Understanding Mathematics Identity and Belonging in an Undergraduate General Education Terminal Mathematics Course

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Abstract

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With the goal of enchancing student egagement and equity in undergraduate general education terminal mathematics courses, Homp et al (In Progress) devised instructional strategies, focused on highlighting the contributions of historically minoritized mathematicians. As a part of this multi-sectioned course, the students wrote four biographical assignments about the previously mentioned minoritized mathematicians. A pre- and post-survey adapted form Hazari et al (2020) revealed a significant increase the feeling of belonging of the students in the broader mathematical community. Using Guiterrez' (2012) equity in mathematics education dimensions of access, achievement, identity and power, we examine for each student three of their biography assignments and thematically analyze how the views on mathematics, mathematicians, and their connection to themselves evolved over the semester. Our findings indicate that early in the semester, students initially focused on the achievements of their selected mathematicians, and as the semester progressed, students found more human ways in which they connected with the mathematicians. This suggests the instructional tasks described here, which are relatively simple and inexpensive to implement, can have a significant impact on improving mathematical identity for students in a general education mathematics course.

Key Terms: Inclusive course design, inclusive instruction, mathematical identity, sense of belonging

1 Introduction

A team of mathematicians implemented several strategies in a multi-section course at University of Nebraska - Lincoln with the goal of enchancing student engagement and equity. These strategies included an Open Educational Resource Textbook, available freely online. At the end of various sections of the textbook, biographies of historically minoritized mathematicians were included. These are current mathematicians who are active in the mathematical research community, in topics ranging from Statistics and Data Science, modeling disease spread, to doing research involving gerrymandering and other political issues. Three times during the semester, the students were tasked with writing short biographies on a mathematician of their choice that corresponded with the material learned in that part of their class. In between the second and third biography, the students were tasked with choosing a mathematician from Mathematical Association of America's *Living Proof* (Henrich et al., 2019) book, and writing an assignment about them.

Among the students who take math courses like this are typically non-scientists, and often include future primary school teachers, artists, and anyone whose undergraduate degree does not require College Algebra, or any courses that College Algebra is a prerequisite to. At the start of this course, many of the students felt like they did not belong to the mathematical community, or felt alienated by the community. At the end of the course, the students sense of belonging showed the most significant increase, given by a pre- and post survey.

This article seeks to further explain how the students sense of belonging in the broader mathematical community increased by using a modified version of Gutierrez' framework for conceptualizing equity in mathematics education using identity, power, access, and achievement. (Gutiérrez, 2012)

2 Literature Review

Before investigating equity, we first have to define it. Merriam-Webster defines Equitable to mean something is fair in a way that accounts for and offsets disparities in the way people of different races, genders, etc. are treated. (Merriam-Webster, n.d.) This means that instead of only trying to create equal access to mathematics and mathematics education, we need to try to implement strategies that specifically target the context of the people - that is, targetting their connection to the subject in the areas of race, gender, etc. In 2002, Gutierrez claims that Equity means "the inability to predict mathematics achievement and participation based solely on student characteristics such as race, class, ethnicity, sex, beliefs, and proficiency in the dominant language." (Gutiérrez, 2002) It seems that in order to have our desired outcome of students leaving mathematics courses where they have some deeper understanding of the course topics, focusing soley on the identity of the student may not be sufficient. Instead, Gutierrez proposes contextualizing the students with the creation of a critical axis, consisting of identity and power, and a dominant axis, consisting of access and achievement, and how understanding the intersection of the two may provide valuable insight to supporting students in mathematics. We need to start with the definitions of these 4 objects:

Identity is who you are. It's the langauges you speak, where you are from, your cultural practices, and how you see the world.

Power is your ability to make changes in the world. It could be your voice in class, framing mathematics in different contexts, being critical of society, etc.

Access refers to your access to quality education, tools, and tangible resources to participate in the mathematical community.

