Water Quality CURE: Creating a Chemistry Success Course With a Focus on Place-Based Education and Social-Emotional Support

Derek Hallett
New Mexico Tech

Malsha Indeewari Kanaththage
New Mexico Tech

Megha Khandelwal
New Mexico Tech

It is essential to engage and retain first-year undergraduates within STEM majors to fulfill the growing workforce requirements in the United States. Both academic and non-academic factors, such as social-emotional support, affect a student's ability and willingness to continue pursuing a STEM major. The Course-based Undergraduate Research Experience (CURE) has been shown to improve student engagement; however, combining this with place-based education to connect students with their physical space and community has not been thoroughly investigated. We designed a Chemistry Success Course using various student engagement tools and employed qualitative analysis to evaluate both the perceived and actual benefits of this approach.

Keywords: STEM engagement, undergraduate research, chemistry education, and student retention

INTRODUCTION

Course-Based Undergraduate Research Experiences (CURE) have emerged as an approach to engage students in STEM disciplines in several aspects, including authentic research, collaboration, data analysis, literature review, and result dissemination. CURE acts as the bridge between structured, experimental practice-focused lab experiences and self-directed experimental design. The majority of CURE connects the interpretation of experimental results to real-life issue. Place-based education is another promising approach that connects a learning process to a physical location, typically where students are situated. Place-based education provides an opportunity to engage in authentic learning based on real-world problems within their local communities. In this study, we employed a novel approach to combine CURE and place-based education in designing a Chemistry Success Course, aiming to better engage and increase retention among first-year students at a rural STEM-focused institution.

Water plays a vital role in life, essentially in human health and well-being. Although water covers two-thirds of the Earth, only 1% of the freshwater is accessible for human consumption. Water scarcity is a critical environmental problem. Emerging pollutants, overconsumption, climate change, inadequate infrastructure, and other factors contribute to the accessibility challenges of drinking water for various populations worldwide. The recent literature states mostly that indigenous, less educated, older, and poorer communities in the US are affected by the chronic Safe Drinking Water Act violations and Clean Water Act noncompliance. Consuming unsafe levels of contaminants can cause various health impacts. Therefore, the WHO (World Health Organization) and the EPA (Environmental Protection Agency) have implemented regulated standards for various types of water, including drinking water, to improve and restore water quality. Regular monitoring and assessment of water quality parameters are crucial for detecting pollutants and managing water resources sustainably. Water quality characteristics can be categorized into three main categories: physical, chemical, and microbial. For this study, surface and groundwater samples were collected across New Mexico from both urban and rural settings. Experiments were conducted, considering only the physicochemical parameters, due to time constraints and the simplicity of the task for first-year students. The water quality of the samples was assessed by analyzing total dissolved solids (TDS), pH, conductivity, alkalinity, hardness, major cation and anion content.

The first year of college for a first-generation college student is an exciting but challenging time. First-generation college students (FGCS) now comprise 25 percent of new college students, but fewer than 20 percent of them graduate within four years. In STEM in particular, the rates of switching to non-STEM majors and dropping out of institutions are considerably higher among FGCS compared to their peers. FGCS struggle to perform in college because they lack the same background and social support as students from families that have gone to college. This manifests in poor academic performance and feelings of isolation in traditional courses. Undergraduate research experiences can help engage these students and provide them with the support they need to succeed. This leads to increased satisfaction in school in the first year and long-term benefits, including improved GPA and graduation rates. However, opportunities for research are limited and may not be a good fit for first-year students who lack the skills or experience to contribute significantly in a lab setting. In some cases, undergraduate research experience can lead to students feeling isolated and decrease their enjoyment of science, which is challenging to control for in non-standard lab environments. Therefore, developing courses that can help bridge this gap is essential to retain FGCS in STEM disciplines and boost their academic success.

New Mexico Tech (NMT) is a small, rural, research-focused university located in central New Mexico. NMT had 1,087 full-time degree-seeking undergraduate students enrolled in the 2023-24 school year. Only about 57% NMT graduates are within 6 years of starting college. Most students who drop out do so in their first year. Only 77% of all students starting their first year at NMT remained enrolled in the following fall. This demonstrates a clear need for a novel approach to first-year integration of students. As a small, rural, STEM-focused public university, NMT faces specific challenges with student retention, as there are fewer opportunities for students to switch to a non-STEM major. It is essential that these students feel supported and engaged in the STEM curriculum during their first year to ensure they remain enrolled, feel comfortable at the school, and meet the university's academic standards. There is no universal-level College Success Course offered at NMT; typically, these courses improve retention rates by introducing first-year students to campus resources, providing peer mentorship, offering other social-emotional support, and teaching time management skills. Undergraduate research experiences are highly encouraged at NMT, but staff time limitations and other resources make it impossible for every student to be engaged in research in their first year of college. In order to give first-year Chemistry majors the benefits of engaging in research as well as provide social-emotional skills, a Chemistry Success Course was developed and implemented in the past year.

This study is a qualitative evaluation of the experiences and learning outcomes of a group of four first-semester undergraduate students. Three of the four students enrolled in the Chemistry Success Course were first-generation college students. The data presented here comes from lab reports, interviews, and survey questionnaires. Data from the lab reports reflect student learning and engagement, while the interviews and questionnaires reflect student feelings and retention in STEM. The learning objectives of the course were to help students explore campus resources, develop social-emotional support, engage with the CURE, and the place-based education curriculum. This study evaluates the perceived and actual benefits of the CURE project, which incorporates place-based education, in promoting student engagement, retention, and socialization among STEM majors in their first year of college.

METHODOLOGY

Structure of the Chemistry Success Course

During the newly designed Chemistry Success course, first-year undergraduate students met with the instructor weekly throughout the Fall 2024 semester. The course was developed to focus on exploring college campus resources for first-year undergraduates, including developing resilience through social-emotional support, engaging students in Course-based Undergraduate Research Experiences (CUREs), and place-based education to connect Chemistry with real-life scenarios. Additionally, it aims to connect first-year students with their peers, including senior undergraduates and department faculty members. Students were introduced to campus resources by visiting the university library, writing lab, and Office of Student Learning (OSL). Students were introduced to social events by signing up for the university's Connect website, and the events were discussed each week to provide opportunities to find a companion, join a group, club, or participate in a sport, etc. Students were asked to enter a journal entry for their high and low experiences each week. The issues were discussed among the group for possible solutions.

