio-economic status families. Hispanic and Native American student and community demographics in the state are higher than most of the U.S. Food insecurity, free or reduced-price lunch rates, and English learner demographics are also often higher, whereas student achievement, graduation rates and household income are lower than many of the eastern seaboard states, where various and impactful educational initiatives have historically been developed.

A student's enrollment and success in certain courses can oftentimes help to ascertain a student's success with academic engagement, intent to graduate, and further interest in the STEM fields (Sadler et al., 2014; Weiss, 2022). Utilizing the high school counselor lens to scrutinize the unique NM student population can help the greater education community in understanding the STEM-based student outcomes of PBL education strategies. Capturing relevant student experiences from across NM's diverse educational stage can expedite the identification of patterns that build success

or create barriers for various underrepresented minorities students and STEM education.

1.1 Background for Study

The U.S. has a widely varying population of students. New Mexico educates over 330,000 K-12 students throughout 89 school districts and in 96 charter schools (New Mexico First, 2016a). These students are ethnically diverse with a majority Hispanic population (61.3%), as well as a large portion of Native American students (10.2%) in comparison to the rest of the U.S. student population (see Appendix, Figures 1 and 2).

When using math proficiency scores as a gauge across national platforms, NM fourth and eighth grade students rank near the bottom for student achievement. Their collective standardized math and reading test scores have been among the lowest across the nation when compared to their peers (New Mexico First, 2016a, 2016b). Using the past decade as a longitudinal landscape, in 2013 the national student math proficiency level was a notable 10 percentage points higher than the NM student proficiency level of 31% (New Mexico First, 2016b).

Teaching STEM literacy through PBL methodologies naturally combines the interdisciplinary range of STEM education, teamwork, and project management while purposefully connecting students with their surroundings and culture. Yosso (2005) refers to culture as "behaviors and values that are learned, shared and exhibited by a group of people." Described as an array of characteristics, culture can also be evidenced in the material and nonmaterial interpretations of a people. Culture is commonly and systematically identified as "values" and is often driven by societies' privileged groups (Yosso, 2005).

The culture of NM is unique and varies across race, region, economic, political, and family belief structures. The prevalent culture of NM's underrepresented minority students is often unrecognized and/or undervalued by larger society. This societal inequality can put students in circumstances of educational disparity, particularly in the STEM career pathways. Increasing the skill set of NM's student population necessitates building the capacity and understanding for culturally relevant and engaging curriculum, team building and training for school faculty and staff, and increased resources to support these activities on K-12 campuses across the state.

STEM-linked PBL education reform efforts can assist in reaching student equity goals by focusing on the development and delivery of intentionally positive and constructive teacher professional development (PD) opportunities (Bybee, 2010; Wells, 2008). These opportunities can be built to utilize the structure of the STEM fields while purposefully integrating PBL components to help create well rounded, economically viable, and STEM literate student citizens. This STEM PBL education concept labors to enhance the U.S.'s ability to build a workforce that is competitive globally (Reeve, 2015), while highlighting the creative components of pedagogy. STEM PBL education functions to maintain rigor and encourage diverse thinking by students through different perspectives in thought, interpretation, and action.

1.2 High School Counselors as Interpretive Guides to Student Success

Looking through the high school counselor lens, the original and distinct intersection of social sciences and STEM educational pathways in our public schools can be revealed. The high school counselor's position with the K-12 school system is unique as they oversee multitudes of students

within their educational ecosystems. Their observations and responses represent the nuanced professional voices where NM public education intersects with STEM student interest and cultural influence.

High school counselors work to hold an interdisciplinary and professional perspective. Their engagement with students across various comparative abilities helps them to have a broader view on the career spectrum than perhaps a single or multi-subject teacher. School counselors are trained to help students to engage in academic achievement strategies, manage their emotions, harness and employ their interpersonal skills, and develop their postsecondary options (ASCA, 2022). School counselors intersect with the average high school graduate at points of the human decision-making paradigm that encompasses the high school graduation process. They also help to oversee the successful completion of NM graduation requirements as mandated by law.