Achievement is your measureable achievement in mathematics. This can be your class participation, course grades, knowledge of mathematical careers, and the jobs available to you because of your mathematical knowledge, or lack of knowledge. (Gutiérrez, 2012)

Riley utilizes Gutierrez' dimensions of equity to understand successful mathematicians in the American Mathematics Society publication, *Testimonios*. (Harris, 2022) Riley explored the positive and negative experiences shaping these Hispanic and Latinx mathematicians, leading us to believe that one of the biggest factors in mathematical success is the support from teachers and mentors. Some of the other positive experiences include a supportive family, mathematical role models, and mathematics enrichment. The biggest negative experience that impacted these mathematicians was the limited education of their parents. Some of the other negative experiences included imposter syndrome and limited latinx representation.

Beyond the mathematicians Riley explored lay our students. The mathematicians studied by Riley are wildly successful in their fields - and they experienced imposter syndrome. The experts in their fields struggle with a feeling of belonging

- so too must our students, who are taking a general education, non science major mathematics course. (Riley, 2022)

The study conducted in this article follows directly from Homp et al., n.d. Homp seeks to increase the engagement of students in a terminal general education undergraduate mathematics course at the University of Nebraska - Lincoln. Homp employed the tools previously discussed - Employing an Open Education Resource textbook (OER) with the previously mentioned biographies of mathematicians. They also had instructor led discussions on those mathematicians. The students wrote three biographies, and an essay on a mathematician chosen from Living Proof. Pre and Post surveys revealed a significant increase in the feeling of mathematical belonging. It's from this point that we begin our investigation into the three mathematician biography assignments.

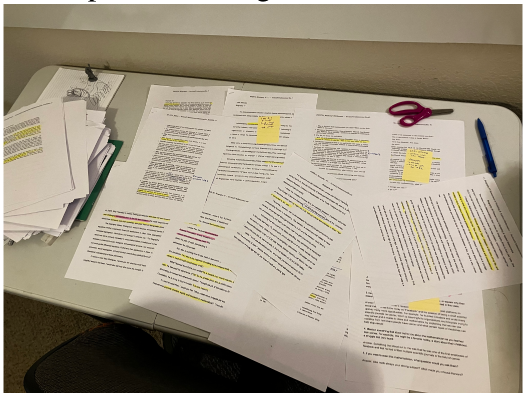
3 Methods

The study was reviewed and approved by the Institutional Review Board (IRB) at the University of Nebraska – Lincoln. Informed consent was obtained from all participating students. 118 students consented to the study out of 128 total students. Researchers at University of Nebraska, Lincoln (Homp et al., n.d.) collected pre-surveys and post-surveys on students taking a terminal general mathematics course to understand their feeling of belonging, interest, recognition, and utility/confidence. The students sense of belonging showed the greatest statistical change. As a part of the course, students were exposed to various mathematicians with different backgrounds and research interests that aligned with the topics from the course. A free and open textbook was used as a part of the course, and each chapter concluded with biographies of these various mathematicians doing work similar to the topics in the chapter. The students were then tasked at 3 different times throughout the semester with writing a biography on the mathematicians. They were also tasked with writing one longer biography over a mathematician featured in the Mathematical Association of America's Living Proof (Henrich et al., 2019) book. In this paper, we analyzed the three biographies written by students to better understand why their sense of belonging increased. We are excluding the biography the students wrote on a mathematician from Living Proof, as the prompt given was different from the other three biographies. The Living Proof assignment was also done before the final, third biography was written by students, so it may have some effect on the third biography's student responses. In this paper we analyze one of the five available sections of data.

3.1 A First Look

The first task for us was to read the artifacts. In order to better understand the students and their work, we printed them, as seen in Figure 1. This enabled us to more easily search through the artifacts and scatter the papers in a way that promoted easier study. However, the papers were not marked with any information to identify which assignment it was, nor which student number it belonged to. So, a bash script was created using the pandoc package to convert any docx files to pdf, then the cpdf package to insert text displaying the student identification number, and labeling the assignment.

Figure 1: The first pass of coding, before a codebook was created.



3.2 Devising a Codebook

After this premlinary analysis, we devised a codebook, and moved from pen and paper to Microsoft Excel. Our Excel Spreadsheet contained a list of quotations taken from the student artifcats, and allowed us to categorize the quotation into the codes.

