Mind the 's' in Individual-With-Contexts: Two Undergraduate Women Boosting Self-Efficacy in Mathematics

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Investigations of students' identities are shedding light on the processes that generate differential learning. In this paper, we expand the construct of dispositions to account for what individuals carry through their bodies and beliefs across contexts. While bringing back the attention to individualized dispositions, we avoid the trap of innateness. After we create a three-layered framework of dispositions to explain why and how two undergraduate women, Bettie and Melissa, develop differential confidence in mathematics through a semester-long number theory class. We learn that individualized dispositions can change throughout time, and desensitize or make individuals vulnerable to gendered, racialized, and sexualized stigma.

Keywords: Self-efficacy, Equity, IBL, Situated Learning, Dispositions.

The scholarship on identity, specifically in Mathematics education, has demonstrated the mutual construction of individual identities, preferably called positionings, and the contexts within which these identities emerge (Cobb & Bowers, 1999; Greeno, 1998; Hand & Gresalfi, 2015; Lave & Wenger, 1991; Martin, 2000; Nasir, 2002). The revised concept of *dispositions* is particularly illuminating. Following a situated approach, Cobb and Gresalfi (Gresalfi, 2009; Gresalfi & Cobb, 2006) define dispositions as ways of engaging with an activity organized by sets of ideas, perspectives and values. In an IBL activity, dispositions can include: "working together or individually," "providing developed or succinct explanations to a groupmate," "offering critical comments to others," "using the textbook (when and how)," "preferring to study with others or alone" and others. Contexts and individuals determine which dispositions emerge and become patterns of engagement. For instance, a student may actively participate in a group and be a passive listener in another type of group or class (Hand & Gresalfi, 2015). In this paper, we expand the construct of dispositions and create a framework to explain why and how two undergraduate women in a number theory class, Bettie and Melissa, developed differential confidence in mathematics.

Bettie and Melissa self-reported a low self-efficacy at the start of their number theory class. During exit interviews at the end of the semester, Bettie reported a robust increase in self-efficacy while Melissa reported only a relative confidence in her mathematical ability. Their number theory course used predominantly small-group work; after the third week students stayed in the same groups. Bettie and Melissa were the only women in their five-member groups.

As we conducted a situated approach analysis of Bettie's and Melissa's group work, we observed how group dispositions explained the differential roles they took in groups and classroom dispositions. Particularly, a classroom norm to not look at textbook solutions, shaped the construction of their differential self-efficacies. In addition to classroom and group dispositions, Bettie and Melissa activated dispositions that were produced in historic contexts or outside the studied classroom. Melissa enacted a collaborative disposition and Bettie a solitary reflective disposition. The collaborative disposition rendered Melissa vulnerable to groupmates' unresponsiveness, while the latter left Bettie immunized.

The reported analysis shows three interlaced layers of dispositions: classroom, group and individualized dispositions. These offered different learning opportunities to Bettie and Melissa, and fostered different mathematical identities (see Figure 1).

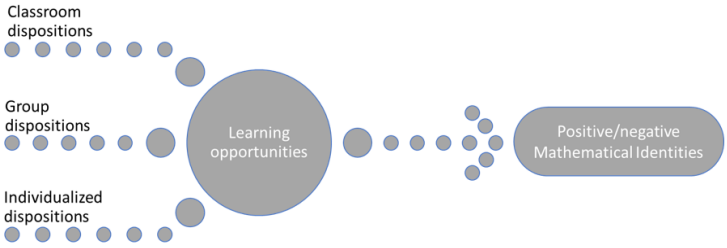

Figure 1: Three layers of dispositions construct learning opportunities that shape mathematical identities.

Classroom dispositions are constructed through interactions between an authority, either institution or instructors, and students. Social and socio-mathematical norms (Yackel, Rasmussen, & King, 2000), as enacted in a classroom, are the best examples of classroom dispositions. When students work in small-groups, *group dispositions* are constructed. For example, if group members assign a high mathematical authority and social influence to a group member, group dynamics may easily turn into a tutoring disposition. Esmonde (2009) showed that mechanisms of group dispositions are independent from, but may connect to, classroom dispositions. The new construct to a situated approach introduced herein is *individualized dispositions*, by which we conceive the interconnectedness of individual-with-context**s**.