2 METHODOLOGY

Research question: How does participation in STEM PBL education activities encourage underrepresented minority student achievement in STEM career field trajectories?

Through this research (Scheerer, 2022), interviewees' thinking was probed by engaging them with in-depth interview questions. The questions were constructed to allow participants to share their experiences and perceptions. This allowed for themes to emerge that were utilized to construct meaning. Bounded within the geographical state lines of NM, there were 19 subjects interviewed: seven high school counselors and 12 STEM education organization personnel.

2.1 Research Design

An exploratory research design was utilized to examine the relationships between ethnicity, PBL, and student achievement (particularly in mathematics). Seven original high school counselor interviews led to the development of a second set of interview questions. Secondary questions were used during supplementary interviews with 12 STEM education organization partners identified in the initial interviews with NM counselors. This second set of interviews assisted in facilitating a bridge of understanding to enhance STEM education support throughout NM and nationally.

2.2 Methods

The qualitative interviews were recorded via Zoom in 2021 and 2022 using a semi-structured interview protocol consisting of open-ended questions. Efforts were taken to conduct geographically diverse interviews with STEM organization personnel and high school counselors from NM public schools (see Appendix, Figure 3). To address potential internal validity threat, interview answers were verbally verified in real-time and notes were reviewed for accuracy and/or ambiguity.

3 RESULTS

The highlights of interviewee's perception of STEM and STEM-related education opportunities are shared below.

3.1 Whose Voice are We Hearing?

All high school counselors interviewed for this study were able to identify the unique characteristics of the students and the communities in which their students live. Some descriptors the counselors noted included but are not limited to: they come from multi-generational families, there are many bilingual students, it's a Title 1 school, there are multiple English Learners (EL), students are a majority Hispanic/Latinx, the students are polite and respectful, there is a large agricultural influence, the students are accepting, and there is a small Native American/American Indian population.

All of the STEM organization personnel interviewees in this secondary round of interviews had obtained their Bachelor's degree at the time of their interview. The majority, but not all, of the participants earned degrees in STEM or STEM related fields. One-third of the professionals interviewed in the second round had earned their Master's degree. Four of the 12 participants earned doctoral degrees representing a variety of fields.

3.2 What Does a High School Transcript Tell Us?

High school counselors were asked what stands out on the transcript of a student on a STEM career track. This question probed counselors to assess student's alignment with STEM or STEM-relevant trajectories in either higher education, certificate based/trade opportunities, the U.S. armed forces and/or related workforce support. Forty-three percent of respondents noted Advanced Placement (AP) classes. Five of the seven counselors mentioned dual credit courses, where high school students enroll with an institution of higher education for credit at both entities. Seventy-one percent of counselors also identified STEM and/or STEM adjacent elective courses as pertinent. All seven interviewees shared that success in mathematics sequenced classes stands out on student transcripts.

When STEM organization personnel were asked what stands out on the transcript of a student on a STEM career track, 9 of the 12 interviewees stated that math was an early indicator of, or barrier to, a student's success. AP courses and dual credit options registered somewhat similarly to the counselors with 42% and 58% of interviewees respectively. The 12 STEM organization personnel mentioned elective courses less than their counseling counterparts; just three of the interviewees brought these courses up during their interview.

Interestingly, four of the participants (33%), commented on grade point average (GPA). Notably, these comments were not to suggest to students needing to obtain a high GPA but rather in reference to how a student's GPA merely tells a fraction of an academic story about a student. In contrast, none of the counselors mentioned GPA in response to this question.

3.3 Programs and/or Organizations that Grow Students through STEM Education

When high school counselors were asked "when you think of educational enrichment programs or organizations that really 'get it right,' who comes to mind?" an inventory representing local, regional, and national entities was created. The 12 secondary interviewees were pulled from this inventory. When the counselors were encouraged to expand on the reasons why they liked or appreciated the different organizations or programs noted there were 52 responses coded into 4 categories, see Table 1 below.

