Studying Latina/o Undergraduates' Scientific Literacy in an Immersive Science Research Experience

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Abstract:

Latina/o individuals are underrepresented in the sciences at all levels of postsecondary education (Carpi et al., 2017; McGee & Bentley, 2017; Neally, 2022). This study presents survey results from a group of Latina/o undergraduates in a National Science Foundation (NSF) funded research opportunity, which emphasized Latina/o students' cultural and linguistic identities. Pre and post surveys examined students' self-perception regarding their comfort using and evaluating scientific literature, scientific processes, and scientific communication. Results demonstrated significant differences for all except participants' future plans in STEM, which solidified their initial interest in the field going into the program.

Objectives or Purpose:

Latina/o individuals are underrepresented in the sciences at all levels of postsecondary education (Carpi et al., 2017; McGee & Bentley, 2017; Neally, 2022). This lack of representation may reflect that Latina/o students have fewer chances to develop scientific literacy in K-12 schools due to socioeconomic or cultural factors (Taningco et al., 2008). Scientific literacy refers broadly to the "familiarity with the enterprise and practice of science" (National Academy of Sciences, 2016, p. 1) and comprises requisite content knowledge, understanding of scientific practices, as well as recognition of science as a social process (Howell & Brossard, 2021). It requires students to develop skills in thinking metacognitively, reading and writing in a scientific manner, and developing scientific arguments (Wallace, 2004). Accordingly, scientific literacy is a cornerstone of students' future academic achievement in the sciences.

Multiple studies have explored the retention and attrition of Latina/o undergraduates in STEM disciplines (Borum & Walker, 2012; Chang et al., 2014; Cole & Espinoza, 2008; Ong &

Smith, 2018). Such studies have identified numerous barriers to Latina/o retention in STEM fields, including impostor syndrome, unwelcoming institutional climates, institutional and social barriers in their departments, racial/ethnic stereotyping, and lack of role models or mentors (Cole & Espinoza 2008; Malone & Barabino, 2009; Robinson et al., 2016). As a result, many Latina/o students question a future in STEM fields and choose not to continue (McGee, 2017).

A key challenge to promoting scientific literacy among Latina/o undergraduates is the racialized systems endemic to both higher education and STEM more specifically. Latinas/os regularly experience both racial microaggressions, i.e., thinly veiled race-based insults, and racial stereotypes, racialized assumptions about Latina/o students' admission, performance, and academic abilities (McGee, 2016; Yosso et al., 2009). The "subtle snubs, dismissive looks, and insulting tones" by largely white peers and faculty communicate to these minoritized undergraduates that "their identities—their very bodies—do not fit those of exemplary STEM students" (McGee, 2016, p. 1629).

Thus, recognizing the racialized bases of science disciplines, this proposal presents survey results from a group of Latina/o undergraduates in a National Science Foundation (NSF) funded research opportunity (NSF Grant: 1852290). In an immersive research experience, six cohorts of students conducted individual and group research projects in Mexico. Central to this REU was the purposeful incorporation of students' cultural and linguistic identities, which led to the overarching research questions for the study: 1) Did the immersive REU project meaningfully connect to students' personal and cultural identities, and 2) Did these associations impact the Latina/os' likelihood to pursue STEM fields in the future?

Theoretical framework:

We situate this study in Latino Critical Race Theory (LatCrit). LatCrit is a scholarly movement, derived from Critical Race Theory in response to the invisibility of Latinas/os in the United States (Valdes, 2005). Similar to CRT, LatCrit originated within legal studies in an effort to critically examine the "social and legal positioning of Latinas/os, especially Latinas/os within the United States, [and] to help rectify the shortcomings of existing social and legal conditions" (Valdes, 1998, p. 3). However, it, too, has expanded beyond the judiciary realm and used to reveal the ways Latina/os' lived experiences intersect with race, class, and gender and such issues as immigration, citizenship status, and language (Osorio, 2016; Solorzano & Delgado Bernal, 2001).