For the CURE project, students were asked to gather water samples from one or two locations of their choice. These samples were returned to the university and tested using the relevant research methods described in Section 2.3 below. Students were then asked to analyze the data and give their interpretation of the results in the form of a lab report.

Two senior undergraduate students were invited to one of the classes to provide an introduction to the Chemistry department's resources and skills required for a Chemistry major. Moreover, the first-year students visited at least two Chemistry research laboratories to gain exposure to ongoing research projects. The course participants discussed research projects with the faculty members and met the graduate and undergraduate researchers.

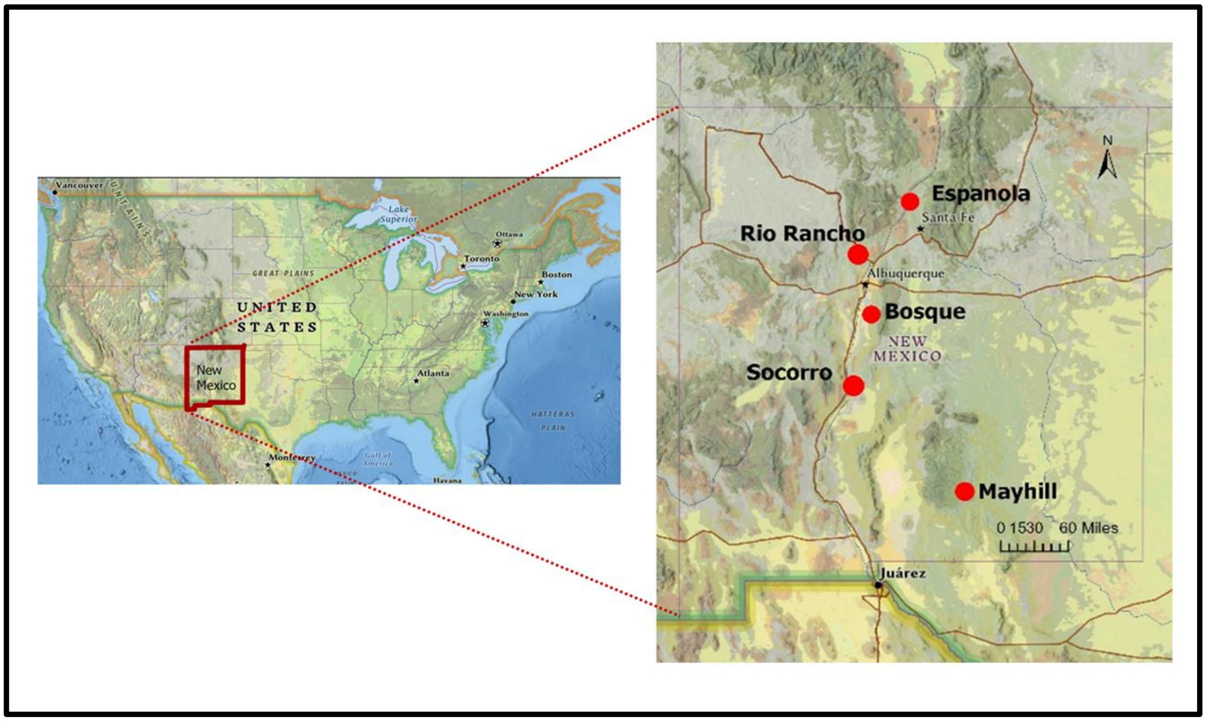
Survey Questionnaires

Adopted questionnaire from our group's previously published research. Written questionnaires were distributed to students during the middle of the Fall 2024 semester to assess their overall experience of starting at a new school. The questions focus on student backgrounds, why they chose this school and STEM fields, how supported they felt, and what challenges they faced during their first undergraduate year.

Course-Based Undergraduate Research Experience (CURE) and Place-Based Education

The six water samples were collected by four first-year undergraduate students from various locations in New Mexico and are listed in Figure 1. Note that only the name of the city is mentioned here, as most of the locations are student residential areas. The collected samples were stored in the refrigerator until the analysis. Direct measurements are taken for the pH, conductivity, alkalinity, and hardness. According to the standard protocol, the samples were filtered and acidified with HNO_3, then kept for 12 hours before analysis for cations and anions.