Coded Category	Percent of Total Responses	Category Descriptor
Academic Support	38%	Additional academic support, beyond the regular school experience, is provided for students.
Broadens Network	37%	The activities/actions of the program or organization works to broaden the students' network.
Hands On Education	19%	The student gains exposure or experience with hands-on education learning styles.
Other	6%	Responses beyond those categories listed above.

Table 1: Coded responses (n = 52) showing what high school counselors perceive that educational enrichment programs and/or organizations do for students on their campus that they like or appreciate.

The two categories with the highest response rate, nearly 40% each, are the groupings that identify an increase in academic support for students while also broadening their networks. Nineteen percent of high school counselor responses shared that engaging students' directly with hands-on education styles serves as an asset.

It is important to note that one counselor did share a student barrier to academic support and therefore perceived STEM success on their campus. They stated that due to their school community's rural location, there were not many programs and/or organizations available to the students. The counselor articulated that the distance to the school can serve as a travel barrier for program and/or organization staff. As the majority of NM lands are rural, this response serves as an indicator of counselor awareness regarding the lack of student opportunity due to expansive lands and low population.

To expand on those programmatic and/or organizational experiences, the counselors were asked, "how do you think these programs help students to succeed, if at all, with their college of future career plans?" The 49 responses are presented in Table 2.

Coded Category	Percent of Total Responses	Category Descriptor
Engagement Builds Skill Sets	39%	Student engagement grows and/or builds the student's skill sets beyond the traditional classroom and/or campus experience.
Fiscal Security	4%	Identifying the fiscal security of numerous STEM career pathways with students.
Mentoring	18%	Mentors and/or mentoring is provided for the student.
Student Support	31%	The student is supported in ways that are beyond the traditional classroom and/or campus experience.
Translation Services	2%	Translation services are provided beyond that traditional classroom and/or campus experience; specifically Spanish.
Other	6%	Student success is outside of the categories mentioned above.

Table 2: Coded responses (n = 49) showing how high school counselors perceive educational enrichment programs and/or organizations help students to succeed with their college or future career plans.

Engaging students beyond the traditional classroom and/or campus experiences to build skill sets is the category coded with the highest number of responses (39%). Student support (31%) was identified in a variety of ways, including career guidance, paying or waiving fees, providing access to STEM friendly spaces, cooperation in bringing guest speakers to campus, as well as getting kids off campus.

Over the course of the interviews, participants were asked about any barriers to a student's STEM success they may be able to identify. Answers were based on interviewee perceptions, access to academic records, and knowledge of their community. One counselor shared that district contracts with local colleges and/or universities can be difficult to navigate for staff and students. Their dialogue was interpreted to mean that they were unsure of what agency (school, district, or Public Education Department) managed those negotiations. Another counselor mentioned the lack of availability of computer science courses for high school students.

3.4 STEM Programmatic and/or Organizational Influence

Multiple NM based influential organizations were identified and their impacts on STEM interested students and high school campus life were cataloged. Secondary interviews were with people whose careers were dedicated to assisting students along various STEM and STEM-related pathways. The STEM organization personnel were asked, among other questions, what their program and/or organization did for STEM-interested students that they like or appreciate. The data was coded into four response categories. The 69 collective responses are exhibited in Table 3.

Coded Category	Percent of Total Responses	Category Descriptor
Broadens Network	29%	The activities/actions of the program or organization work to broaden the students' network.
Educator Growth	9%	Educators on the school campus that are involved with the program or organization have access to additional PD experiences beyond that of a regular school campus.
Financial Support	20%	Students, educators, and/or the larger school campuses have access and exposure to specific funds that help to acquire resources, equipment, and/or materials beyond the scope of the regular campus experience.
Student Growth	42%	Students have exposure and opportunities to engage in learning pedagogies and resources that enhance student growth through interactive personal and academic learning experiences.

Table 3: Coded responses (n = 69) showing what STEM organization personnel perceive that educational enrichment programs and/or organizations do for students that they like or appreciate.

Noticeably, 42% of coded responses identified components of student growth. Examples of replies in this category included referencing a student's "well-roundedness," specific curriculum that engages critical thinking, and/or experiences with "hands on education" styles.

