MATHEMATICS LEARNER AND MATHEMATICS EDUCATOR IDENTITIES IN A PROBLEM-SOLVING FOCUSED MATHEMATICS CONTENT COURSE

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In this study, we sought to understand what might be learned about preservice teachers' mathematics learner and mathematics educator identities in the context of a problem-solving focused mathematics content course. Twenty-two preservice teachers participated in this study as part of their undergraduate teacher preparation program. We implemented a narrative identity lens which operationalized stories as identity with a sociocultural understanding of learning. In our findings we discuss examples of how mathematics learner identity influenced mathematics educator identity, and vice versa. In addition, we emphasize the importance of the way that preservice teachers define mathematics and how this influences mathematics identities.

Keywords: Preservice Teacher Education, Problem Solving, Instructional Vision, Affect, Emotions, Beliefs, and Attitudes

The purpose of studying identity in mathematics education is to emphasize the whole person—inclusive of but expanding beyond one's mathematical skills and knowledge (Lerman, 2009). In this sense, mathematics identity research enables a broad view of "what counts as mathematics" and where mathematics learning occurs (Saxe, 1988, p. 14). Researchers of mathematics identity acknowledge the multiple identities that an individual holds and seek to understand how those identities interrelate (Berry 2008; Gresalfi & Cobb, 2011; Wenger, 1998). These multiple identities are enacted in the many roles that one performs (Darragh, 2015). In the context of teacher education, an undergraduate preservice teacher plays the roles of both *learner* and *teacher* while simultaneously enacting countless other identities, perhaps of roommate, artist, first-generation student, etc.

Undergraduate preservice teachers enroll in a university with already well-developed concepts of what it means to play the role of teacher (Lortie, 1975). Still, the formal action of enrolling in a teacher education program suggests an intentional step toward developing one's understanding of this role. This particular juncture of entering a teacher-education program seems an appropriate context to take up calls for more research understanding the link between learner and teacher identity (Graven & Heyd-Metzuyanim, 2019; Lutovac & Kaasila, 2018). By maintaining a whole-person-view of preservice teachers' multiple identities, we aim to contribute to further understanding of both mathematics learner and mathematics teacher identities.

A Problem-Solving Focused Mathematics Content Course

Preservice teachers can be expected to teach similarly to how they were taught without some means of intervention to create a "break with experience" (Ball, 1990, p. 11). The context of this study is a mathematics content course for primarily first-year undergraduate preservice teachers that attempts to intervene in this cycle of teaching. In doing so, instructors of this course not only teach content knowledge, but model pedagogical strategies that preservice teachers might adopt in their future practice to engage all students in learning.

The curriculum developers of this problem-solving focused course assume that enrolled students have generally experienced a traditional, teacher-centered mathematics classroom in

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which direct instruction of procedures to follow is the norm (Masingila et al., 2011). They push back on a traditional, or instructionist model of teaching (Sawyer, 2006), and have designed the course to encourage learning through collaboration and discussion. In this way, the course holds promise for interrupting previously developed conceptions of what it means to learn and to teach mathematics. Given this background, the course is an appropriate setting for understanding participants' existing and developing roles of both learner and educator. Our research was guided by the following research question: What might be learned about preservice teachers' mathematics identities of *learner* and *educator* in the context of a problem-solving focused mathematics content course?

Mathematics Identity

Researchers of mathematics identity have called on the field to be explicit in defining the construct to ensure theoretical and methodological coherence and also to prevent the term from becoming synonymous with other related but different constructs such as beliefs or attitudes (Darragh, 2016; Sfard & Prusak, 2005). In response to this call, we first describe key features of mathematics identity and then expand further on two sub-constructs of mathematics identity: mathematics learner identity and mathematics educator identity.

A key feature of mathematics identity is performance—identity is what we do (Darragh, 2015). In addition to this, mathematics identity can be viewed as storied—it is the stories we tell (Sfard & Prusak, 2005). One has multiple identities and may perform them at the same time (Berry 2008; Darragh, 2015). Not only this, but these multiple identities interact together and need not be confined to the mathematics classroom. For example, Berry (2008) found that alternative identities, such as religious identity or athletic identity, contributed to the success of African American boys by helping them to overcome barriers that may have otherwise limited their access to more advanced mathematics. From a socio-cultural perspective, these performances of identity are formed within one's social environment while simultaneously shaping that environment (Wenger, 1998). In addition to these key features, mathematics identity over the last few decades has split into sub-categories of learning and teaching (Darragh, 2016; Graven & Heyd-Metzuyanim, 2019; Graven & Lerman, 2020).