In order to perform the qualatative analysis on these student submissions, we defined a codebook that roughly follows the Gutierrez framework - that is, the Achievement and Access axis, and Identity and Power axis (Gutiérrez, 2012).

An early reading of the artifacts revealed that plainly labeling everything into these four codes wasn't sufficient, as the students wrote both about their own identity, and the mathematicians identity, which are different. Some artifacts only contained one, and not the other. So, we differentiated them into 8 codes:

Table 1: Codebook

Code	Definition
Mathematician Access	Access to mathematics training, mathematics teachers, mathematical tools. Also, access to education in general.
Self Access	Access to mathematics training, mathematics teachers, mathematical tools. Also, access to education in general.
Mathematician Achievement	The research the mathematician is conducting, their achievements in mathematics and in general, or lack thereof.
Self Achievement	The job of the person, their college admission, their achievements in general - mathematics or otherwise. Or, lack of achievement.
Mathematician Identity	The specific details of the mathematician. Their gender, country of origin, ethnicity, hardships, name, marital status - basically, who they are.
Self Identity	The specific details of the student. Their gender, country of origin, ethnicity, hardships, name, marital status - basically, who they are.
Mathematican Power	The ability of the mathematician to make social changes. Using their position to enact change.
Self Power	The ability for the student to make social changes. Using their job, their education, etc. to make some kind of social change, or desire to make change.

3.3 The Coding Process

With these codes, we began thoroughly investigating each student artifact. Over the course of a few weeks, each artifact was broken down into some quotations. Not every part of every artifact was kept and coded, as many pieces of the artifacts were just informational sentences to maintain the ”flow” of the student’s paper. Some pieces didn’t fit into the 8 codes, and there wasn’t enough information to classify it into any new codes.

To ensure that that the codebook and coding process was repeatable, Dr. Jorgensen reviewed Ryan’s codes and found some discrepencies, which were resolved by correcting definitions, and providing more examples. For example, Dr. Jorgensen’s coding involved selecting each code the quotation fell into, where Ryan only selected the primary, or main code. We agreed on only using the primary code. In another instance, Dr. Jorgensen had categorized instances of immigration stories into mathematician power, or mathematician access, where Ryan categorized the same quotations into mathematician identity. For consistency, we agreed on placing immigration into the identity category, as being an immigrant is often a fundamental piece of identity.

Figure 2 shows the three biographies written by a single student. When coding

Figure 2: Coding Example

Biography #1
I choose Jordan Harrod because she is woke enough to use YouTube (I actually watched her videos after and loved them). Jordan Harrod is from Montclair, New Jersey. She currently is a student apart of the Harvard-MIT where she studies brain stuff. She publicly speaks on artificial intelligence. Basically, she studies the brain and how it works with itself as of right now. The better we understand the brain the more we can benefit ourselves as people and it would benefit medically as well. The more she learns about the brain the more statistics we can create related to the brain. This could benefit the medical field by gaining these statistics. I think it's really interesting how she uses AI in her work as well. She talks about the reality of AI and I think that's great.
Questions for her: How did you get into AI and the brain? How do these relate to one another to you?

Biography #2
Moon Duchin is a professor at Tufts University teaching mathematics. I choose Moon because one her name was really interesting, and she just looked like an interesting gal with some stories to tell. She is a leading expert in gerrymandering. This could keep political parties in check. We were taught about the basics of gerrymandering, but she is an expert. She really wanted to be a baseball player which I though was fun. Unfortunately, she's a woman and they would have been like no baseball for you. She's also not straight (why I picked her as well) so I though that was fun and relevant. How did you decide to study gerrymandering? How does one get into that field?

Biography #3
Ricardo Cortez is a professor at Tulane University. He is from New York City but moved to El Salvador. I choose him because he seemed like a nice guy, such a dad. Man studies engineering which is necessary to make the world go round. That is meaningful. Richard described moving countries to be a struggle at first. He had to adjust to to the cultural norms. How did moving affect your life and get you into math?