Twenty-nine percent of responses, coded as Broadens Network, identified the student impacts of widening their baseline of discovery, mentoring, and community. Financial support was listed in 20% of responses. This support could be provided directly to the student in the form of employment, stipends, or scholarships or more indirectly in terms of equipment, time, and educational

materials. This category also included more general financial support responses related to benefits a classroom or campus might experience due to leveraging collaborative partnerships.

Differing from the high school counselor responses, STEM organization personnel exhibited knowledge of the benefits their programs or organizations had for educator development. Nine percent of participants shared information about how their program or organization helped to bring workshops and/or training to help develop educators in their networks. This included providing access to PD in STEM relevant and related content areas.

Next, STEM organization personnel interviewees were asked how they thought that their program or organization helped students to succeed with their college or future career plans. The 60 responses are coded in Table 4 below.

Coded Category	Percent of Total Responses	Category Descriptor
Educator Growth	7%	School based educators that are involved with the program or organization have access to additional professional development training and experiences.
Financial Security	15%	Comments identifying the financial contributions of the program and/or organization to either students or school campuses.
Mentoring	18%	Mentors and/or mentoring is part of the student experience.
Off Campus Excursions	10%	Students are specifically engaged with education activities in their community and beyond the traditional school campus.
Student Growth Through STEM Experiences	50%	Students have exposure and opportunities to engage in learning pedagogies that enhance student growth through interactive STEM learning experiences.

Table 4: Coded responses (n = 60) showing how STEM organization personnel perceive their program or organization helps students to succeed with their college or future career plans.

Half of the responses were coded in the student growth category. A notable quote illustrating student growth declared that students learn to be "a team member and how to work with others." Other comments referred to gains in critical thinking skills, increasing a student's well-roundedness, accountability, attendance, as well as the enhancement of soft skills, and developing an open mind to deal with problems.

Additional responses to this question referenced opening doors in terms of financial security (15%), mentoring opportunities (18%), and off campus excursions (10%). This collective 43% works to shuttle students into career field trajectories via support mechanisms that provides exposure to professionals, locations of study and/or employment opportunities, and financial supports beyond their local school campuses.

The final four responses (educator growth, 7%) described how STEM organization personnel deem educator PD opportunities to be important to student success with their college or future career plans.

STEM personnel participants were also asked about any barriers to a student's STEM success they may be able to identify. Two interviewees noted that many college/university students were

underprepared or did not have the sufficient scaffolding of courses for certain STEM-related higher education courses. One person, verbalizing the same concern, spoke excitedly about the concept of co-requisites as an approach to encourage student persistence in STEM career fields.

3.5 Resources for Personnel to Develop Their Toolboxes of Best Practices

One interview question asked the participants to respond as to how their organization helps them to develop best practices for dealing with underrepresented students and communities. The 12 STEM organization personnel had 73 collective responses; coded descriptor categories are shown in Table 5.

Coded Category	Percent of Total Responses	Category Descriptor
Culture of Inclusion	45%	Support and collaboration is apparent and encouraged at a variety of executive and programmatic levels.
Off Campus Excursions	7%	Student participants are specifically engaged with educational development activities beyond their traditional brick and mortar office buildings.
Pedagogy Methodology	18%	Testimonies of PBL education interfaces.
Transparent Communication	14%	Relevant information is transparently passed along established communication lines.
Workshops & Training	16%	Additional PD in the form of workshops, training, webinars, conferences, etc. are available.

Table 5: Coded responses (n = 73) showing how STEM organization personnel perceive their organization helps them to develop best practices for dealing with underrepresented students and communities.

Statements illustrating a culture of inclusion at executive and programmatic levels defined 45% of best practice responses. As an example, the larger impacts of executive level support were obvious in one statement: “I know I have an administration that is as passionate about STEM and underrepresented [student] equity as I am.”

Testimonies of positive PBL education interfaces with students were evident in 18% of responses. One of these responses described the specific educational strategy of using technology to purposefully engage youth. In addition, having relevant information through established communication lines in a timely and professional manner compromised 14% of best practice statements made by STEM organizational personnel. An interviewee shared that their program “is consistent, but it changes with the needs as they come up.”