Mathematics Learner Identity

Mathematics learner identity can be thought of as a category under the "umbrella" of mathematics identity concerning the identities of those learning mathematics. Darragh and Radovic (2020) defined mathematics learner identity as

> a socially produced way of being, as enacted and recognized in relation to learning mathematics. It involves stories, discourse and actions, decisions, and affiliations that people use to construct who they are in relation to mathematics, but also in interaction with multiple other simultaneously lived identities. (p. 582)

Though researchers may use the more general term mathematics identity, the content of their studies have largely focused on mathematics learners. For example, Cribbs et al. (2021) developed a questionnaire intended to be a proxy for mathematics identity. They found that the constructs of recognition and interest were predictors of whether learners participating in their study were likely to pursue a STEM-related career. Similarly, Bishop (2012) used the term mathematics identity and focused on learners. Bishop's work displayed how discourse between two seventh-grade students not only revealed their mathematics learner identities but also how those identities influenced and shaped one another as learners.

Mathematics Educator Identity

Mathematics educator identity is the act of being or becoming a mathematics educator and a sense of belonging to mathematics education (Graven & Lerman, 2020; Skott, 2019). Many researchers adopt the term mathematics teacher identity as their studies involve practicing educators with the titles of "mathematics teacher" or "elementary teacher." For example, Drake et al. (2001) studied elementary teachers and found that mathematics teacher identity influences whether a teacher is likely to adopt reform-oriented mathematics instruction. For cases such as this, Lutovac and Kaasila (2018) suggested the term mathematics-related teacher identity to acknowledge the fact that not all mathematics teachers are specialists in mathematics (i.e., elementary vs. secondary school teachers). Building on this, we are proposing a shift in terminology from mathematics teacher identity or mathematics-related teacher identity to *mathematics educator identity*.

In using this term, we hope to expand what it means to be a mathematics teacher. In the context of a school, this shift in language acknowledges that counselors, librarians, administrators, and personnel indeed contribute to a mathematics learner's development. Beyond the school, this term acknowledges the mathematics educating role that family members and community stakeholders play. In addition, adopting mathematics educator identity carries implications for researchers of mathematics identity. This shift necessarily expands a currently limited research scope focused on professionals with titles similar to "mathematics teacher" to include the many contexts where mathematics learning occurs and the influence of a wide range of educators who are in fact *teaching* mathematics.

Regardless of terminology, some researchers investigating mathematics identity have considered both mathematics learner and educator identities. For example, Gujarati (2013) studied the mathematics identities of three elementary teachers through autobiographies, interviews, and observations. Though she did not explicitly describe learner and educator identities as subsets of mathematics identity, Gujarati found that her participants' previous negative experiences as mathematics learners positively influenced who they had become as mathematics teachers. In addition, Maloney and Matthews (2017) found that a teacher's care for students, mediated by a sense of connectedness in the classroom, is crucial for students' development of a positive mathematics learner identity and perceived relevance of mathematics, especially for traditionally disenfranchised students. These examples show how a distinction between mathematics learner and mathematics educator identities is helpful for understanding how these dual identities are enacted.

Narrative Identity

We approached this research with the theoretical lens of narrative identity. Drawing primarily on Sfard and Prusak's (2005) operationalization of stories as identity and Wenger's (1998) communities of practice, narrative identity emphasizes stories as a reification of identity while simultaneously viewing mathematics identity through a broader socio-cultural lens (Langer-Osuna & Esmonde, 2017). Sfard and Prusak (2005) viewed identity as the many stories that one says about themselves, and especially the first-person stories that one shares to themselves. Instead of viewing identity as an abstract and elusive "core" of one's person, narrative identity defines identity as the stories one tells. This definition makes identity accessible to researchers through methods that elicit stories of both learners and educators such as interviews or autobiographies (Langer-Osuna & Esmonde, 2017). These stories may take the

form of actual or designated identities. Actual identity stories are told in the present tense while designated identity stories envision oneself in the future.

In the narrative identity framework, learning is inherently linked to identity because learning is defined as shifts in participation recognized by others (Esmonde, 2017; Lave & Wenger, 1991). Wenger (1998) discussed the importance of discourse in defining identity and emphasizes the lived experiences within a community that shape one's identity. This perspective views an individual's identities as constantly evolving and shaping one another through one's participation in a community. In other words, the stories one shares are reflections based on their experiences of participation in a community context.