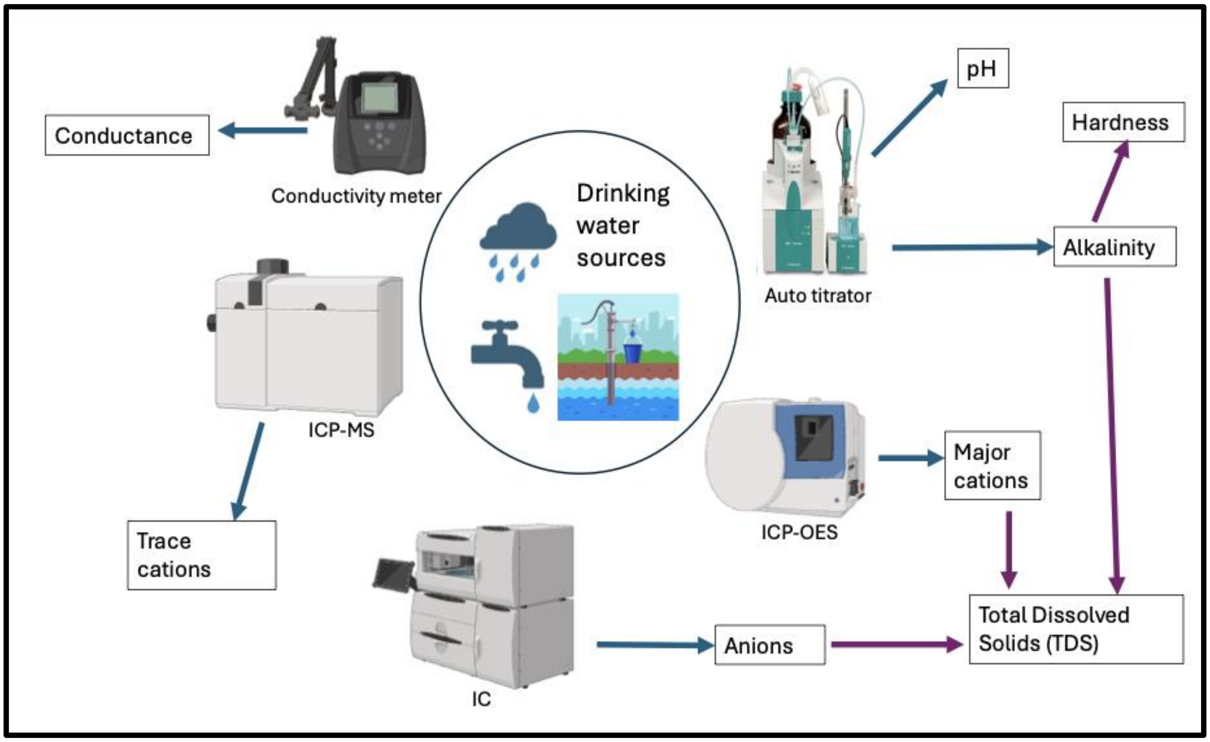
FIGURE 1
MAP OF WATER SAMPLING LOCATIONS IN NEW MEXICO, USA



ArcGIS Pro software was used to prepare the map of water sampling, highlighted with red dots. Student Alex collected Bosque_ Well and Bosque_Rain water samples from his grandfather's house in Bosque. Student Oak collected the Socorro_Tap water sample from her dorm at NMT. Espanola Tap and Rio Rancho Tap water samples were collected by Student Meg later from her house. Student Ted collected Mayhill_Well water samples from the well at his house.

Specific conductance was measured using a YSI 3200 conductivity meter. Major cations were analyzed using optical emission spectroscopy (ICP-OES) with a PerkinElmer Optima 5300DV. Major anions of the water samples were analyzed using a Dionex ICS-5000 DP ion chromatograph. Trace cations in the water samples were analyzed using an Agilent 7500 ICP-MS (inductively coupled plasma mass spectroscopy). A Metrohm autotitrator was used to measure alkalinity and pH. TDS (total dissolved solids) is a measure of dissolved organic and inorganic substances in water, typically reported in parts per million (ppm) to assess the water's quality. Hardness is referred to as the concentration of dissolved calcium and magnesium minerals in water. The TDS and Hardness were calculated from the cation and anion measurements following the literature.

FIGURE 2
ANALYTICAL TECHNIQUES USED TO ANALYZE DIFFERENT DRINKING WATER QUALITY PARAMETERS



A conductivity meter was used to measure conductance, an auto-titrator was used to analyze pH and alkalinity, trace cations were analyzed with ICP-MS, major cations were analyzed with ICP-OES, and anions were analyzed with ion chromatography (IC). Hardness was calculated based on alkalinity data. Anions, major cations, and alkalinity data were used to calculate the TDS of the samples. Blue arrows represent the direct measurements, and purple arrows indicate secondary calculations from the direct measurements.

Interviews

Participant interviews were conducted three weeks before the end of the student's first year at college. Two Interviews were completed in person, with one being done through Zoom. The interviews started with the IRB disclaimer, and permission was taken to record. The responses to the questions were audio-recorded and simultaneously noted using Google Docs' voice typing feature. Interviews were later transcribed in full using Nota AI transcription software and then manually reviewed. The first part of the interview was a repeat of the questionnaire given at the beginning of the year, while the second half consisted of questions specifically designed to evaluate the CURE course experience. The interview questions in the second half of the interview were designed to have students reflect on the novelty, relevance, engagement, support, and scientific rigor of the CURE course six months after completing it, in order to understand the longer-term impact of the course.

Comments From the Participants

All direct comments from the participants are italicized. Personally identifiable information was removed. To further protect the identities of the participants and facilitate the organization of the paper, pseudonyms were used to identify the four participants. The text was corrected for grammatical errors and edited (summarized or provided contextual information) to improve readability.

Positionality Statement

We aim to be transparent by clearly stating our positions and acknowledging that the authors' backgrounds and experiences may have influenced some of the data interpretations in this study.

Author D.H. is a graduate student at New Mexico Tech (NMT) pursuing a PhD in biotechnology. D.H. is an out-of-state student who completed his undergraduate studies at the University of California, San Diego, and his master's degree in the Netherlands. D.H. began his studies in the spring 2025 semester at NMT and was not present or involved in the actual running of the course, but came in as an outsider to evaluate course outcomes and compile data. D.H. became involved in this project due to his interest in education and how teachers can better engage students in learning. D.H. also helped to develop some of the possible future directions for this course based on results and feedback from students who participated in the course. As an outsider, D.H. can only make conclusions based on collected data and end-of-the-year interviews, and so cannot directly attest to lived experiences in this course.

Author M.I.K. is a PhD candidate in chemistry at NMT. She received her BS in Environmental Sciences in Sri Lanka and joined the NMT in Fall 2022. Her research centers on the environmental and health risks associated with anthropogenic pollutants. Her work integrates analytical chemistry, materials science, and toxicology to address real-world environmental challenges. In addition to her research, M.I.K. serves as a graduate teaching assistant for various undergraduate chemistry laboratory courses. She was involved as a teaching assistant for this course due to her strong research background on methodologies related to the research topic covered in this CURE course. M.I.K. analyzed water sample testing data and evaluated the students' understanding by reviewing their lab reports, focusing on the structure of the lab report, understanding of the method, data interpretation, and overall grasp of the experimental procedures. With her strong analytical research background, M.I.K. provided her comments and feedback in a more generalized manner, taking into consideration the students' varying backgrounds on the research topic, thereby ensuring that her comments supported their learning experiences.

Author M.K. was a first-generation graduate student in the US and completed her PhD in Chemistry at a Hispanic-Serving Institution. Afterward, she worked as a high school science teacher. She has been supervising Teacher Ed Programs at NMT since 2017. In 2023, she accepted the position of Assistant Professor of Chemistry. Throughout her career, she has worked with underserved students, including those from low-income backgrounds and potential first-generation college students. M.K. was the instructor for the CHEM 0130 Issues in Chemistry and Biochemistry course in Fall 2024. She redesigned this course to introduce various support systems for first-year students and, for the first time, used a CURE model in a Chemistry course at NMT. She would like to acknowledge that her struggles with a new education system, as well as her work experience at NMT, may affect the data interpretation for this study.