The remaining 16% of coded responses relate to workshops and training. These workshops and training, which can be offered by the interviewee’s organization, in partnership with another entity, or provided by a state or a national collaboration, were identified by seven of the 12 interviewees as best practice efforts.

4 DISCUSSION

STEM PBL education serves as a platform for the advancement of underrepresented minority students. It is a viable and methodological path forward to increase student cultural capital and therefore success in STEM and STEM-related fields. Studying New Mexico's unique population and engagement with those challenges, creates a platform for success in other states with high populations of Hispanic and Native American students.

4.1 Summary of High School Counselor Interviews

Overall, the responses of high school counselors and their perceptions of STEM career trajectory opportunities for NM students highlight many of the positive support mechanisms, faculty positions, systematic policies, as well as collaborative programs and organizations in the state. However, after spending time with each counselor, their professionalism, perspectives, and honesty revealed many of the opportunities for continued study, support, and growth within NM. There is not a large pool of STEM research and/or data from the high school counselor point of view. Nor do most counselors focus on or engage in learning about various teaching methodologies. Although high school counselors are not directly involved in the delivery of PBL educational content, they do recognize the larger notion of enhanced student outcomes in an array of collective concepts. Their guidance regarding PBL education activities helped to direct the second round of interviews, which dove more specifically into educational practices.

4.2 Summary of STEM Organization Personnel Interviews

The responses of personnel from STEM organizations show how student participation in STEM education activities encourage achievement in STEM and STEM-related career field trajectories.

STEM organization personnel interviewees were aware of the impacts of successful attainment of math proficiency. Many of the comments revolving around effective program and/or organization practices and student success involved student growth. STEM organization personnel also recognized the importance of financial security/support for students interested in pursuing their STEM interests. Whereas mentoring components were present in nearly a fifth of success stories, professionals interviewed may have "undersold" or underestimated their own impact as a mentor within their smaller network and larger community. Wood (2022) reminds us of the power of mentoring, especially for students of color and girls. Role models help students to see the real-world applications and the possibilities within the STEM subjects (Wood, 2022).

It is strongly suggested that STEM education influencers continue to honor their successes using PBL through off campus excursions, engaging pedagogical methodology, and continued educational workshops and training. The anecdotal and data-driven responses of this secondary interview cohort support the research (Han et al., 2015; MacMath et al., 2017; Tsai & Chiang, 2013; Young et al., 2013) that show PBL as a positive and impactful educational strategy for working with lower performing groups, which are often composed of underrepresented minority students. In addition, Connealy's (2018) NM-focused qualitative study determined that institutional and organization influences on STEM collaborations with schools contributed value and innovation. She describes how the STEM education partnerships can be challenging, yet sustainable when rooted in communities (Connealy, 2018).

Educator growth via PD was noted in multiple interviews. Leonard's (2016) qualitative research, amplifying the voices of teachers and principals at six northern NM schools, supports this measure. His study identifies how job-embedded professional learning can influence school culture (Leonard, 2016). Leonard (2016) and Wilson's (2016) work reinforces that administrators must make time for structured teacher collaboration. A school community supporting rigorous and sustainable STEM PBL PD properly can grow educators' capabilities (MacMath et al., 2017), helping to close the STEM gap for their students.

4.3 Recommendations

The findings of this study of public high school counselors' and STEM organization personnel's perceptions informed the development of seven recommendations. These reccommendations' are appropriate for education administrators, district leaders, and policy makers in NM and other regions. They address the lessons learned through the research (Scheerer, 2022) about student participation in STEM PBL education activities and underrepresented minority student achievement in STEM career field trajectories.

