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Mathematical identity transformations

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This paper examines the case of Ruby, a prospective mathematics teacher, and explores the transformation of her mathematical identity as she moved through her studies from grade school through university. I utilize the conceptual framework of multiple “I-positions” from Dialogical Self Theory to reflect on the changes in Ruby’s mathematical identity through analyzing her retrospective self-narrative. Based on this case study, I determine that the dynamics of I-positioning, involving emergent coalitions of I-positions or the emergence of a single I-position of greater authority, may play an important role in the formation of a positive or negative mathematical identity. I also find that significant events such as changing circumstances, new reflections, decisions, and actions may act to precipitate the reconfiguration of I-positions, and thereby bring about the transformation of one’s self-understanding as an (in)competent student of mathematics.

Keywords: Mathematical identity, mathematics learners, prospective mathematics teachers, dialogical self theory.

Introduction

Identity has been explored through various theoretical frameworks, (Beauchamp & Thomas, 2009), several of which are featured in mathematics education research on the concept, e.g., Holland et al. (1998), Sfard and Prusak (2005), and Wenger (1998). Inspired by Lev Vygotsky, Mikhail Bakhtin and Pierre Bourdieu, Dorothy Holland et al. (1998) conceive of identities as resulting from processes in which people are both agents and subjects of simultaneously culturally constructed and socially imposed worlds. Following on such conceptualizations, Boaler and Selling (2017) consider mathematical identity to be informed by the “ways in which students think about themselves in relation to mathematics, and the extent to which they have developed a commitment to, are engaged in, and see value in mathematics and in themselves as learners of mathematics” (p. 82).

Similarly, Wenger’s sees identity as developing through “negotiated experiences of self” through dialogue in communities of practice (1998, p. 150). He understands identity formation as a *learning trajectory* in which “the past and the future [are] in the very process of negotiating the present” (p. 155)—a theoretical approach that emphasizes identity continuity and malleability. Following on this conception, Rø (2019) characterizes teacher identity development as a result of identification and negotiation in the process of participation in and at the boundaries of various communities of practice. Finally, a substantial number of identity studies in mathematics education have adopted, following on the work of Paul Ricoeur (1992), the conception of identity as based on narrative (e.g., Sfard and Prusak, 2005 (Kaasila, 2007; Lutovac, S., & Kaasila, 2014, 2018).

Earlier studies that analyzed the identity narratives of mathematics learners and pre- and in-service teachers have described identity changes but have not provided sufficient information about the mechanisms that account for them. This study attempts to add this information through analyzing the

retrospective self-narrative of one pre-service mathematics teacher. The study does not focus on her current self-narrative as a pre-service teacher, but rather traces shifts in her mathematical identity as she moved through her studies from grade school through university and until she enrolled in a teacher education program. As such, I aim to analyze transformations in one pre-service teacher's mathematical identity and the process of its realization, and to do so in the context of Dialogical Self Theory, which provides us with an epistemic and analytic lens through which to consider those processes.

Theoretical Framework

Dialogical Self Theory

Hubert Herman's and Els Hermans-Jansen's notion of identity formation as a process of telling and retelling one's self-narrative in dialogue with oneself or another person(s) is congruent with the conceptualizations mentioned earlier (1995). Dialogical Self Theory (DST) (Hermans & Hermans-Konopka, 2010) begins with the assumption of selfhood as multi-voiced and intrinsically dialogical, composed of a dynamic multiplicity of varied internal narratives--"I-positions"—representing multiple perspectives of the self. Each I-position has a voice and is in dialogue with other I-positions, all of which reflect different relationships with independent others. The self is comprised of both internal and external I-positions. Internal positions reflect aspects of the individual's identity (e.g. Korean, prospective mathematics teacher, immigrant, daughter, friend, etc.). In addition, any current set of I-positions includes, not only those existing in the present, but may incorporate past positions as well—for example "I- as once a struggling math student"—as well as external I-positions that represent the attitudes and example of people seen as significant in one's life—a parent, teacher, good friend or boss, for example (Hermans & Hermans-Konopka, 2010). Past and present I-positions are likely to speak in voices that are in conflict, and to present ideas that contradict each other, which puts the self in a position of struggling to reconcile the different views in a coherent narrative.

For DST, the self is both stable and dynamic, always undergoing reorganization of positionings, and making meaning of experiences old and new. In fact, in Herman's and Hemans-Jansen's words "the self is an organized process of meaning construction." (1995, p.14). As part of this process, we construct our self-narratives, which we tell and retell. In these narratives, we give special significance to some events over others. Some special events might disrupt or challenge an established self-narrative. These have been described by Carla Cunha et al. (2012) as Innovative Moments (IMs)—which may be, for example, new actions, thoughts, feelings, intentions. The IMs are seen as voices that are potentially disruptive to the dominant self-narrative and represent a possibility for the emergence of new I-positions, and for a self-narrative reconstruction. The transformation of self-narratives involving IMs's emergence and expansion has been used in DST-based psychotherapy (Gonçalves et al., 2009).