Legend
Mathematician/Self Achievement
Mathematician/Self Access
Mathematician/Self Identity
Mathematician/Self Power

short submissions like these, I enter the entire essay into the Excel sheet, and break it down into several quotations, each with a different code. If anything didn't fit into any codes, it was removed. In the third biography, this student mentioned how their chosen mathematician moved from New York to El Salvador. Maintaining consistency with our coding scheme identifies that quotation as Mathematician Identity.

3.4 The Prompts

The students were given the following prompt for the three main biographical assignments, as shown in figure 3. Figure 4 was the prompt given for the other mathematician essay. The difference in the prompts is the reason the Living Proof essays were not included in the coding process.

Figure 3: The Main, repeated biography prompt

1. What is the name of the statistician or data scientist you chose. Where are they from? Where do they work?
2. Why did you choose this individual?
3. Describe their research (as best as you can) in your own words; or explain why their research is meaningful and how it relates to the mathematics learned in this class.
4. Mention something that stood out to you about the mathematician as you learned their stories. For example, this might be a favorite hobby, a story about their childhood, a struggle that they faced.
5. If you were to meet this mathematician, what question would you ask them?

Figure 4: The prompt given to students for their Living Proof assignment.

- Indicate the name of the mathematician you selected and where they teach or work.
- What made you decide to choose the mathematician that you did?
- Describe something that stood out to you as you read their story.
- What are some barriers they encountered on their journey and who or what helped them overcome these difficulties?
- While you might not be pursuing a career in mathematics, everyone faces obstacles at some point while working toward their goals. What are your career goals? What obstacles have you faced as you pursue these goals and how are you overcoming them?
- Consider the barriers faced by this mathematician and those which you encounter. How are they similar or different? Can you see in this person's life experiences something that connects to your own life and challenges?

4 Results

The students primarily talk about their chosen mathematician's achievement. This is expected, as it is directly the prompt they are given. As the semester progresses, it seems the students are incorporating other things into the artifacts, like identity, power, and access. Several students picked a mathematician based only on the fact that they were a woman, or person of color. Some students picked their mathematician because they weren't aware of the various jobs mathematicians do. Some students picked their mathematician only because of their achievement.

- I chose her as the mathematician because I thought it would interesting *[sic]* **since she is a woman of color** and I want to read more about her story.

- I chose Federico Ardila because he seemed the most interesting while reading about his **contributions.**

- I chose this person because **is experts** *[sic]* **in gerrymandering which seemed interesting to me.**

- I chose Ron Buckmire because I found it interesting that he spent **four years at the national science foundation.***[sic]*

- I chose Candice because she got her doctoral degree in mathematics from the **University of Iowa. I'm from Iowa, so I was biased.**

Initially, the artifacts covering Living Proof were included, so some analysis was done - we noticed a sharp increase in students talking about self identity, self access, and other non-mathematician achievement topics. After this assignment, the third biography was assigned, and completed. We believe the prompts from Living Proof may have had some influence on the third biography.

4.1 Code Counts

Table 2: Code Counts through the semester

	S. Access	M. Access	S. Achievement	M. Achievement	S. Identity	M. Identity	S. Power	M. Power
Bio #1	5	8	0	53	2	30	0	18
Bio #2	2	4	0	39	3	32	1	31
Bio #3	6	11	2	43	4	26	0	13

At the start of the semester, the students mentioned something about the mathematician's achievements 53 times. By the end of the semester, this count reduced to 43. During the second biography assignment, students mentioned mathematician power significantly more, counting at 31 times. Self Power only came up one time, during the second biography assignment.

5 Discussion

By discussing current mathematicians who are doing varied research, it seems the students found opportunities to connect personally with some mathematicians. Some students may have merely wrote facts on the mathematicians achievement, many students took the opportunity to also discuss interesting pieces of the who the mathematicians were, and found great interest in the varied research of mathematicians. Previous to taking the course, the students may not have had the opportunity to learn about non-textbook examples of mathematicians. For example, in a standard Texas Geometry class, a class all Texas college students would have to take before enrollment at a Texas university, the learning (TEK) objectives focus on Euclid's Elements and Descarte's analytical geometry techniques. The work of historically minoritized geometers seems to be excluded, which may have had great impact on the students sense of belonging at the start of the course.