RESULTS AND DISCUSSION

Outcome of the Combined CURE and Place-Based Education Project

Course-based Undergraduate Research Experiences (CURE) have been shown to increase graduation rates and completion across STEM disciplines. Place-based education has been identified as another tool to engage first-year students; however, its impact on retention rates has not been assessed. For this project, we combined place-based education with CURE to assess water quality from student-collected samples. A comprehensive water quality assessment of six samples, comprising tap water, rainwater, and groundwater from various regions in New Mexico, reveals significant spatial variability, reflecting a combination of geogenic processes and potential anthropogenic influences.

TABLE 1
RESULTS OF WATER QUALITY PARAMETERS OF THE SAMPLES WITH STANDARD AND RECOMMENDED LEVELS FOR DRINKING WATER ACCORDING TO US EPA, USGS, AND THE STATE OF NM

Sample	Specific conductance (µS/cm)	pH	TDS (mg/L)	Hardness $CaCO_3$ (mg/L)	Cations			Anions	
					Na^+	Fe^{3+}	As^{3+}	F^-	SO_4^{2-}
Bosque_Well	394	7.9	274	151	29.8	0.159	0.004	0.38	54.2
Bosque Rain	61	9.7	37	25.5	1.46	1.24	ND	ND	ND
Socorro Tap	339	7.9	229	63.7	51.6	ND	0.015	0.61	30.1
Espanola Tap	345	7.9	243	4.69	79.0	0.025	0.002	2.99	47.3
Rio Rancho Tap	933	7.6	618	100	167	ND	0.006	0.76	130
Mayhill Well	852	7.6	612	499	22.7	0.362	ND	ND	163
Drinking water quality standards and recommendations	***<1000***	***6.5 to 8.5***	***500***	***0-60 = soft water 61-120 = moderately hard water 121-180 = hard water >180 = very hard water***	***20***	***0.3***	**0.01**	***4, 2.0***	***250***

Rainwater harvesting and reuse are one of the main sources of water for human consumption that have been practiced for decades. Rainwater has been used as a primary water source in many countries; however, the lack of minerals and high levels of dissolved gases, such as CO_2, make the rainwater more acidic, making it unpalatable for use as drinking water without treatment. According to USGS, groundwater is water that exists underground in saturated zones beneath the land surface. Groundwater moves slowly through sand and gravel in an aquifer; as a result, the water could remain in an aquifer for hundreds of years. Due to water being in contact with aquifers for a long period, groundwater is enriched with high mineral content. Groundwater is the source of about 40% of the water used for public supplies in the US. Tap water is treated water monitored by municipal or local authorities to meet safety and quality standards set by government regulations. Water is delivered to consumers primarily through a pipe distribution system.

Higher conductivity in Rio Rancho_Tap and Mayhill_Well indicates elevated mineral and ion contents, while Bosque_Rain shows low conductivity as expected, with all samples remaining below the US EPA's recommended limit of 1000 µS/cm for conductance. Low pH (acidic pH) can lead to the dissolution of metals and pose potential health risks, while high pH (basic or alkaline pH) can affect the taste of water and cause pipe scaling. All the samples were in the neutral range, except for Bosque_Rain, which is highly alkaline, potentially indicating contamination. The standard non-enforceable TDS limit is 500 mg/L for drinking water. Bosque, Well, Socorro Tap, and Espanola Tap show lower TDS levels, which are ideal for drinking and domestic use. Bosque_Rain, which exhibits very low TDS, may not be suitable for drinking as it lacks essential minerals, and on the other hand, can lead to corrosiveness in plumbing systems. Rio Rancho Tap has elevated levels of TDS, which may be due to contamination. Mayhill_Well may have elevated levels of TDS may be due to geological contact. According to the standard classification for water hardness, samples Bosque_Rain and Espanola_Tap fall into the soft water category. This indicates water may be lacking sufficient minerals. Socorro_Tap and Rio Rancho_Tap show moderate hardness. Bosque_Well contains hard water, and Mayhill_Well consists of very hard water, as the samples are underground aquifers that contain carbonate-rich minerals and may affect the taste of drinking water if used without any treatment. These samples may cause scaling in pipes, heaters, and household appliances, especially Mayhill_Well water.

The analysis of major cations of the six water samples revealed significant geochemical variability. Mayhill_Well stands out with exceptionally high Ca^{2+} (155 mg/L), consistent with very hard water likely derived from carbonate-rich mineralogy. Rio Rancho_Tap exhibits the highest sodium concentration (167 mg/L), suggesting possible ion exchange and anthropogenic impact, as the sample is treated. Bosque_Rain shows elevated iron (1.24 mg/L) exceeding typical aesthetic thresholds, indicating reducing (anoxic) conditions of the rainwater due to the water being stored in a metal barrel. Espanola_Tap, with very low Ca^{2+} but high Na^{+}, may represent a case where the treated water is influenced by a secondary factor in ion exchange processes. Trace metal analysis revealed that most elements were below health-based regulatory limits; however, arsenic in Socorro Tap (0.0158 mg/L) exceeds the EPA maximum contaminant level (0.01 mg/L), raising concerns given that the sample source is tap water. Iron concentrations in Bosque_well and Bosque_Rain exceed the secondary aesthetic limit, potentially affecting water color and taste. Espanola_Tap contains fluoride levels of 2.99 mg/L, which exceed the EPA secondary water standards. The U.S. Public Health Service recommends a fluoride concentration of 0.7 mg/L in drinking water to prevent tooth decay; however, higher quantities may pose long-term health risks, particularly dental or skeletal fluorosis. Mayhill_Well has the highest sulfate (163 mg/L), likely reflecting natural rock-water interactions such as weathering of gypsum or oxidation of sulfide minerals. Bosque_Rain, by contrast, is chemically dilute due to rainwater, indicating minimal geogenic or anthropogenic input.

Overall, the findings emphasize the importance of continuous monitoring, particularly for arsenic, fluoride, and nitrate, to ensure drinking water safety. Further, localized treatment may be required in selected wells to meet health guidelines. The variation across samples highlights the impact of both natural geology and human activities on groundwater quality in the studied samples.