In recent years, researchers have also applied LatCrit to postsecondary science education as a basis for analyzing and critiquing factors related to the underrepresentation of Latinas/os in science, technology, engineering, and mathematics-related disciplines (National Science Board, 2017; National Science Foundation, 2017; Munoz & Villanueva, 2022). For instance, Contreras Aguirre et al., (2020) investigated the personal interactions between Latina/o peers and faculty and found that while essential, such interactions are often missing and thus discourage Latina/o students from remaining engaged in the field. Another factor for Latina/o student disengagement with sciences derives from a "STEM equity disconnect" (McGee & Bentley, 2017). While prevailing views of STEM underscore such fields as means of increasing US economic and technological competitiveness and of achieving personal financial success, a greater preponderance of Latina/o students perceive STEM as a means for bringing about social change (Garibay, 2015; Gibbs & Griffin, 2013). More broadly, LatCrit has challenged the epistemic culture of higher education for minoritized and under-represented students, especially in STEM disciplines (Solorzano & Delgado Bernal, 2001; Villalpando, 2004). Thus, programs for Latina/o

students should be evaluated through this critical lens to determine if they are in fact resulting in increased success for the participants, particularly in their skill development, self-confidence, and motivation to persist in science (Cole & Espinoza, 2008; McGee, 2016; Hortencia, 2017).

Methods, techniques or modes of inquiry:

A survey containing Likert scale questions was given on the first day of the REU program each year, as well as after the last day of the program. The Likert scale questions were grouped into four major categories: 1) scientific literature, 2) scientific communication, 3) scientific processes, and 4) future science plans. Likert scale survey items are regularly used to measure participant attitudes or agreement, and this type of clustering is recommended when the concepts researchers are measuring are not fully captured by a single survey question (Sullivan & Artino, 2013). Sample statements included: I am comfortable evaluating the reliability of a source of scientific information; I can evaluate the quality of research methods and designs; I am comfortable understanding scientific journal articles; and I am comfortable conducting literature searches using research related databases. The post-survey had several additional questions reflecting on future plans for academics and career.

Likert scale responses for each clustered group were converted to numerical responses and averaged for each participant's pre and post survey responses. Although Likert response data is generally considered non-ordinal, which would suggest a nonparametric test, parametric tests are still appropriate and robust for this type of data (Norman, 2010). A paired t-test, a type of Student's t-test used to compare means from samples that are paired in some way (Skaik, 2015) was used to analyze the difference in pre and post survey responses. The of normality of differences, and assumption for this type of test (Kim, 2015), was met for each grouping ($p>.05$ using the Shapiro Wilk test), and outliers were kept in order to best represent each individuals'

specific responses. A Cohen's d to estimate magnitude of reported effects in a consistent way was also run and analyzed against standard effect sizes for small (0.2), medium (0.5), and large (0.8) (Lakens, 2013).

Data sources, evidence, objects, or materials:

The data for this study included responses from 35 participants from the NSF funded REU program (NSF Grant: 1852290) between 2017 and 2022. For the first 3 years of the program, there were 6 participants and then 8 for the remainder. The response rate for participants was 83%. The surveys were created based on a handbook for project evaluation (Fretchling, 2010).

Results and/or substantiated conclusions or warrants for arguments/point of view:

Statistical analysis was done on the survey data from cohorts between 2018 and 2022. The survey from 2017 was different, and so data was omitted. Survey questions were clustered to examine three markers of scientific literacy: comfort using and evaluating scientific literature, comfort and confidence with scientific processes, and comfort and confidence with scientific communication. Additionally, the participants were asked why they chose this REU and what their future academic and career goals looked like. In terms of their rationale for choosing this specific REU through NIU, 100% of participants indicated that they wanted to explore their interests in science, gain hands-on experience in research, and be challenged intellectually, and 86% indicated they already knew they were interested in pursuing a career in science research.

