Diving into the Vortex: Examining Math Identity, Science Self-efficacy, Sex, and Race

Talisa J. Jackson, George Mason University, United States
Joanna G. Jauchen, George Mason University, United States

The IAFOR International Conference on Education - Hawaii 2019
Official Conference Proceedings

Abstract
As the global population increases to approximately 8.3 billion people, the United States National Intelligence Council (2012) predicts a 35% worldwide increase in demand for food, 40% increase in demand for water, and a 50% increase in demand for energy. Thus, educating and cultivating a workforce that can identify ways to meet these demands will be paramount; the U.S. Bureau of Labor Statistics' predicts that science, technology, engineering, and mathematics (STEM) jobs will be among the fastest growing fields. However, STEM fields continue to struggle to attract and retain men from historically underrepresented groups and women (NSF, 2017). The underrepresentation of women, Blacks, and Latinxs becomes even more pressing as demographic models of the US predict a future population that is majority-minority (Landivar, 2013; Ortman, & Guarneri, 2009). Therefore, identifying ways to make STEM accessible to all, and increase representation in STEM-related careers is vital to addressing future global needs (NSF, 2013; Committee on Underrepresented, 2010).Previous work has shown that mathematical identity and science self-efficacy are factors in choosing STEM disciplines (Boaler & Greeno, 2000; Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011). Our presentation will explore how mathematical identity and science self-efficacy interact with each other and differ by sex and race. We draw on literature and multiple regression analysis to examine the complex interplay between these constructs and reflect on how our results may impact both current and future practitioners

Keywords: mathematics, science, STEM, identity, self-efficacy, race, sex

Introduction

While the United States faces an increased need for more STEM majors, STEM disciplines continue to struggle to attract and retain female, Black and Latinx students (Bureau of Labor Statistics, 2018; National Science Board, 2018; National Science Foundation, 2017). A significant amount of research has examined the reasons for this continued underrepresentation of women and minorities, largely centered around achievement. But the history of that literature has been critiqued as an "achievement gap gazing fetish" (Gutierrez, 2008, p. 357) which has not yielded significant changes in STEM. Gutiérrez suggested that practitioners and researchers alike need to reconceive equity work to address three factors in addition to achievement: access, identity and power. Gutiérrez's work is part of a larger sociocultural (or what some deem socio-political) turn in STEM education .

Mathematical identity is one of the socio-cultural constructs that researchers have studied in the context of STEM equity work (Boaler & Greeno, 2000). Identity is "being recognized as a certain 'kind of person'" (Gee, 2000, p . 99) and is socially constructed. Sfard and Prusak wrote that identity is "man-made and as constantly created and re-created in interactions between people" (p. 15). This social construction means that identity represents "how individuals know and name themselves …, and how an individual is recognized and looked upon by others" (Grootenboer, Smith & Lowrie, 2006, p. 612). Mathematical identity, as conceptualized in this work is made up of two components. First, do students see themselves as being a mathematical person, and second, do others consider that student a mathematical person.

A connected, though distinct construct is self-efficacy. Self-efficacy, first described and studied by Bandura (1977) is a person's confidence that they can complete a task (Lent, Hackett, & Brown, 1999). When self-efficacy is studied in the context of science classrooms, we call that construct science self-efficacy, which is a student's confidence in their ability to independently complete their science work. For example, a student with high science self-efficacy may feel completely capable of reading their science textbook on their own. These two constructs, science self-efficacy and mathematical identity, have been studied previously in a body of literature that has, as Gutiérrez noted, centered on how these constructs were connected to achievement.

The literature also routinely draws on two related constructs: math self-efficacy and science identity. We provide a brief review of that work here. Math identity has been linked to STEM career interest (Cass, Hazari, Cribbs, Sadler & Sonnert, 2011). A similar study showed that math self-efficacy likewise was connected to STEM career interest (O'Brien, Martinez-Pons & Kopala, 1999) and several studies have included both as predictors to STEM career interest and examined how that prediction differed by sex and race (Cribbs, Piatek-Jimenez, & Mantone, 2015; Briggs, 2014; Kotok, 2017).