1. Allocate state, district, and/or school resources to make space for specific PD and best practices for high school counselors as allies for NM public school students interested in STEM career pathways.
2. Spanish (and other) translation services and related NM PED endorsements for teachers are viewed as support services that enhance in NM public schools for underrepresented minority students that may have interests in STEM career field trajectories. Continuing to fund and increasing the allocation for resources and personnel to these endeavors is strongly encouraged.
3. Public education sectors in NM should support and enhance the efforts of honoring the integration of authentic Native American mathematical contributions in student education communities (Lipka et al., 2011).
4. Educators that serve as STEM student influencers in NM should be given opportunities to learn more about the impacts of and resources available for PBL and how PBL supports underrepresented minority students.
5. Teachers, schools, administrators, districts, and state policy makers can look to established STEM education programs and/or organizations for guidance with STEM PBL education for students, educators, families, and communities.
6. Additional fiscal support for programs and/or organizations in NM that serve as PBL hubs is necessary to expand the reach and draw of underrepresented minority students and their teachers.
7. NM educational institutions should work to review, update, and integrate STEM PBL pedagogies and/or the academically adjacent place-based education and/or STEAM education to boost student interest in STEM career fields.

5 CONCLUSION

For students, STEM PBL can foster deep integration across educational disciplines and enhance STEM career trajectory interest and readiness. STEM education converged with PBL methodologies could leverage community support while broadening student networks. It provides students with enriched academic support that cultivates their STEM skill set development and enhances their ability to earn income. Best educational practices for students with STEM career trajectory interests highlight developing growth mindsets through mentoring, off campus excursions, and interactive STEM learning experiences.

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ACKNOWLEDGEMENT

I would like to thank my STEM education influencer circle for their continued support and engagement. I would also like to acknowledge NM MESA and the University of New Mexico School of Engineering Student Success Center which supports STEM interested students with enthusiasm, knowledge, and collaboration.