According to Cunha et al. (2012), in successful cases of psychotherapy there is a noted emergence of three types of IMs: action(s) through which the person challenges the dominant self-narrative; new reflections that run counter to person's previous ways of thinking, and protest; action or thought that refuses the current self-narrative. They "announce" a potential emergence of new positions, which may bring forth a different dynamic between I-positions, as well as new dominant I-position(s). The

appearance of these IMs is followed by emerging “reconceptualized IMs”—new actions, reflections and protests, and chances for reorganization.

Narrative Inquiry

Mathematical identity is here understood in terms of the narratives persons tell in order to situate themselves not only in relationship to mathematics and their mathematical lives (cf. Kaasila, 2007a; Connelly & Clandinin, 2000; Sfard & Prusak, 2005), but also in relation to significant persons, groups, or cultures (Hermans & Hermans-Konopka, 2010). I consider the notion of the “extended self” (Hermans & Hermans-Konopka, 2010), to be a further development of George Herbert Mead’s concept of the “generalized other” and Lev Vygotsky’s (1962) internalization of cultural and individual voices. All three approaches suggest that mathematical identity includes not only one’s view of oneself as a mathematics learner in the context of one’s classroom and the work with one’s peers, but also the internalized voices of one’s peers, teachers, parents, and other significant others. As such, in analyzing the following case study, I use a multi-voiced dialogical conception of mathematical identity, which acknowledges its extension to include real or imagined voices (views) of those others. Mathematical self-identity is plural and made up of multiple I-positions in continual dialogue (Hermans & Hermans-Konopka 2010).

Here I examine the case of Ruby, a young Korean American undergraduate student completing her coursework in mathematics education and explore her shifting mathematical identity. I reflect on the changes in her retrospective self-narrative, tracing her trajectory as a mathematics learner as she moved through her studies from grade school through university. I use DST and the conception of IMs to identify changes in the relations of authority between internal and external I-positions, reflect on the emergence and dynamics of a coalition of positions, and their significance in the realization of the ongoing reconstruction of her mathematical identity.

Methodology

This study adopts a case study methodology in order to explore and report the details (Creswell, 2005; Stake, 1995) of one prospective teacher’s mathematical identity and its changes over a period of roughly six years. The subject, Ruby (pseudonym), was a twenty-one-year-old Korean American full-time undergraduate mathematics education student in her third year of preparation as a prospective mathematics teacher in a public university in the northeast US. She was a student in an introductory mathematics education course that I was teaching at the time. She was an intelligent and diligent student; her assignments were always on time, and she was detailed-oriented and thorough. Ruby had finished 10th grade in Korea, after which she had relocated with her entire family to the US, and she finished the last two grades of high school in a large urban public school.

Data collection occurred over the course of one academic year during Ruby’s completion of the introductory mathematics education course. Three semi-structured interviews were conducted throughout – two of them administered consecutively within a week, and the third roughly four months later. Each interview was introduced by an invitation to talk freely about her experiences as a mathematics learner in middle, high school, and university. The interviewer asked follow up and clarification questions. The interviews were transcribed and comprised the main data source for this study. Additional informal discussions helped me develop an in-depth understanding of issues

(Creswell, 2012) related to the study of the changes in Ruby's mathematical identity. I used open coding (Creswell, 2006; 2012) to identify and explore the themes that emerged from the data.

Adopting methods from narrative analysis (Polkinghorne, 1995), I sought to identify coherent themes running through the interviews. First, I divided the interview transcripts into episodes reflecting four major narrative shifts related to Ruby's middle and high school experiences in Korea, high school and university in the US. Each episode was further divided into segments, each of which was associated with a specific I-position—for example, I as trying hard in mathematics (internal I-position), or I-as always failing math tests (internal I-position), and I as being encouraged and helped by my mother (an external I position representing the internalized voice of Ruby's mother). Based on a comparison of the segments within and across interviews, I developed codes for the I-positions relevant to the episodes in the self-narrative. Furthermore, I reviewed all identified I-positions, selected the ones that involved self-reflection and observing one or more of the other I-positions, and coded them as meta-positions.