Teaching Experiences From the CURE and the Place-Based Education Project

Author M.I.K. served as a teaching assistant for this combined CURE and place-based education project. The participants (first-year students) showed notable enthusiasm as they were involved in sample collection. They actively discussed how they gathered the samples and described the water source. Student Alex *“My samples were from my grandfather's well in Bosque and a rainwater collection barrel.”* Student Meg *“The Espanola water sample was gathered from the tap in a house in Northern Espanola on October 17, 2024. The Rio Rancho water sample was collected from the tap in my house on October 26, 2024.”* Student Meg mentioned the location and reported the dates of collection which suggests that students understand the importance of documenting the details of a sample to ensure the reliability and traceability of environmental sampling. Student Ted's lab report states, “*The water sample was procured from a well at my house in Mayhill on the 3rd of November, approximately 3 days before the sample was brought in for examination. During this 3-day period, the water was stored in plastic containers which were kept in a cool but not cold fridge until the day the sample was examined.”* Here, students understood that the storage method would affect the final data; therefore, it is essential to report how the samples were stored from the time of collection until the day of analysis. This helps to assess any potential errors or contamination and to take necessary precautions before the analysis. Many students collected samples from their neighborhoods and were curious about the quality of the water.

Students were intrigued by the research lab environment, as many of them were only familiar with the general chemistry teaching labs. Many expressed fascinations with the various instruments used in the lab, questioning how each instrument works and what we can analyze with it. A common and engaging moment occurs when students see the teaching assistant operating analytical instruments; they eagerly ask, *"What are you doing with that?"* indicating a genuine curiosity to understand the scientific process beyond teaching and opens up valuable opportunities to explain analytical chemistry concepts that are applied in research to solve real world environmental issues.

As conversations unfolded while waiting for analysis runs to complete, students began asking questions such as, *“What kind of research do you do?”*, “*Is this instrument part of your work too?”* These questions opened the door to meaningful dialogue about the TA’s graduate-level research in environmental and analytical chemistry. This exposure significantly elevated student interest. Many expressed surprise and excitement upon realizing that their TA was not just a facilitator of lab exercises but also actively involved in cutting-edge scientific research. The TAs' openness about their research journey, including challenges and motivations, seemed to inspire students who may have never been exposed to research in general.

CURE and Place-Based Education Project Report Review

As part of the lab component, students were required to submit formal lab reports that summarized their sample collection, analytical procedures, data analysis, and interpretations. The review of these reports provided valuable insight into student understanding, critical thinking, and engagement with the scientific process. Most students adhered well to the expected structure of their general chemistry course lab reports. It consisted of clear sections for introduction, methods, results, discussion, and conclusion. While some students required guidance on the report writing, as they hadn't taken any chemistry lab classes.

Three out of four students demonstrated a solid grasp of the analytical methods. They were able to explain why specific instruments were chosen. Students were using Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) and Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) to analyze the cations. Student Ted mentioned, *"The water samples were analyzed using Atomic Absorption Spectroscopy (AAS)/Inductively Coupled Plasma (ICP) to identify and quantify the mineral content in each sample. The concentration of minerals such as calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), and potassium (K^{+}) was determined based on known calibration curves."* Although the statement made by student Ted is not entirely correct, it is understood that they grasped the general concept of measuring unknown cations using standardized calibration curves. Student Ted also mentioned *that "water hardness was measured using a standard EDTA titration method," demonstrating an understanding of the* basic theories behind the instrumentation. It is important to note that all the tests mentioned for the water analysis were demonstrated in the lab for students within a short period of time. Despite that, students were able to understand the basic concepts of each instrument and why it is used.

The strongest reports featured a thoughtful discussion section where students attempted to interpret their results in the context of existing literature, such as guidelines to compare the possible impacts. As an example, Student Oak *"The trace amount of arsenic in the sample was found to be 0.0158 mg/L, which falls above the EPA's "maximum contaminant level" of 0.01 mg/L.* Student Oak has identified discrepancies in the data, highlighting the potential risks associated with consuming contaminated water and emphasizing the importance of monitoring drinking water quality. "*This value can be due to contamination of drinking water or simply natural deposits of arsenic dissolving into groundwater. Arsenic does not affect the taste of drinking water. While, the value in this sample is only slightly over the "maximum contaminant level" as set by the EPA, it is still worthwhile to consider the potential health effects of continued arsenic consumption in drinking water, which include stomach pain, nausea, vomiting, skin problems, and in more serious and higher levels of consumption include cancer in several organs, cardiovascular disease, and diabetes."* Also this same report states, *"which can explain why some sources of water here at college campus have a slightly opaque white appearance."* which shows students connecting their day to day observations with the scientific concepts. Student Ted's statement, "*The findings suggest that the sample from the Mayhill Well might be in a place that has high levels of limestone that could suggest the higher levels of calcium in the water,"* showcases the understanding of how geology, such as limestone, can affect the chemical composition of the water. In other words, student Ted understood that the concept of geochemistry of the surrounding water source can affect the water quality.

While not all students were confident in comparing their findings to published data, those who did try to explain reasons for the discrepancies and suggest explanations. Student Ted *"Possible sources of variation in mineral content include geographic differences in the places the water samples were collected, contamination from man-made structures and or metals that might have been present, or agricultural runoff, or variations in local water treatment practices."*

Several students related their findings to environmental conditions in their neighborhoods, personal interests in their health. Student Meg *"This means that the drinking water could cause your teeth to discolor, as well as change the taste of the water."* and "*In the Rio Rancho tap water, the amount of Sodium* *is flagged to be a health risk in individuals with a restricted Sodium intake." "The hardness of the water does not have a health advisory or warning. However, when the hardness of the water increases, the amount of erosion found in household appliances increases."* Student Alex compared well water and groundwater from the same location and compared them with drinking water standards. They found that groundwater is safer to drink, while rainwater is not. Student Alex states, *"This is most likely due to the fact that the rainwater is collected at the end of the system gutters,"* indicating that the student also understands that environmental factors, such as rainwater collection gutters, can accumulate more contaminants, which can affect the water quality.

These reflections added depth and authenticity to their reports, illustrating genuine engagement with the material and the motivation behind their participation. Student Oak: "*Comparing this tap water collection sample from the city of Socorro to that of other cities throughout New Mexico also proved to be interesting."* This also shows that students' beginning to recognize how the geographical location and sources can influence the water quality. These comparisons also reinforced the relevance of their lab work within a broader scientific framework.