Science education researchers have performed similar work around the science constructs. For example, high science identity has been shown to be predictive of scores on a chemistry assessment (Robinision, Perez, Carmel, Linnenbrick-Garcia, 2019). High science self-efficacy has also been linked to higher levels of achievement

(Britner & Pajares, 2006). Further, high science identities combined with high science self-efficacy has also been shown to be predictive of science achievement (White, DeCuir-Gunby, & Kim, 2018). In research that included constructs from both math and science education, results suggest that strong math and science identities were linked to the pursuit of STEM careers, and the results there differed by sex (Lock, Hazari, & Potvin, 2013).

Few studies have considered how these individual constructs may depend on each other. In this study, we considered how mathematical identity might impact science self-efficacy. A conceptual map of our question is provided in Figure 1. We did not include science identity or math self-efficacy as variables in our regression analysis. Thus, our research aims to address the following research questions:

1. Controlling for socioeconomic status (SES), do mathematics identity, race, and sex predict science self-efficacy?
2. Does sex moderate the relationship between mathematics identity and science self-efficacy?
3. Does race moderate the relationship between mathematics identity and science self-efficacy?

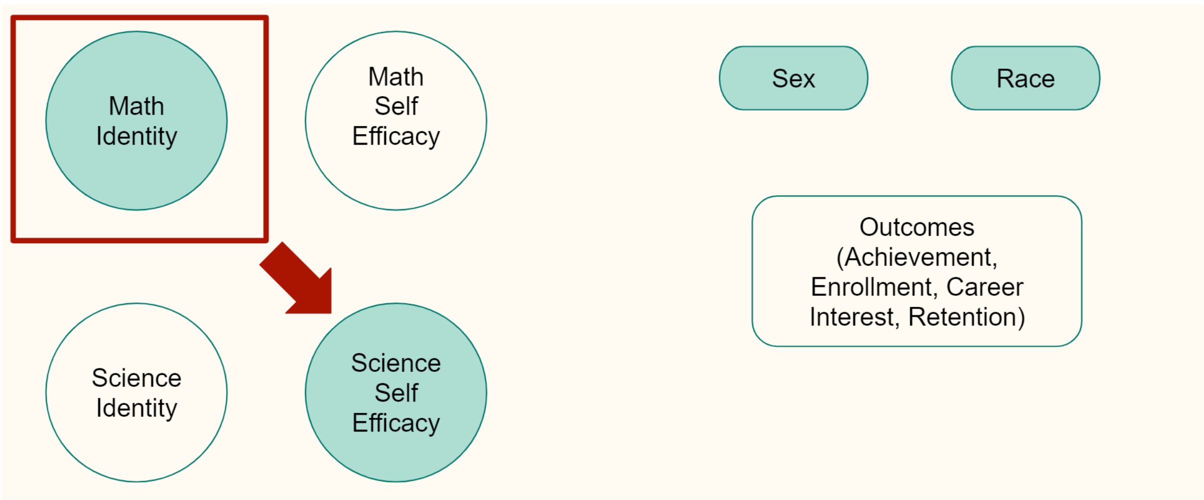

Figure 1. Concept map between math identity and science self-efficacy (Our framework)

Conclusion

We used the High School Longitudinal Study of 2009 to run three regression analyses of approximately 17,000 ninth grade students within the United States (Ingels et. al, 2011). Our analysis suggest the following:

1. Math identity, sex, and race, are significant (p <.05) predictors of science self-efficacy.
2. Sex significantly (p <.05) moderates the relationship between math identity and science self-efficacy.
3. Race, significantly (p <.05) moderates the relationship between math identity and science self-efficacy. It is important to note that although race was a significant moderator, there was only a significant difference between Black, White, and Latinx students.

From the knowledge gleaned from our results, we have more of an understanding regarding the ways in which socio-cultural constructs relate to each other. The results from this analysis also provide more insight into the cross-disciplinary relationship between mathematics and science. More research is needed to explore the longitudinal impacts these sociocultural factors have on each other.