These perspectives of identity-as-stories and learning in the context of a community are compatible in that an individual's acts of participation in a social setting inevitably become the stories they share about their experiences (Darragh 2013; Langer-Osuna & Esmonde, 2017). For the purpose of understanding preservice teachers' mathematics learner and mathematics educator identities, these stories allow insight into how participants simultaneously embody these dual identities. Furthermore, the problem-solving mathematics content course provides a setting to frame preservice teachers' experiences as stories. Applying the narrative framework in this study allows for operationalization of participants' identity-as-stories while contextualizing the influence of the problem-solving mathematics content course.

Data Collection and Analysis

This study took place at a private university in the northeastern United States. Participants in this study were recruited across three sections of the problem-solving focused mathematics content course. This course is a requirement for preservice teachers beginning in early childhood and elementary teacher-preparation programs. The course sequence covers two semesters for a total of six credits, however, data collected in this study focused solely on the first semester of the course.

The purpose of the study was explained to participants, and they were invited to volunteer by submitting three artifacts of data. The first two artifacts were a written mathematics autobiography, which was an assignment as part of the course, and an online questionnaire developed for this study. These two artifacts were collected within the first week of the semester to establish participants' mathematics identities at the beginning of the course. A third data artifact took the form of a semi-structured, in-person interview in the final weeks of the semester to understand how the course may have influenced participants' mathematics identities. In total, 22 preservice teachers participated in the study and were evenly spread across all three sections.

To organize data, interviews were transcribed and then all artifacts were uploaded into and analyzed via MAXQDA software (VERBI Software, 2021). Data were analyzed following Corbin and Strauss' (2008) approach to qualitative research. Analysis began with immersion in the data by reading through all data artifacts that were collected. Memos were written after reading through each artifact. Data were then coded using comparative analysis focused on similarities and differences between incidents and axial coding to understand how concepts broadly relate to one another (Corbin & Strauss, 2008). The researchers made passes through the data until conceptual saturation was achieved and themes were developed. The data excerpts displayed below were selected because of their richness in exemplifying the themes we generated when analyzing data; however, we do not intend to suggest that this is an exhaustive display of all such examples from the data set.

Results and Implications

Based on our review of relevant research literature, we predicted that the context of a problem-solving focused mathematics content course would produce valuable insights into understanding preservice teachers' mathematics learner and mathematics educator identities. Below we share the results from our study. Note that all names used are pseudonyms.

Mathematics Educator Identity Influences Mathematics Learner Identity

As preservice teachers in this study were not yet teaching in field placements outside of the university, their mathematics educator identities took the form of designated identities. One's designated identity "[consists] of narratives presenting a state of affairs which, for one reason or another, is *expected* to be the case, if not now then in the future" (Sfard & Prusak, 2005, p. 18, emphasis in original).

For example, Julie's personal background and experiences have resulted in a passion for educating elementary students with special needs. This designated identity as an educator directly influenced Julie's mathematics learner identity by generating motivation and a sense of purpose for her work in the problem-solving focused mathematics course. She maintained a clear focus on her role of teaching future students while enacting the role of mathematics learner. Julie shared:

> I know that, like, the point of doing this right now is not to learn how to find the least common multiple, or, like, what the factors of the prime factorization of a number is. It's more like understanding how to teach it, which is like what I want to do. So, it's more beneficial to me. … [I] see myself developing as, like, a better critical thinker, which I know will help me in teaching and like other ways of my life. I, like, kind of see the purpose now.

Julie maintained awareness of her designated identity of mathematics educator throughout the course which supported her current role as a mathematics learner. In another example, we asked participants at the end of the semester what they might title their time in the content course as if it were one chapter of their broader story related to mathematics. Julie titled her chapter as "math benefitting my future."

In contrast with Julie, some preservice teachers' mathematics educator identities negatively influenced their mathematics learner identities. For example, Sadie did *not* view mathematics as relevant to her designated role as an educator. She shared, "I want to be an early intervention specialist. So that's why, like, this class does nothing for me, not, like, not, like, nothing, but you know, I would rather not take it."

Though Sadie's goal is to be an educator, she did not see her future role specifically involving mathematics. When asked generally how the content course was going, Sadie shared,

> It's going fine but I don't like it. I'd say it's just, like, thinking about math in a different way, which is … I don't want to think about math in a different way. So that makes it difficult. But in general, I feel like I have an okay understanding of it.