In the first biography assignment, Mathematician Achievement is the most frequently used code, coming in at over 50 mentions. Students likely did not make as many connections between themselves and the mathematicians identities until later in the semester, when the count of mathematician achievement reduces, meaning the students spent more of their essays writing on other issues. The students seem to have shifted from thinking heavily about the success of mathematicians, to finding other ways of connecting with them.

During the second biography assignment, students abnormally spoke on Mathematician power. This likely comes from the topic of the second biography assignment: Mathematicians doing research on voting issues, like gerrymandering. In this second biographical assignment, students directly wrote praise to the mathematicians for enacting change to try to solve the gerrymandering issue.

In between the second and third biography assignment, the students wrote an essay over a mathematician in ”Living Proof.” (Henrich et al., 2019) It seems that the different prompt on this assignment may have had an impact on the third biography. At first, we were reading and categorizing the content of these artifacts. After noticing substantial differences in the frequency of various codes, we looked into the prompt to find it was different. So, it was excluded from this study. However, it may have impacted the way the students wrote the following biography assignment, as this Living Proof assingment had directly prompted the students to personally connect with the mathematicians. Perhaps by directly asking the students how they personally connect with the mathematician, the students are forced to make the connection and join the broader mathematical community.

5.1 Limitations

In this study, our biggest limitation was time. This study was conducted over ten weeks in the summer in between the Spring and Fall semesters. This only allowed us to look at one of the available five sections. If certain groups of students were unable to take these one investigated section, they were excluded from this study. However, looking at only this one section still shows a huge benefit from implementing the biography assignments in the course. Talking about mathematicians who have been historically minoritized is still beneficial to the creating students who feel like they can connect directly to mathematicians, making them feel they belong,

This study only looks at one section, in one course, in one University, in Nebraska. The school is predominantly white. This can affect the way the students are or are not able to connect to historically minoritized matheamticians. Plainly, if they aren't a minority, connecting to a minority might be harder. Even still, the results still show that their feeling of belonging did increase, and the students did spend more time writing about categories other than mathematician achievement.

This research was the first time undergraduate mathematics student Ryan Arif conducted qualatative analysis. Every tool used, all of the literature, was not previously researched until the start of the project. This can mean that some themes may have been overlooked.

5.2 Future Work

Investigating more courses at more universities should be a priority, following this article. Increasing the feeling of belonging in the mathematical community can have great results in helping close the achievement gap, and getting students interested enough to succeed in a mathematics course. Investigating how implementing these strategies in non-terminal mathematics courses should be investigated - will showing mathematics students current day mathematicians help ease their imposter syndrome, or that feeling of alienation? Will teaching engineers that mathematics is more than just numbers and equations help them feel they belong in the mathematical community?

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References

Gutiérrez, R. (2002). Enabling the practice of mathematics teachers in context: Toward a new equity research agenda. *Math. Think. Learn.*, *4*(2-3), 145–187.

Gutiérrez, R. (2012). Context matters: How should we conceptualize equity in mathematics education? In *Equity in discourse for mathematics education* (pp. 17–33). Springer Netherlands.

Henrich, A. K., Lawrence, E. D., Pons, M. A., & Taylor, D. G. (2019). *Living proof: Stories of resilience along the mathematical journey*. The American Mathematical Society : The Mathematical Association of America.

Harris, P. E. (2022). *Testimonios: Stories of latinx and hispanic mathematicians*. MAA Press.

Riley, T. S. (2022, May). *Exploring gutiérrez's dimensions of equity in mathematics in the testimonies of latinx and hispanic mathematicians* [Master's thesis]. University of Texas at Arlington.

Homp, M., Jorgensen, T., & Rezac, L. (n.d.). Impact of inclusive instruction on sense of belonging as a construct of identity in a general education mathematics course [In Progress.].

Merriam-Webster. (n.d.). *Equitable*. https://www.merriam-webster.com/dictionary/equitable (accessed: 08/10/2025).