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APPENDIX

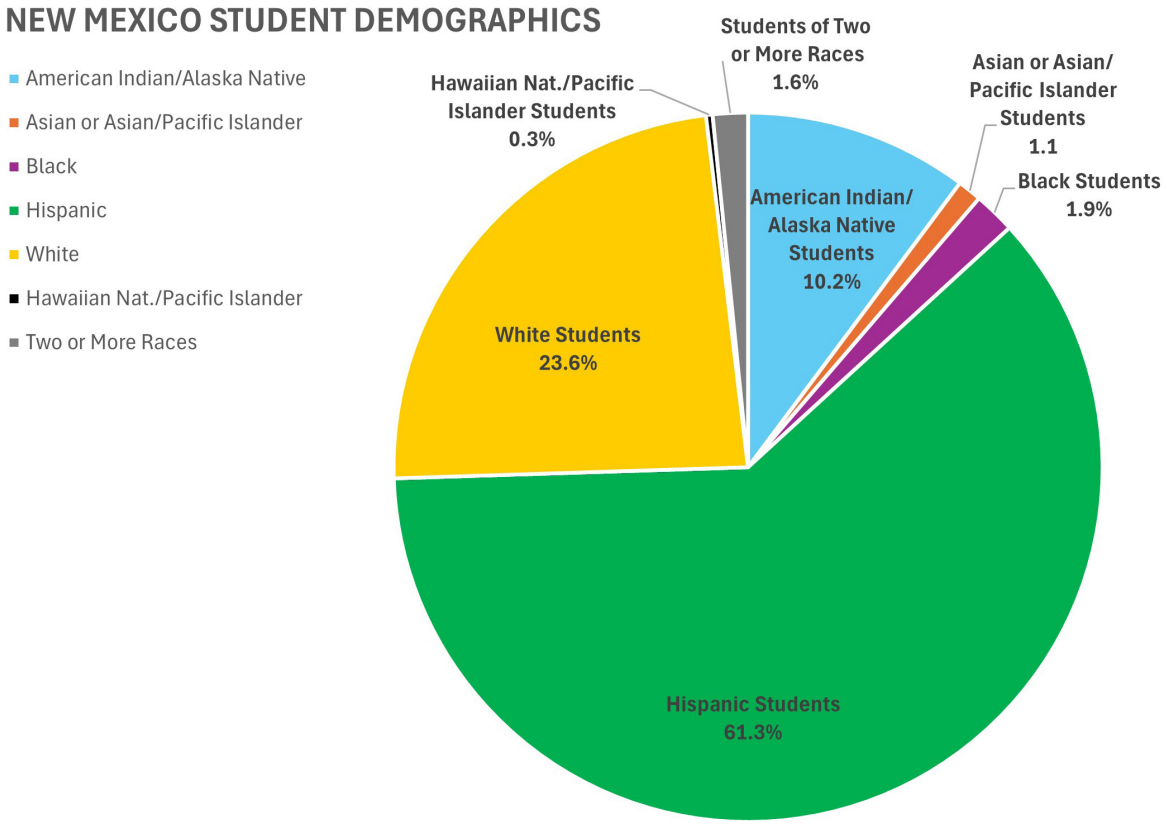

Figure 1: A pie chart of New Mexico Student Demographics created from the U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD), 2015-2016.

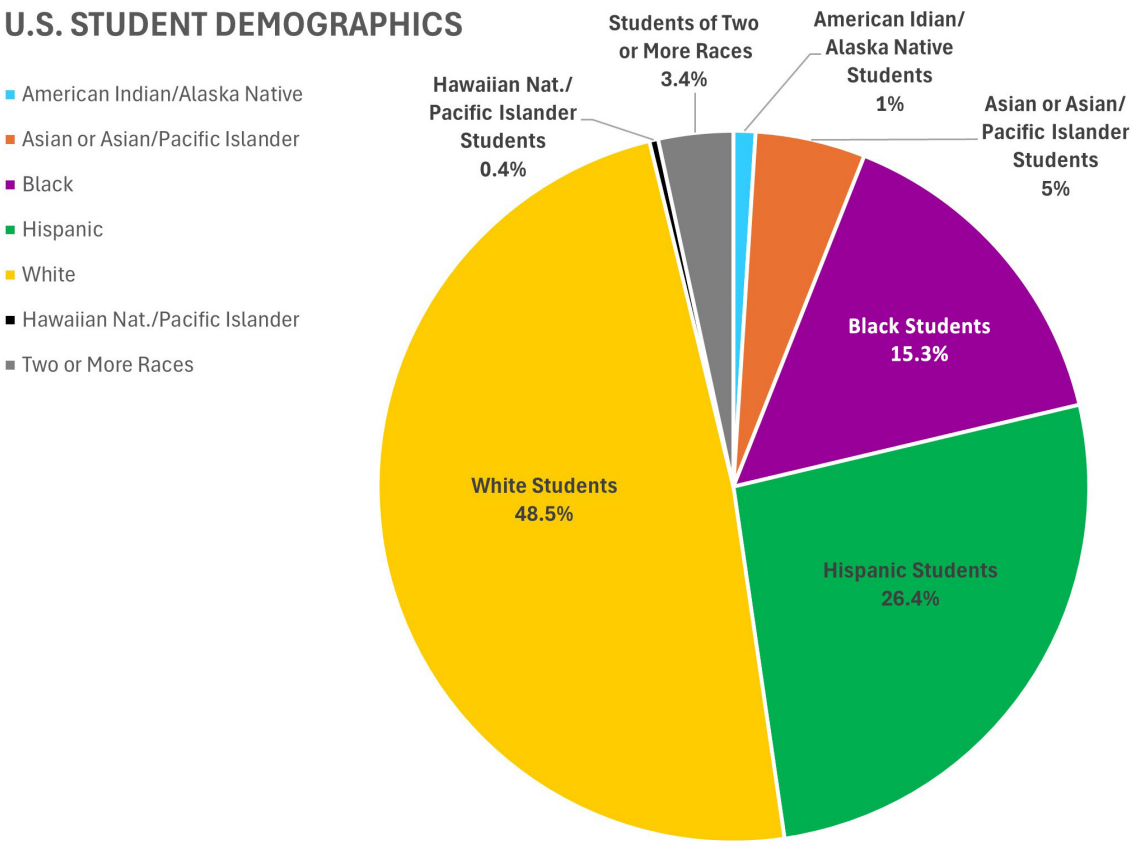

Figure 2: A pie chart of U.S. Student Demographics created from the U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD), 2015-2016.