When we think of individuals as embedded within a context, we must account for the ways individuals navigate through and connect multiple contexts simultaneously or consecutively. We propose two mechanisms by which dispositions transfer from one individual-with-context to the same individual in a different context. First, dispositions can transfer across contexts through the individual's body. Performativity theorists (Butler, 2010; Kramsch, 2010) have shown that repetitive enactment of dispositions leave embodied marks in individuals. To use an external resource, Erickson (2004) observed that linguistic and gestural behaviors common to an environment, e.g. home or church, may become reflexes that individuals carry to the educational environment. Second, dispositions may translate into beliefs or narratives that individuals can carry into other contexts. Boaler and Greeno (2000) documented students, who enacted classroom dispositions aligned with traditional teaching. They believed that mathematics lack creativity, which influenced their decisions of major choice in college. Sfard and Prusak (2005) documented narratives produced during family meetings about the mathematical ability of East-European immigrants to Israel. The narrative identities transferred to classroom behaviors: students from these communities were renown of persevering at solving challenging math problems. We shall call the transferred dispositions *individualized dispositions,* since transfers occur through the individual's body or beliefs.

The selection of relevant concomitant and historic individual-with-contexts is challenging. Relevant transferred dispositions must be triggered by current individual-with-context. Thus, we find mediated and unmediated interviews to be an optimal data collection method to investigate individualized dispositions. Further discussion is in the methods section.

Methods

Activity and Participants

Data reported was collected from a semester-long number theory class at a Northern California University. The class met for one hour ten minutes twice a week. Professor Hoffmann, the instructor, used group work as the predominant form of teaching in class for the first time in his career. He gave students worksheets of theorems and problems to solve in class with their groups. Students could find the proofs of theorems in the assigned textbooks, but Hoffmann encouraged them to "use [their] brains not the textbooks" to solve the problems. A weekly homework, consisted of writing the solutions to selected problems from the worksheets, was assigned to be submitted individually and graded. Students took a midterm and final exams.

The class included students from diverse ethnic backgrounds and mixed gender, 10 women and 13 men, the majority of whom were majoring in Mathematics for teaching. The African-American ethnicity was not represented in this class. Students composed their groups at their will and stayed in the same group by the third week of class. There were total of 5 groups of 4 or 5 members each. One group did not participate in the research.

Melissa and Bettie were selected for focal study, because both worked with four men in their groups and reported low self-efficacy at the start of the class. Melissa was majoring in Mathematics for teaching and Bettie in Mathematics for liberal arts. Melissa's group (GM) and Bettie's group (GB) had three vocal members and one predominantly silent member. GM's members were Robert (Math for teaching major, vocal), Tom (Math for advanced studies, vocal), Emil (Math for liberal arts, vocal), Tito (Math for teaching, silent). GB's members were Ted (Math for teaching, vocal), Jeremy (Math for advanced studies, vocal), John (Applied Math, vocal) and Boutros (Math for teaching, silent).

Data Sources

Starting from the second week of class, four group's group work, including GM and GB, were *videotaped*. Students took *early and exit surveys* and submitted *individual memos* after every group session. They participated in an *early individual interview*, where they were asked about their motivations for majoring in mathematics, feelings about the mathematics discipline, history with mathematics classes in high school and college, experience with group work in classes, and first impressions about current group members. They also participated in *individual interviews by the end of the semester*, where they were asked about their understanding of number theory, confidence in the material, the changes throughout the semester in their learning methods and behavior in group work, and the roles their groupmates tended to play.

Students participated in SCNI interviews (Stimulated Construction of Narratives about Interactions; see El Chidiac, 2017) every other week. In the SCNI interviews, participants watched a video of their recent group session and commented on their social interactions. The SCNI interviews were conducted individually and within twenty four hours of the end of class. The SCNI sessions of GM and GB took place within five hours of the end of the class. GM participated in one and GB two out of the four SCNI interviews. Emil (GM) and John (GB) did not participate in any interview.

Results

Developing Two Types of Self-Efficacy

At the beginning and throughout the semester Melissa showed low levels of confidence in relation to her peers. She stated in the early interview on 9/17 that "every single person I've met has understood more than I have which is really you know, makes me feel very insecure about my decision to be a math major when everybody's you know - smarter than you." During the exit interview Melissa showed a shift in her perception.