Figure 1 shows the comparison of average responses to the survey questions on the pre- and post- survey. Participants' comfort with using and evaluating scientific literature (cluster 1) showed statistically significant improvement after the REU ($t=3.925$, $df=33$, $p<.001$) with a moderate effect size (Cohen's $d= .670$). The same was true for participants' comfort and

confidence with scientific processes (t=4.678, df=33, p<.001) with a large effect size (Cohen's d= .802), as well as scientific communication (t=-5.068, df=33, p<.001) with a large effect size (Cohen's d= .869). Participant's indication of future plans in STEM did not show a statistically significant difference (t=1.695, df=32, p=.05), as they already had relatively high averages for those responses to begin with (mean = 4.15 before vs 4.311 after). In addition, the post survey data for questions about the community aspect of science all showed an average over 4.1 on a scale of 1-5, with 5 being the highest, showing respondents had strong feelings of community and belonging. Thus, results demonstrated significant difference for all except participants' future plans in STEM, but the free responses suggested that plans to go into a masters or PhD program in some area related to environmental studies were maintained after their REU experience.

While not able to be analyzed quantitatively, we posit a basis for the statistically significant findings deriving from the immersive context in Mexico. In this research experience, program faculty view students' linguistic and cultural heritage as assets to the scientific endeavor, rather than distinct from practices of science. One specific element of this context draws from the cultural value known as *familismo. Familismo* references the powerful connections Latina/os experience to their family and community (López et al., 2019; Taningco, Matthew & Pachon, 2008). Given that this sense of belonging is often undermined in traditional academic settings, especially those in science, this research experience instead emphasized this cultural cornerstone in order to help the undergraduates feel more comfortable (Cole & Espinoza, 2008; Muñoz & Villanueva, 2022). Finally, it prioritized inclusive and collaborative scientific engagment, supported by mentors and peers, thereby reflecting a deeper communal and familial connection within the Latino community.

Scholarly significance of the study or work:

The data from this research shows that this REU program had a positive impact on the participants' scientific literacy and reinforced their desire and enthusiasm for pursuing a future in a science field. The design of this program can thus provide a framework for other, similar, programs that aim to increase representation and diversity in STEM fields, for Latina/o students, or for students with other cultural backgrounds who would benefit from a different approach than what is typical in our undergraduate educational system.

References

Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, *54*(2), 169-194.

Chang, M. J., Sharkness, J., Hurtado, S., & Newman, C. B. (2014). What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups. *Journal of Research in Science Teaching*, *51*(5), 555-580.

Cole, Darnell & Espinoza, Araceli. (2008). Examining the academic success of latino students in science technology engineering and mathematics (STEM) majors. *Journal of College Student Development.* 49. 285-300. 10.1353/csd.0.0018.

Contreras Aguirre, H. C., Gonzalez, E., & Banda, R. M. (2020). Latina college students' experiences in STEM at Hispanic-serving institutions: Framed within Latino critical race theory. *International Journal of Qualitative Studies in Education*, *33*(8), 810-823.

Frechtling, J. (2010) *The 2010 User-Friendly Handbook for Project Evaluation*. NSF.

Garibay, Juan C. (2015). STEM students' social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students? *Journal of Research in Science Teaching* 52 (5): 610–32.

Gibbs, K. D., & Griffin, K. A. (2013). 'What do I want to be with my PhD?' The roles of Personal values and structural dynamics in shaping the career interests of recent Biomedical science PhD graduates. *CBE-Life Sciences Education 12*(4), 711–23.

Guajardo, A. D., Robles-Schrader, G. M., Aponte-Soto, L., & Neubauer, L. C. (2020). LatCrit theory as a framework for social justice evaluation: Considerations for evaluation and

evaluators. In L. C. Neubauer, D. McBride, A. D. Guajardo, W. D. Casillas, & M. E. Hall (Eds.), *Examining issues facing communities of color today: The role of evaluation to incite change. New Directions for Evaluation 166*, 65–75.

Hortencia, Lara. (2017). Latinx students in STEM education research: A CRT and LatCrit analysis of NSF funded projects. [Master's thesis, University of Nebraska.] http://digitalcommons.unl.edu/cehsedaddiss/284

Kim, T. (2015). T test as a parametric statistic. *Korean Journal of Anesthesiology*, *68(6)*, 540-6. doi: 10.4097/kjae.2015.68.6.540.

Lakens D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in Psychology, 4(863)*. doi: 10.3389/fpsyg.2013.00863.