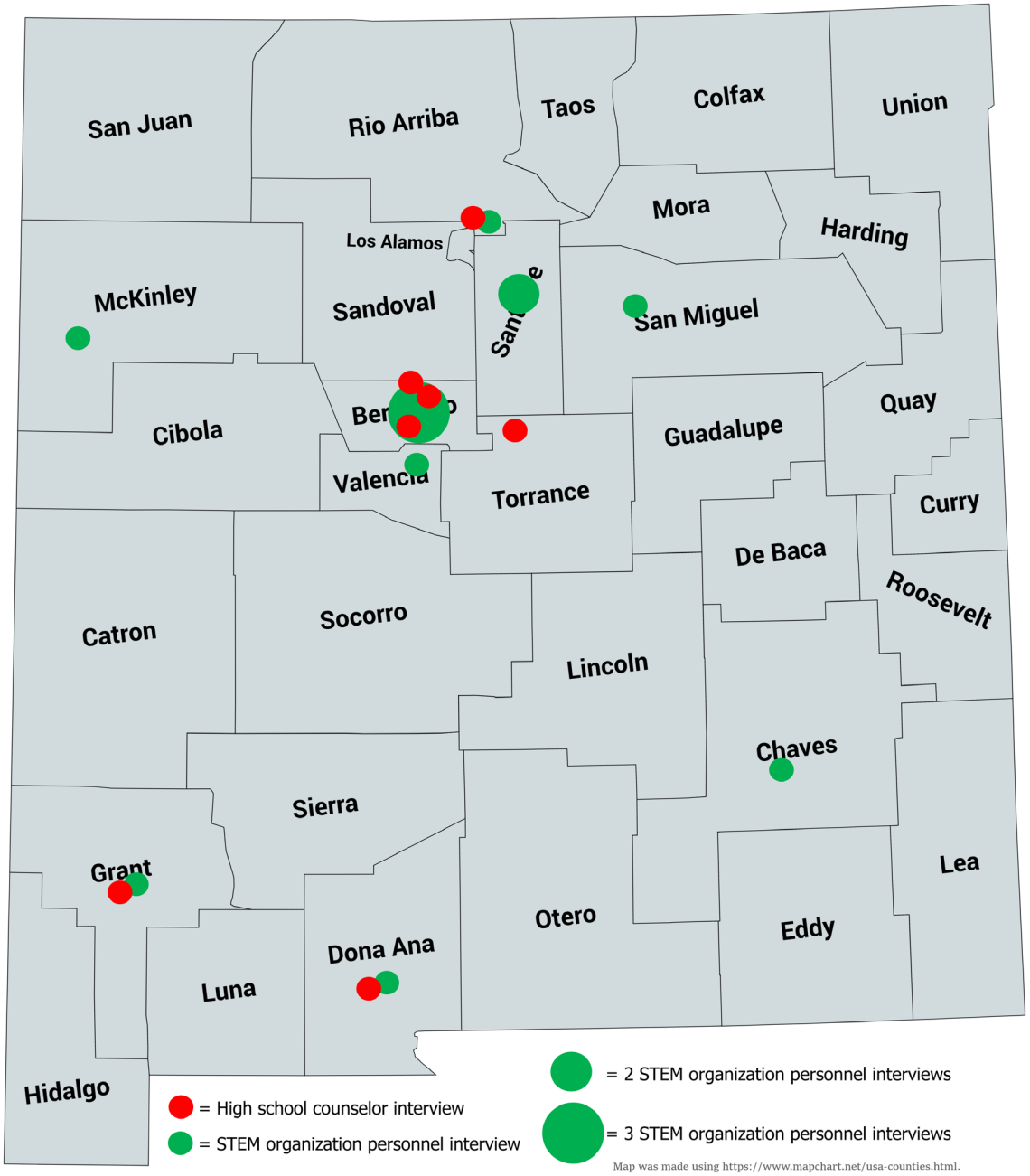

Figure 3: A geographical map of New Mexico research interview communities; map from https://www.mapchart.net/usa-counties.html.