> Melissa: So, then I started contributing more […] cause at first I felt like I was not the smart one of the group, and I'm not. But, I also felt, feel now that I'm at least at a level playing fieldish, more at a level playing field of like, brain capacity [laughs] I guess, and um knowledge in general. Um, because I don't know sometimes I shock myself when you know, I get something and then like Robert doesn't get it or Tom doesn't get it and I'm just like why don't why don't you understand, it's this, come on now. You know. Um. But that makes, that makes me feel more confident in myself and it makes me want to participate more cause then you know, I'm not actually like helping them, but I'm helping them in my not understanding. (Interview 12/02)

Melissa developed a relative type of self-efficacy. She constructed a confidence not on her own mathematical ability, but based on noticing her groupmates were not as smart as she previously believed. Even at the end of the semester, Melissa felt she did not fully understand the material ("I'm helping them in my not understanding"). She started the class with an individualized disposition from her prior proof course, in which she "struggled" (Interview 9/17). She reiterated this perceived inability later in the semester, "I'm just really bad at writing proofs" (SCNI 11/05). We note that in both interviews, Melissa revealed an individualized disposition about her mathematical ability, namely *evaluating one's own mathematical ability in contrast to one's perception of others' abilities*.

Like Melissa, Bettie started the class feeling she was not smart enough. In the early interview on 9/22, she stated, "I feel like I'm not super um I don't know I guess smart so it takes me a while to understand things I have to see it done a couple times and like I have to do it a couple times to like completely fully understand it." Unlike Melissa, Bettie's perception of her non-smartness depended on her slow learning processes and not her comparison to other people's abilities.

Like Melissa, Bettie expressed a struggle with proofs in previous classes. But unlike Melissa, she was satisfied of her learning in this number theory class. In the exit interview on 12/02, she stated, "for me I feel like theory in general is just like learning proofs and . I don't know . it's just been really difficult for me. But . uhh out of all the proof classes I've taken this is probably the most that I've . like . learned . I guess you can say. Cause a lot of the time I kinda just got by. and I feel like this one I'm actually understanding like . why."

When asked about their learning methods, both Melissa and Bettie stated at the start of the class that they learn by memorizing. On 9/22 Bettie said she used to learn by "keep doing it, repeating it, just memorizing." When asked how she prepared for the midterm, Melissa said she "wrote up cheat sheets," looked through her notes and homework and "tried to memorize it all." By the end of the semester, Melissa reported no change of learning methods ("I pretty much learn the same," Interview 12/02). However, Bettie emphatically affirmed a move away from learning by memorizing towards learning by understanding. On the exit interview (12/02), answering whether she endured a change in her ways of learning, she responded as follows.

Bettie: "yeah definitely. I kinda just . not really change it but it made me realize what . my style of learning is . kinda thing. I would just study and I didn't really know what was beneficial and what wasn't. now I realize I need to read, obviously . I have to read through the book. I have to . like do the homework . like slo::owly at my own pace and like do it myself. and . um . that's like the only way I'm gonna retain anything or like know what I'm doing. Because before I would just like do the homework. but I wouldn't really . like know what I was […] I was just like copying and pasting . finding answer online . and writing it out and like hoping it was the right answer. but now that . I'm actually like reading the book, working with friends, like doing the homework, actually doing the homework myself, I just feel like this is just what I need to start doing."

Bettie and Melissa differentially boosted their mathematical self-efficacy: Bettie improved her learning methods, while Melissa only repaired her perception of groupmates' mathematical abilities. This differential improvement of self-efficacy was reflected in their exam achievements as well (Table 1). Given the self-reported significance of group learning and use of textbooks, we shall investigate them next. [For lack of space, we leave the study of textbook usage to the extended paper]

Table 1: Melissa's and Bettie's grades on the midterm and final exams

	Melissa's grade	*Bettie's grade*
Midterm exam	45%	53%
Final Exam	20%	61%

Learning During Group Work

We watched the videos of GM and GB group sessions and coded the instances when Bettie and Melissa offered explanations (Figure 2), contributed mathematical ideas (Figure 3) and sought explanations (Figure 4) by group sessions over the semester. Melissa increased her participation in the group work after 10/15. This evidence corroborates her comment (above), her increase of confidence made her "want to participate more" (see quote above). Bettie's pattern of participation in group work remained low throughout the semester. Overall, Melissa participated more in group work than Bettie. However, the latter surprisingly showed more learning gain than the former. Why was Melissa's participation in group work not conducive to learning?

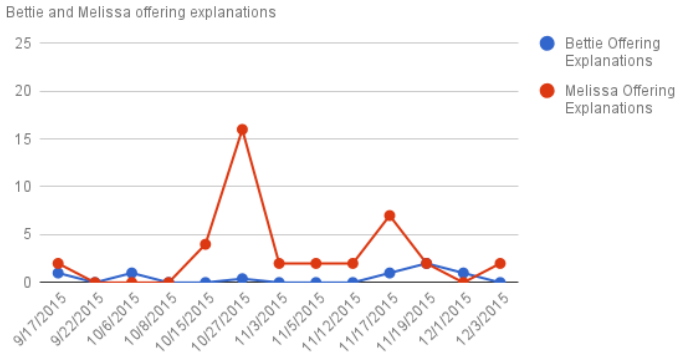

Figure 2: Instances of offering explanations for Melissa and Bettie over the semester.