With our definition of mathematics educator identity, we believe that Sadie would still very much play a role in educating her future students in mathematics, even if her specific title is "intervention specialist." In this role she may not directly teach mathematics but, at the very least, her mathematics identity will shape and be shaped by the future school community that she participates in. At most, it is quite possible that her desired role as an intervention specialist would involve directly working with students to facilitate and assess their learning in mathematics. Regardless of the specifics of Sadie's future role, it is clear that Sadie's designated

mathematics educator identity shaped her role as a learner because she did not see mathematics' relevance to her goals. Sadie's story exemplifies how mathematics educator identity may shape mathematics learner identity in a negative way.

Mathematics Learner Identity Influences Mathematics Educator Identity

One unit in the course was intended to teach students about place value and required problem solving in bases other than base 10. This particular unit seemed to highlight how mathematics learner identity influences mathematics educator identity as many students articulated how their experience as learners in this context facilitated an awareness of how their future students might feel. For example, Jeff shared,

> Like, it was difficult, but I feel, like, that was the most valuable thing, like, or the not necessarily the most valuable, but it definitely sticks out the most in my mind in terms of when I had a moment where I was, like, Whoa, like, that was, like, an eight-year-old in my classroom. You know, I mean, like, me now, like, that's gonna be someone in my classroom. You know?

Jeff's experience in his role as a learner prompted him to consider his future role as an educator. Julie also had a similar experience and connected it to her role as an educator. She shared,

> **…** in the beginning, we learned in different base systems and, like, basically, the goal of it was for us to be as confused as our students will be when we're teaching them base 10, because they have no idea what we're talking about. And so, like, I think it definitely, like, shed light on, like, how, like, I literally have to start from zero when teaching when, like, I always forget that, like, when I go into a class, I have some form of, like, a background knowledge of an idea.

In the excerpts above, Jeff and Julie's remarks show how the problem-solving course created an experience that was challenging for them as learners, which in turn caused them to consider their future role as educators. Mathematics teacher educators may leverage this influence by intentionally creating similar learning experiences for preservice teachers and prompting reflection on their mathematics educator identities.

Defining Mathematics

In analyzing our data, we were consistently cognizant of how preservice teachers defined what it means to do mathematics and what it means be successful at mathematics. Our findings suggest that the context of the problem-solving focused mathematics content course intervened by challenging students' definitions of "mathematics" and, in their stories, exposed both their mathematics learner and mathematics educator identities.

Problem-solving definitions of mathematics. Some preservice teachers understood mathematics as problem-solving based and student-centered instead of procedural and lecture based. For example, Julie articulated her identity of mathematics learner by viewing the mathematics classroom as "a space where you're supposed to be able to…ask questions, develop, be curious." In her autobiography, she reflected on a previous positive experience in which a mathematics instructor "prioritized giving each student an opportunity to make mistakes in order to learn and grow."

Julie connected her current success in the course to the way that she defines mathematics as problem-solving based instead of her previous experiences defining mathematics as procedural. She said,

> You have to, like, genuinely understand the concepts in order to … get the right answer. And I think in math, like algebra, and calculus, and things like that… it's really just, like, plug and chug. And so that's definitely, like, changed. … And I just feel, like, I'm also, like, I'm doing well in the course. And so, like, that has definitely continued to, like, boost my confidence and … my understanding of, like, if I just, like, focus and put effort into it … I can do it.

Julie's problem-solving focused definition of mathematics shaped her mathematics learner identity by not only helping her to define herself as successful in mathematics but has also motivated her to engage in learning and doing mathematics.

Procedural definitions of mathematics. Other students defined mathematics as procedural and this negatively affected their mathematics learner identities. For example, Georgia shared,

> Yeah, no, math is, like, not my thing. I'm way more, like, English, history. But I've always, like, tried math; I've just never been good at it. I'm not good at, like, memorizing things because if you give me, like, a problem,, like, I'll solve it with an equation, but then, like, when you have a quiz or test and they don't give you all the equations, you have to memorize those.

Georgia viewed mathematics as an exercise of memorizing procedures for testing performances. Because she had historically struggled with performing well on tests, she did not view herself as good at mathematics. The way that Georgia defined mathematics ultimately became the measure that she used to assess her sense of belonging to mathematics, and in this case, negatively affected her mathematics learner identity and inhibited meaningful learning.