In many cases, students relate their results by comparing the EPA standards discussed in class to assess the quality of the water they collected. Data interpretation includes explanations of their observation on the water that they use with the scientific data they collected. This level of comprehension suggests that the hands-on experience, combined with guided instruction, effectively supported the assessment of water quality in a scientific manner.

Student Engagement With CURE and Place-Based Education Project

During the interviews conducted at the end of the students' first year, questions were asked to evaluate the long-term outcomes of the CURE and place-based education project from the students' perspective. The primary goal of these questions was to determine students' attitudes toward the CURE course and the influence it had on their early undergraduate experience. Three of the four students in the course were interviewed. All students interviewed viewed the CURE and place-based education positively, feeling that it provided additional value to their traditional chemistry courses. Common themes across all three interviews included feeling supported, a sense of camaraderie, and a space to talk and learn. Students did not emphasize feeling greater autonomy in the course, with most describing the class as academically similar to the traditional chemistry lab that they were taking concurrently. Student Oak put it as "*It was pretty similar, I would say. Yeah, I structured it pretty similarly to how I did my gen chem lab reports…*" Students felt their research was somewhat novel, with most students expressing that the procedure felt different from normal chemistry courses but still routine. Student Meg found the course the most novel out of those interviewed, "*I've never done anything like that. It was definitely a learning experience because I didn't know that water hardness had to do with different kinds of ions in the water and everything. So that was it was super cool, and I got to learn a lot, and then I got to learn about how different places in New Mexico are going to have completely different kinds of water.*" Students Oak and Ted emphasized that the findings on the water confirmed their expectations of their water resources. Student Ted in particular expressed this saying, "*I would say it wasn't too surprising, the percentages in the water, whatever we did this only because it's like been a known issue in our house that sometimes our water will turn red and kind of wrench and like stain our tubs. But you know, I kind of figured that our water was high in calcium, which it was.*" While three out of four students in the Chemistry success course were chemistry majors, they were all first-semester students who lacked significant experience with college-level chemistry, so it is possible that they did not have sufficient experience to fully appreciate how this represented novel research. This course did not require students to disseminate their results to the outside world, but communication between students in the course was a major driver of engagement and long-term retention of knowledge from the course. Student Oak, when asked what she remembered from the course, said, "*It's just interesting how much it differs, and it's like not super noticeable to just the average person. I thought it was really cool how student Meg did look at how hardness of water affects like her hair.*" while Student Meg said "*...Not particularly in my experiment but when we were going over some of the other students I found it super crazy there's so much arsenic in that water*" referring to student Oak's findings. This is an interesting finding, as these students found their peers' results more interesting than their own findings and even remembered these findings months later, with some prompting. The process of sharing their results also helped deepen students' appreciation for their homes and communities, as well as the differences between them. Student Oak noted, "*I thought it was really interesting just to look at the water here compared to in different places that use well water, or the city water.*"

The primary CURE principles in this course were discovery, relevance, and collaboration. Students were asked to find their own water samples and analyze them. This clearly resonated with students as they remembered the results several months later. Interestingly, students actually seemed to remember the discoveries of their peers better than their own results. The testing of locations relevant to the students' lives made a big difference for retention and investment in the course. This place-based research enhanced the relevance and discovery outcomes of the CURE course, as students became more invested in the data due to its significance to their homes and those of their friends. This place-based education contained a component of learning as students discussed their concerns about the quality of the water they found and how they would personally respond to the results. Based on the results of the questionnaire and interviews, collaboration was found to be hugely important for the long-term impact of this CURE project, as well as for the students' ability to succeed in their future studies. This finding aligns with other research, which demonstrates that collaboration plays a significant role in enhancing students' emotional investment in science, ultimately leading to improved long-term retention of the subject matter in the CURE course. The importance of the novelty and relevance of the research was comparatively low to the students. This is likely a result of the inherent limitations of a course designed for first-semester students, as they have not yet had the opportunity to develop the specialized knowledge and skills necessary for conducting novel research. However, we feel this is not a huge drawback for the course in this case, as novelty and relevance have been shown to be of lower importance for success in the course when the student lacks a strong existing background in the subject. In addition, while the discoveries students made were relevant to them, the technique they used was standardized, and students seem to recognize that, diminishing their feelings of agency and novelty. However, the involvement of an expert in the field in the course did seem to increase student engagement as they felt that the work they were doing was more real. This study involved highly guided hypothesis development, as the limited amount of class time available did not allow for extensive background research and instruction necessary for more student-directed hypothesis development. As an introductory CURE course, the decision was made not to spend as much time on hypothesis creation, allowing students more time for fieldwork and data processing. We still feel this represents a full CURE course in function, as CURE courses have significant variability in the amount of time spent on the core CURE components. While this CURE and place-based education project had significant limitations due to time and structure, the unique collaborative environment created left a lasting impression on students and provided connections and support that ensured students were able to succeed in their first year.

Explore Campus Resources and Support

Our recent publication has identified that the first-year students, in particular, First-Generation College Students (FGCS), struggle to utilize college resources and reach out for help. Three out of the four students in this study were identified as FGCS. The instructor (author M.K.) explored campus resources with the participants (first-year undergraduates) by visiting and speaking with staff members at the New Mexico Tech (NMT) library, writing lab, and the Office of Student Learning (OSL) during the first few weeks of the Chemistry Success course. The instructor provided weekly updates on campus social activities, which are published on the NMT's Tech Connect webpage but are often overlooked by first-year students. The author, M.K., as the instructor of this course, provided a safe space for students to discuss planning to go to the social events or sports club as a group. This created a good opportunity for participants to form study groups, explore common hobbies, or attend events with a fellow first-year student as a companion.

Based on participant responses to the first survey questionnaires, this initiative was successful. All students in the course were familiar with the academic support services available on campus, which were introduced during the first semester by the middle of the course. In response to the questionnaire, students reported feeling supported by the admission and department staff. However, there was significant variation in the utilization of academic support for courses. Student Meg heavily utilized tutors and class-based academic resources. Student Alex utilized the Office of Student Learning (OSL) the most. Student Oak and Student Ted did not mention utilizing any specific resource. Regardless of the support structure each student used, most students indicated that they felt well supported overall during their first semester and had no suggestions for how the school could offer better support. Student Alex did mention that he would feel better supported if teachers would "*write why the answer is wrong on the test*".