The positions in each narrative episode were analyzed in terms of configurations: were there many different I-positions speaking in single “voices” or were they forming a coalition of voices that spoke as a “choir,” and how were these configurations related to Ruby's self-narrative and her positive or negative self-identification as a mathematical learner? For each episode, I searched for evidence of relatedness between Ruby's I-positions, and for the existence of power differences as reflected in the relative dominance of some. I also looked for significant events as identified in Ruby's self-narrative, and for changes in her I-positions around the time of these events. Guided by Cunha et al.'s (2012) conception of Innovative Moments (IMs) I noted new reflections and actions on Ruby's part, and examined them in relation to new I-positions that had emerged.

Findings

Ruby's Self Narrative

“I wasn't good at math back then”

When Ruby was in middle school, she liked math. She described herself as “being interested” and as “enjoying the math classes.” She liked all subjects and thought that she was good at them. Things changed when she moved to high school. Ruby said that there were lots of tests, and she was not performing well on them. There were always students who had better test scores. “I don't know what I was doing, but I always had errors [on the tests].” Her high school math teacher was “very strict and stern.” Ruby thought he believed that she was not putting enough efforts and being “lazy”, although she said that she was trying hard. She felt he was “angry and disapproving of her.” He had told her that “she didn't have the mathematical mind.” To my question whether her parents were helping her, she described her mother as encouraging and supportive and trying to help with homework. Ruby “dreaded” her math classes and was afraid of failure. When I asked her about this period, she started describing it with “I wasn't good at math back then [in Korea]”

“Not loving math, but OK”

Things had changed somewhat when she moved to US. Her last two years of high school were not easy—she was trying to catch up with English--but she suddenly found that she was doing much

better in her math classes. She “knew lots of the math stuff” they studied, especially during her first year in the US. To my question whether she felt successful, she replied that she was doing much better than before [in Korea], but that she didn’t think at the time that she would study math in the future. She had A’s at the time, but at the interview she described herself as “not loving math, but OK”

“I had decided that I can do it”

When she finished high school, Ruby applied to a public university close to her hometown and started her first year as an undeclared major. She had to find out what she wanted to study, but at this point she knew “it wouldn’t be math.” However, Calculus was a mandatory course and she registered to take it, among other courses. She wasn’t sure about it and was afraid of failing it. Then she discovered that she liked the course. It seems like it was the instructor at first and the course structure. “The instructor was amazing,” Ruby told me, and she “liked everything about this class”—the instructor and students, the group work and the assignments. “I loved it [the course],” she told me with enthusiasm. Ruby felt that she was doing very well, and she began to think that she might continue to study mathematics and look into related programs. In the following semester she decided to take the next Calculus course with the same instructor. She felt successful, and this is when she began thinking that she might want to become a math teacher. Her mother advised her that it would be a good profession for her. “By the end of this second semester,” Ruby said, “I had decided that I can do it [could be successful in becoming a math teacher] and applied to the mathematics teacher program.”

The interviews with Ruby revealed the various I-positions she took while she was a middle and high school student in Korea, a student in high school in US, after she moved to the US, and as a university student. Table 1 below shows some of these, identified on the basis of the interviews conducted with her.

Table 1. Ruby’s I-positions

Periods	Some of Ruby’s I-positions as a mathematics student
Middle school	I as ... interested in mathematics (internal) enjoying mathematics (internal) good in all subjects (external, my teachers)
High school, in Korea	I as... trying hard in mathematics (internal) always failing math tests (internal) being encouraged and helped (external, my mother) being lazy and not studying mathematics hard enough (external, my math teacher) making my math teacher angry (external) not having the support/approval of my teacher (internal) dreading math (internal)

	not having the mathematical mind (external, my math teacher) not being good at math (internal, metaposition)
High School in US	I as... knowing lots of [math] stuff (metaposition) not loving math, but ok (metaposition) having As in math (internal) doing much better than before [in Korea] (metaposition) not planning to study further math (internal)
University in US	I as... a university student (internal) exploring possible study paths (internal) not sure about taking a Calculus class, and afraid [of failure] (internal) successful Calculus student (metaposition) loving math (metaposition) someone who might be successful in becoming a math teacher (internal) a future math teacher (internal)

These I-positions seem to have informed her mathematical self, and the way she understood herself as a mathematics learner and one (in)capable of learning mathematics. Table 1 shows a dynamic multiplicity of perspectives--I-positions--representing the multiple perspective of the self in the different contexts in which she found herself, e.g. middle school, high school in Korea, high school in the US, and university. These I-positions have informed her changing self-narrative (Hermans & Hermans-Jansen, 1995) and reflect different relationships with independent others or herself.