López, E.J., Basile, V., Landa-Posas, M., Ortega, K., & Ramirez, A. (2019). Latinx students' sense of *familismo* in undergraduate science and engineering. *The Review of Higher Education 43*(1), 85-111. doi:10.1353/rhe.2019.0091.

McGee, E. O. (2016). Devalued black and Latino racial identities: A by-product of STEM college culture? *American Educational Research Journal*, 53(6), 1626–1662.

McGee, E., & Bentley, L. (2017). The equity ethic: Black and Latinx college students reengineering their STEM careers toward justice. *American Journal of Education*, *124*(1), 1-36. https://doi.org/10.3102/0002831216676572

Muñoz, J. A., & Villanueva, I. (2022). Latino STEM Scholars, barriers, and mental health: A review of the literature. *Journal of Hispanic Higher Education*, 21(1), 3–16. https://doi.org/10.1177/1538192719892148

National Academies of Sciences, Engineering, and Medicine. 2016. Science Literacy: Concepts,

Contexts, and Consequences. *The National Academies Press*. https://doi.org/10.17226/23595.

National Science Board. (2018). Science and engineering indicators 2018 (NSB-2018-1). Arlington, VA: National Science Foundation. Retrieved from https://www.nsf.gov/statistics/2018/nsb20181/assets/nsb20181.pdf

National Science Foundation. (2017). Women, minorities, and persons with disabilities in science and engineering: 2017. Arlington, VA: Author. Retrieved from https://www.nsf.gov/statistics/2017/nsf17310/static/data/tab5-7.pdf

Neally, K. (2022). An analysis of the underrepresentation of minoritized groups in science, technology, engineering, and mathematics education. *School Science and Mathematics*, *122*(5), 271-280.

Norman G. (2010). Likert scales, levels of measurement and the "laws" of statistics. A*dvances in health sciences education,* 15(5), 625–632.

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching*, *55*(2), 206-245.

Osorio, S. (2016). Border stories: Using critical race and Latino critical theories to understand the experiences of Latino/a children. *Race Ethnicity and Education, 21*(1), 1-13.

Rincón, B. E. (2020). Does Latinx representation matter for Latinx student retention in STEM? *Journal of Hispanic Higher Education*, 19(4), 437–451. https://doi.org/10.1177/1538192718820532

Skaik Y. (2015). The bread and butter of statistical analysis "t-test": Uses and misuses. *Pakistan Journal of Medical Sciences, 31*(6):1558-9. doi: 10.12669/pjms.316.8984.

Solorzano, D., and Delgado Bernal, D. (2001). Examining transformational resistance through a critical race and LatCrit theory framework: Chicana and Chicano students in an urban context. *Urban Education, 36*(3), 308-342.

Sullivan, G. M., & Artino Jr, A. R. (2013). Analyzing and interpreting data from Likert-type scales. *Journal of Graduate Mdical Education*, *5*(4), 541-542.

Taningco, M. T. V., Mathew, A. B., & Pachon, H. P. (2008). STEM professions: Opportunities and challenges for Latinos in science, technology, engineering, and mathematics. Tomás Rivera Policy Institute.

Valdes, F. (1998). Foreword: Under construction-LatCrit consciousness, community, and theory. *La Raza Law Journal*, *10*, 1-56.

Valdes, F. (2005). Legal reform and social justice: An introduction to LatCrit theory, praxis and community. *Griffith Law Review*, *14*(2), 148-173.

Villalpando, O. (2004). Practical considerations of critical race theory and Latino critical theory for Latino college students. *New Directions for Student Services, 2004*(105), 41–50. Retrieved from http://hf4vl6dz9y.search.serialssolutions.com doi:10.1002/ss.115

Wallace, C.S. (2004), Framing new research in science literacy and language use: Authenticity, multiple Discourses, and the 'third space'. *Science Education*, 88(6), 901-914. https://doi.org/10.1002/sce.20024

Yosso, T., Smith, W., Ceja, M., & Solórzano, D. (2009). Critical race theory, racial microaggressions, and campus racial climate for Latina/o undergraduates. *Harvard Educational Review*, *79*(4), 659-691.

Figure 1

Pre and Post Survey Responses from REU Students