References

Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. Journal of Clinical and Social Psychology, *4*, 359–373. doi: 10.1521/jscp.1986.4.3.359

Boaler, J., & Greeno, J. G. (2000). Identity, agency, and knowing in mathematics worlds. *Multiple perspectives on mathematics teaching and learning*, 171-200.
Briggs, C. (2014). *Mathematics: Self-efficacy, identity, and achievement among African American males from the high school longitudinal study* (Unpublished doctoral dissertation).

Britner, S. L., & Pajares, F. (2006). Sources of Science Self-Efficacy Beliefs of Middle School Students. Journal of Research in Science Teaching, *43*(5), 485–499. https://doi-org.mutex.gmu.edu/10.1002/tea.20131

Bureau of Labor Statistics (2018). Fastest growing occupations. Washington, D.C. Retrieved from https://www.bls.gov/ooh/fastest-growing.htm

Cass, C. A., Hazari, Z., Cribbs, J., Sadler, P. M., & Sonnert, G. (2011). Examining the impact of mathematics identity on the choice of engineering careers for male and female students. In Frontiers in Education Conference (fie), 2011 (pp. F2H–1).

Cribbs, J., Piatek-Jimenez, K., & Mantone, J. (2015). The relationship between mathematics identity and personality attributes with students' career goals. *North American Chapter of the International Group for the Psychology of Mathematics Education.*

Grootenboer, P., Smith, T., & Lowrie, T. (2006). Researching identity in mathematics education: The lay of the land. *Identities, cultures and learning spaces, 2*, 612–615.

Gutiérrez, R. (2008). A" gap-gazing" fetish in mathematics education? Problematizing research on the achievement gap. *Journal for Research in Mathematics Education*, 357-364.

Gutiérrez, R. (2009). Framing equity: Helping students "play the game" and "change the game.". *Teaching for excellence and equity in mathematics, 1*(1), 4-8.

Ingels, Steven J., Daniel J. Pratt, Deborah R. Herget, Laura J. Burns, Jill A. Dever, Randolph Ottem, James E. Rogers, Ying Jin, and Steve Leinwand (2011). High school longitudinal study of 2009 (HSLS: 09): Base-year data file documentation. NCES 2011-328. *National Center for Education Statistics*.

Kotok, S. (2017). Unfulfilled potential: High-achieving minority students and the high school achievement gap in math. *The High School Journal, 100*(3), 183–202.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. Journal of Vocational Behavior, 45, 79-122. doi: 10.1006/jvbe.1994.1027

Lock, R. M., Hazari, Z., & Potvin, G. (2013). Physics career intentions: The effect of physics identity, math identity, and gender. In *AIP conference proceedings* (Vol. 1513, pp. 262–265).

National Science Board. (2018). Science and engineering indicators. Arlington, VA: National Science Foundation (NSB 2018-1).

National Science Foundation. (2017). Table 9-5. Employed scientists and engineers, by occupation, highest degree level, and sex: 2015. Arlington, VA. Retrieved from http://www.nsf.gov/statistics/wmpd/tables.cfm

O'brien, V., Martinez-Pons, M., & Kopala, M. (1999). Mathematics self-efficacy, ethnic identity, gender, and career interests related to mathematics and science. *The Journal of Educational Research*, *92*(4), 231-235.

Ortman, J. M., & Guarneri, C. E. (2009). United States population projections: 2000 to 2050. United States Census Bureau, Retrieved from https://www.census.gov/content/dam/Census/library/working-papers/2009/demo/us-pop-proj-2000-2050/analytical-document09.pdf

Owens, K. (2008). Identity as a mathematical thinker. *Mathematics Teacher Education and Development*, *9*, 36-50.

Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational researcher, 34*(4), 14-22.

White, A. M., DeCuir-Gunby, J. T., & Kim, S. (2018). A mixed methods exploration of the relationships between the racial identity, science identity, science self-efficacy, and science achievement of African American students at HBCUs. *Contemporary Educational Psychology*. https://doi.org/https://doi.org/10.1016/j.cedpsych.2018.11.006