In middle school, the I-positions identified in the interviews, “I as enjoying math”, “I as interested in mathematics,” and “I as being a good student in all subjects” supported each other in creating a coalition of I-positions, whose unified voices supported a self-narrative of a good and capable mathematics student. However, when Ruby transitioned to her Korean high school, her self-narrative dramatically changed. Her high school math teacher became a powerful voice and a mirror through which she saw herself in the way she perceived her teacher saw her—not making enough effort, “lazy,” “not having a mathematical mind.” This powerful external I-position had become dominant, overpowering the voices of her other I-positions, including the supportive external I-position of her mother. It led to her shifting her self-narrative and repositioning to new I-positions as “failing math,” and “dreading math.” The voice of her math teacher had taken on special significance in the multi-voiced self, and had challenged, overpowered, and overridden her previous self-narrative.

However, yet another change in circumstances forced further repositioning. Ruby moved to the USA with her family. She found herself in a 10th grade math class, where she discovered that she knew quite a lot of the mathematics content under discussion. The situational change had in fact delivered her from the power of her Korean math teacher’s voice. A new coalition of voices—her mother’s supportive one, and her own metapositions--“I knew lots of the stuff they studied,” and ‘I was doing much better than before’-- helped her move away from some of her previous external I-positions, e.g.

“I- as not good at math.” Ruby changed her self-narrative again and described herself at this time as someone who was “not loving math, but ok.” At this point, she was not seeing herself as someone who would study math further, and perhaps choose it as a career path.

However, another reconfiguration of new and old I-positions seems to have precipitated yet another shift in her self-narrative when she went to the university. She took a Calculus course with an instructor she liked, in a learning environment she found empowering. Both shifts in her self-narrative seem to have been instigated by innovative moments (IMs)— new reflections of herself as a math learner and her proactive step of registering for a Calculus class, which challenged previous self-valuations (Cunha, et al., 2012). These led to her solidifying new I-positions as a successful Calculus student and as loving math. Table 2 below, identifies some IMs that seem to have contributed to shifting Ruby’s self-narrative and her mathematical identity. Her decision to explore a possible university study trajectory and her coping with her ambivalence about the Calculus course led to new reflections and new actions on her part. Her metapositions at this point seem to have been a powerful factor in helping her de-position the “I as not planning to study further math.” Over the course of fewer than two semesters, Ruby moved to a new I position as “someone who might be successful in becoming a math teacher,” which was, in fact a position of rebellion against the deposed one.

Table 2. Innovative moments (IMs) in Ruby’s positioning

Period	Ruby’s I-positions	Emerging Innovative Moments (IMs)
High School in US	I as... <i>knowing lots of [math] stuff (metaposition)</i> <i>not loving math, but ok (metaposition)</i> having As in math (internal) <i>doing much better than before [in Korea] (metaposition)</i> not planning to study further math (internal)	IM reflection IM ambivalence IM action IM reflection
University	I as... a university student (internal) exploring possible study paths (internal) not sure about taking a Calculus class, and afraid [of failure] (internal) <i>successful Calculus student (metaposition)</i> <i>loving math (metaposition)</i> someone who might be successful in becoming a math teacher (internal) a future math teacher (internal)	IM new action IM new action IM ambivalence IM new reflection IM new reflection IM rebellion/protest IM rebellion/protest

Emerging circumstances, new reflections, proactive decisions, and confronting old I-positions led Ruby to challenge her previous self-narrative and, eventually, to re-write it. Ruby decided to become a math teacher. She applied and was accepted into her university’s mathematics education program, graduated successfully, and currently works as a math teacher.

Conclusion

This paper has examined the case of Ruby, a young Korean American undergraduate mathematics education student, and explored her mathematical identity-transformation narrative as she moved through her studies from grade school through university. I have drawn on Dialogical Self Theory and the concept of Innovative Moments to reflect on the changes in Ruby's mathematical identity through analyzing her retrospective self-narrative. I have determined that the dynamics of I-positioning—emergent coalitions of I-positions or a single I-position of greater authority -- may play an important role in the formation of a positive or negative mathematical identity. I also found that significant events such as changing circumstances, new reflections, decisions, and actions may act to precipitate the reconfiguration of I-positions and lead to identity transformation. As such, the study raises questions about the role of reflection in the reconstruction of self-narratives, as well as what classroom methodologies might best facilitate such reflection. In order to nurture students' mathematical identities, new approaches need to be explored that help and encourage students to challenge established self-narratives in reference to their mathematical identity. Mathematics has become a forbidding gatekeeper for many economic, educational, and political opportunities for students, many of whom have developed self-narratives that act to prevent them from identifying themselves as capable math learners. As such, disrupting such self-narratives and working proactively to reconstruct negative mathematical identities represents an important educational task.

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