Not only did a procedural definition of mathematics negatively affect some students' learner identities, but it led to resistance in learning mathematics through the problem-solving methods that were implemented in the course. For example, Ainsley defined mathematics as sequential and building on itself. She said, "… everything builds upon each other in math. So, if you're, if you get one thing wrong, you're gonna keep getting it wrong throughout the course of the exam." She also, like Georgia, was concerned about understanding this sequence of mathematics for the purpose of achieving a grade. Ainsley became frustrated with the course because she felt she did not receive the supports that she needed to learn mathematics, which would be true if learning mathematics is following a set of procedures in a well-guided sequence of topics. Ultimately, Ainsley resisted learning mathematics as intended by the course instructors and outsourced her learning to online videos. "I've found that I've watched more YouTube videos to learn what we're doing than what the teacher is teaching us. So, I've been getting most of my information and knowledge off of YouTube videos."

This act of resistance to learning mathematics through problem solving based on one's definition of mathematics also appeared through the language participants used to talk about the course and the way they perceived it. For example, Elyse said,

> … this math hurts my head, it confuses me; it makes me hate math more than I have in the past, because math in the past for me has been, like, a lot of equations in formulas, like that, which is why I've learned to like it. That style. And this is just totally, like, totally different.

Elyse defined mathematics as procedural and resisted learning it in this course by compartmentalizing it as "this math," refusing to define what she was learning as actually being mathematics. Similarly, Denise shared, "I really liked math, okay. This, however, is not like normal math."

Redefining mathematics throughout the course. Some students discussed how their definitions of success in mathematics have changed over the course of the semester. At the beginning of the semester, Alyssa was asked if she considers herself a "math person," to which she responded, "I do not consider myself a math person because I am not very good at it and am more interested in/ better at language." In the post-interview, Alyssa described her experience reflecting on her evolving views:

> So, I've always enjoyed math, but I feel I've never been like good at it. Just because, like, I've struggled with it throughout my years of high school, I guess. But … I feel like this course has kind of, like, involved different interpretations of [solutions] too, which I thought I wouldn't enjoy. But I've started to like it because, like, it helps me learn … different ways to get it, like, what I've been saying so many times. … I guess, like, the process [of] getting there has kind of become, like, my definition of how to be good at math. Rather than, like, just knowing the solutions.

Alyssa voiced how the course helped her to redefine what it means to be good at mathematics as focused on engaging in the process rather than focused on correct answers.

In the same interview, Alyssa was asked if she now sees herself as "good" at mathematics. She said, "I think I'm approaching being good at math." When pressed farther and asked, "What if I asked if you're good at problem solving, what do you think?" Alyssa said, "Yeah, I think that, like, that would be more, like, I'd be like, yeah, I'm good at problem solving." Throughout the semester, there was a shift in the way that Alyssa defined what it means to be good at mathematics and how she was beginning to see herself as enacting that role of what it means to be good at mathematics. Interestingly, she *did* claim to be good at "problem solving" but not necessarily "mathematics." Implications for mathematics teacher educators may be to help preservice teachers unpack how they are defining mathematics and any baggage that is being carried with that definition. In this way, preservice teachers might begin to redefine what it means to do and to be successful at mathematics, which will result in shaping mathematics identities.

Concluding Remarks

A limitation to this study is that, though we each have familiarity with the course and experience teaching it, we did not observe students in this setting and instead relied solely on their stories as evidence. However, our research offers greater understanding of the ways in which preservice teachers' mathematics learner and mathematics educator identities are shaped. The context of a problem-solving focused content course created experiences that challenged participants' schemas of mathematics and prompted reflection of their roles as both learners and educators. The way in which preservice teachers in this study defined mathematics shaped their respective mathematics identities. This resulted in differences in the ways that participants engaged in learning mathematics and also how they envisioned their future role of teaching their students mathematics.

Future research on this influential power of defining mathematics is needed, including how mathematics teacher educators might support preservice teachers to *redefine* mathematics and, in doing so, shape their mathematics identities. In addition to this, we have presented several examples of how mathematics learner and mathematics educator identities interrelate and influence one another. Acknowledging the complexity of these interactions, it is possible that mathematics teacher educators might create specific interventions for learners to shape their

educator identities. Similarly, it may benefit mathematics teacher educators to prime preservice teachers to maintain a focus on their future role as educators for the sake of engaging them in learning in the present moment.

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