TABLE 2
CHEMISTRY SUCCESS COURSE PARTICIPANT RESPONSES FOR FREQUENCY OR RATINGS ON SUPPORT RECEIVED FROM VARIOUS NMT OFFICES

Questions	**Student Alex**		**Student Meg**		**Student Oak**		**Student Ted**	
Semester	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Admission support from NMT staff (Likert scale "0" low to "3" high or not needed)	3	n/a	2	-	3	-	3	-
Ease of choosing a major and support from the department (Likert scale "0" low to "3" high or not needed)	3	n/a	3	3	3	3	3	3
This semester, how many times you meet with your advisor per semester (0, 1, 2-3, 4 or more)	2-3	n/a	1	1	1	1	0	4 or more
This semester, how many times you used OSL services (0, 1-2, 3-5, 6 or more)	6 or more	n/a	1-2	0	0	0	0	0
This semester, how many times have you attended tutoring sessions at departments (0, 1-2, 3-5, 6, or more)?	0	n/a	1-2	6 or more	0	0	0	0

In the middle of the first semester questionnaire, Student Alex specifically mentioned, "*Math class makes little to no sense, and understanding the material doesn't seem to matter*". During the Chemistry Success course discussions, Student Alex mentioned that they started this Math course about two weeks after the semester began due to delays in their admission/placement tests, among other issues. Author M.K., as an instructor for this course, encouraged Alex to speak with the Math course instructor, who is a graduate teaching assistant; however, Alex felt unsupported after a few meetings. Instructor M.K. also reached out to the graduate teaching assistant's supervisor (a Tenured faculty member in the Math Department at NMT), but was denied any information since she is not the student's academic advisor, nor did the student receive any further help. Ultimately, Alex ended up withdrawing from this math course after discussing the midterm grades with their academic advisor. We were unable to reach Alex for the end-of-the-first-year interview, but author M.K. has seen them on the NMT campus looking less stressed compared to their first semester.

Based on the information from one-on-one interviews at the end of their first year at NMT, all students from the Chemistry Success Course were still at the school; however, we were only able to interview three out of four participants, though it is known that the fourth student remained enrolled at the school as well. Based on the follow-up questionnaire, students remain engaged with advisors and tutors at a rate comparable to the beginning of their undergraduate year. Student Meg discussed the impact that academic tutoring had on her in her first year, saying, "*I stayed the whole two hours for the physics recitation just to get extra help on the homework…*". Students Oak and Ted, who did not utilize the school-based resources in the first semester, reported that they received most of their academic help from friends during this second interview. Student Oak said that working with friends helped her to succeed in subjects she was weaker in "And *even just making friends along the way, people that are better at things that I might struggle with, like I'm not the best at physics, but one of my friends is a physics major. And so we help each other. He* *helps me with my physics homework. I help him with his chemistry homework.*" demonstrating the impact of social interaction on academic success. Student Ted also utilized friends for academic help as when asked if he used any of the school academic help resources he said "*I would say I haven't this semester, only for the fact that I've had friends that I usually go to if I need help with any questions or problems.*"

Based on the responses of students, the course succeeded in its goal of introducing students to school resources and creating opportunities for them to meet friends and faculty who could provide assistance. This facilitated the success of both students who learn best in more formal teaching environments and those who preferred the more informal collective study style of learning. Exposure to these resources and guidance on how to best utilize them is particularly important for first-generation college students. In addition, this course provided students with an opportunity to be introduced to new learning strategies and systems, enhancing their ability to succeed in other courses. There were limits to what this course could do, however, as seen in the case of student Alex, as the course is currently small and focused primarily on increasing success in the chemistry department. It was not possible for the instructor of this course to directly intervene to help a student in a different course. This represents a more systemic issue in the school, which cannot be resolved with a single course.

Develop Social-Emotional Support

A core goal of this course was to create a non-traditional learning environment that introduced students to support systems and people who could help them succeed in their first year of college. To evaluate the success of this initiative, students were asked to share their challenges, high points, low points, and barriers to success they experienced as first-year college students. The answers to these questions were compared, and changes in student responses were evaluated to understand student experiences and how the Chemistry Success Course helped students in their first year.

The challenges students discussed in this first semester were varied, with some listing academic challenges, while others mentioned finding motivation and overcoming mental barriers as their primary obstacles to starting their undergraduate year. Student Meg said her main challenge was "*... work load + midterms*". Student Oak said her main challenges were "*Lots of socialization when I'm usually more of an introverted person.*" and "*Adjustment to a new schedule.*" For student Alex the main challenge was math class, saying "*Math class makes little to no sense and understanding the material doesn't seem to matter.*" For student Ted his challenge was "*Motivation.*"

During the one-on-one participant interview at the end of the first year, students were better settled socially. Student Meg is now focused on particular classes or topics as their main challenges, while they had high points that were social in nature. "*I think some high points. I met a lot of people here and learned that college is completely different from high school, where you get to learn your own way. It falls on you a lot. And I really liked that because then you have more for yourself to prove. So it makes you feel better about yourself. I can do this. I can get through this college. But I think some low points are just trying to get used to the classes. I had a really hard time this semester getting used to that Gen Chem II class. I struggled a lot at the beginning of the semester because we had three packets a week.*" Student Oak still considered adjusting to her new schedule one of her major challenges "*More so last semester than this semester just the like figuring out how to balance on my priorities and like what to do with this free time.*" but also said " *I just got to put more effort into it (Physics) and I feel like TA is really supportive though and my friends a physics major and it's there's so many people that are willing to help and even like the physics department has a recitation where it's like you sit in a class with the TA and work on your homework and it's there's plenty of opportunity to ask questions.*" When asked about her high point, Student Oak said, "*I got to be pretty involved with the musical that the NMT Performing Arts Series (Macey Center) just did. So that was really fun.*" She did not list a particular low point.

At the end of the first year, students were also clearer on the particular barriers to success they experienced in college. Student Oak cited the difficulty of finding opportunities to do fine arts at a STEM-focused school as their primary barrier in their first year, but said that "*once I started working at NMT Performing Arts Series and getting involved with the community theater, it's kind of like filled that hole in my life. Cause it's like, I really do like a balance of, I love chemistry, but I also love the theater.*" For student

Meg, adjusting to different teaching styles was their primary barrier to success. She said, "*I think just learning barriers, like once again trying to figure out how different styles of teaching work, that's definitely a barrier you have to overcome because not every professor is going to teach the same way. So you have to get used to every professor every semester.*" Student Ted said, "*I would definitely say just coming over here and almost feeling alone sometimes, but you know, making friends here has really helped,*" which is similar to the barrier they described in the first survey, but this time they mentioned how they were overcoming it. Students were now more clear on their barriers, but also they had all found the support and resources to overcome these barriers.

Common themes between all three interviews were feeling supported, a sense of camaraderie, and a place to talk and learn. Each student had their own individual takeaways from the class. Student Meg, when asked if the course helped with her transition to NMT, responded, "*I think it did, because as we were talking about earlier, it helps you get help if you need it. And then it just makes you feel comfortable knowing that there are other people out there, and they're also having their highs and lows in their first semester. And then just being able to talk about it. It's really nice because you can't always do that.*" Student Ted specifically mentioned in his interview that "*one of the people in there, we still talk usually, we have some classes still together this semester and I would say that it really helps with just, you know, feeling more comfortable in the class.*" highlighting the importance of the social focus of the class, as it led this student to become more active and interact more with their peers. They remained in contact with this friend throughout the academic year and supported each other in other courses, thereby enhancing social and learning outcomes for both.

General patterns in student responses indicate that by the middle of the first semester, they were becoming more comfortable socially in the school. By the end of the year, all students interviewed expressed a sense of belonging and had found or developed social environments in which they could thrive. The ways in which students acclimated to college life varied. Some students sought academic support outside of courses, while others utilized almost no outside resources. Regardless, all students interviewed indicated that they had the social and academic support they needed to succeed during their first year. This process of support development was a core component of the course, so this outcome is very encouraging. This is critical as research has shown that emotional and social comfort can be just as important, if not more important than academics, in retaining students. A common challenge cited by students was difficulty adjusting to the college schedule and workload. However, student responses from the second survey indicate they made significant progress with this during the course. Student Oak said, "*I guess I kind of did struggle at first, just because it's so different from how high school works. Because high school is like everything back-to-back. And there's like my schedule is more open here. And it was something I kind of struggled with at first, just to get used to having almost more free time. And it was like, it just was a learning curve of figuring out what I need to prioritize when.*" This shows that while the course was a struggle initially, they had largely resolved their time management issues by the end of the first year. The importance of effective scheduling has been explored in other literature, so addressing this issue significantly enhances the value delivered by the Chemistry Success course. Overall, the student responses to the first and second questionnaires indicate that the first year was a challenging transition period; however, students felt supported academically and found the social environment of the school to be welcoming.

Participant Feedback on Chemistry Success Course

The student feedback was very positive. All three students interviewed stated that they enjoyed the course and felt it had enhanced their first-year experience. When asked for feedback on how to improve the course for next year, student responses were mostly about how much they liked the course and that little needed to be done to improve the course. Student Meg stated, "*I honestly don't think it really needs improvement. I think that class is, it's good as it is, because once again, it helps you. And then you also do fun things in that class that give you a wider respect for what we do at Tech, because I had no idea that they did that at the Bureau of Geology. And so that gives you like more of a broadened, like it broadens your expectations.*" Student Oak felt similarly and said that "*I don't know. I feel like there were a lot of helpful transition things that we talked about in that class. And I did really like how we were able to do like* *a specific little mini research project.*" Student Ted said, "*I would say the course really helped me. It was really engaging. There was not too much more I would wish for. I think it was just really relaxed, and I kind of really enjoyed being able to meet up and just be with some people that are having the same experience.*"

These responses demonstrate not only how much the students enjoyed this course but also how much it contributed to improving their first year at NMT by providing a space where they felt comfortable exploring and meeting new people. This was a major aim of the course, so receiving positive feedback on this represents an important success for the course.

LIMITATIONS AND FUTURE DIRECTIONS

Given the small size of the university, with approximately 1,000 undergraduates in the 2024-25 academic year, we had only four participants enrolled in the CHEM 0130 Issues in Chemistry and Biochemistry course in Fall 2024. Therefore, this is a pilot study that generated qualitative data. Nevertheless, this was the first time a Course-based Undergraduate Research Experience (CURE) and place-based education project were combined for a first-year Chemistry Success Course. This was also the first time that a CURE project was applied in any Chemistry courses at New Mexico Tech. Given the clear learning outcomes and the positive feedback provided, participants in this Chemistry Success Course can be considered successful. This newly designed Chemistry (first-year) Success Course may be adapted by other NMT instructors or used as a guide to improve outcomes for different student demographics at various institutions.

The course is currently planned to run in the next academic year, and feedback from this study will be implemented to improve future courses. A major point of development will be to implement CURE learning objectives that were not included in this pilot course, such as student-driven hypothesis development and dissemination of information. Also, given the student's response to learning directly from an expert in the field, further involvement of outside non-academic experts is another possible future improvement. In addition to this, other stakeholders, such as local homeowner associations and the local government, could be involved as commissioners of the projects and as audiences for data dissemination. This would provide students with a deeper sense of the relevance of their work, as well as increase the social exposure of students beyond the academic sphere. We will be continuing this course in the coming year, making improvements based on the outcomes and suggestions received.

CONCLUSION

A first-year Chemistry Success Course was developed to include water quality CURE (Course-based Undergraduate Research Experiences) with a focus on place-based education and social-emotional support. The CURE place-based education project findings reveal differences in water quality based on sources and locations, highlighting the importance of continuous monitoring, particularly for arsenic, fluoride, and nitrate, as well as treatment to ensure drinking water safety. This learning process fostered students' interest in how environmental and public health standards are applied in real-world scenarios. Students seem curious and inspired by the personal experiences of graduate students in their research activities and the facilities. The lab reports served as both an evaluative tool and a window into the students' evolving scientific literacy in research. Participant responses from the first semester questionnaire and end-of-the-year interviews indicates that this Chemistry Success Course helped them by providing social emotional support, such as finding friends, campus resources, and engaging them through CURE with place-based education, and therefore, the students plan to continue to pursue their STEM (Chemistry) majors in the second year of college.

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