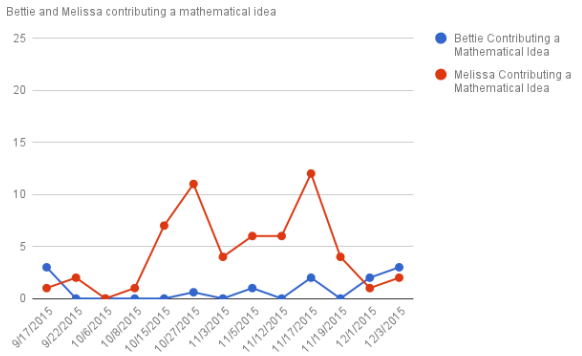

Figure 3: Instances of contributing mathematical ideas, for Melissa and Bettie over the semester

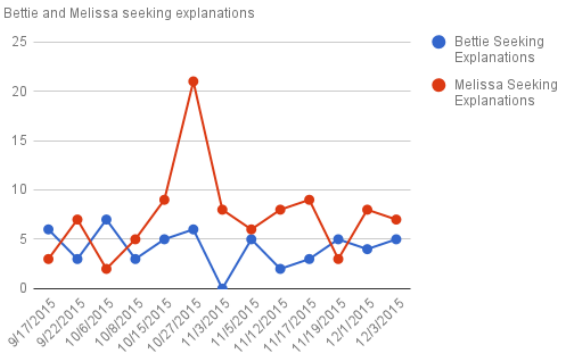

Figure 4: Instances of seeking explanations, for Melissa and Bettie over the semester

To answer this question, we looked at the individual interviews. During the early interview (9/17), Melissa was asked how she felt about the current group. She responded, "yeah I feel very focused um not necessarily like I know what's going on but I feel like I'm not thinking about anything else but what's in front of me on the worksheet and like trying to help […] more more than trying to figure out what's going on I'm trying to help my friends who know better like give them my ideas of what I might be thinking to help them put put it together because once they put it together then they can explain to me what's going on." Later in the same interview, as she was describing the role of her groupmates, she commented, "And so they [Tom, Robert and Emil] are kind of like the three main brains I feel like um and they all just bounce ideas off each other and I try to like this if they stop talking I just kind of like ask a question to get their brains going again because I mean they know way more than I do. I feel like. and then they're also in modern right now. Emil's taking modern and Robert's in modern and I'm pretty sure Tom is taking modern, Tito's taking modern right now. I'm just like over here like I'm still in linear. so they know a little bit more about what's going on." During the SCNI on 9/24, Melissa reiterates, "I don't know where to go from here I hope someone [small laugh] gets something and like, I normally would ask a question to someone, you know to clarify something and usually that gets their brains going, but […] I tried that, and nobody really responded to me, besides Emil."

At the beginning of the semester, Melissa activated a group disposition of helping her groupmates find the solutions and deactivated the disposition of understanding the materials. She took up the role of stimulating the brains of her groupmates because she thought they are more resourceful than she. Nonetheless, the helping group disposition echoed a similar individualized disposition. During the early interview on 9/17, Melissa confessed, "I feel like it's kind of hard for me to relate to [the courses in college] since I'm not going to be using it while I'm teaching I mean I'll have it in the back of my head you know for that one kid that's going to ask me 'well why?'" For Melissa, learning is conditioned by how knowledge can help others.

As Melissa spent more time in group work and realized she could be resourceful, she faced a new challenge: unresponsiveness from her groupmates. During the SCNI interview on 11/05, Melissa paused the video and commented, "oh number two I understood and I'm kind of pissed because, I shout out my idea and no one really listened to me because in the end that's kind of almost exactly what we ended up proving. which kind of pisses me off because I wish someone would have realized, I wish I could have said it better so that they would have understood what I meant." She reiterates this struggle at the end of the same SCNI and the exit interview.

Melissa: I would see that they weren't listening to me […] So I had an idea so I would a- like, act dumb, and kind of you know, ask them about, you know well what about this, what if like we do this or this or this kind of thing. Well like, what about that, to kind of lead them in the direction that I'm already on. […] they can't be told […] how to think. […] So, I just like, ask a question that maybe has them change their perspective to understand what I'm trying to say. (Interview 12/02)

Bettie also faced lack of recognition from groupmates. In the exit interview on 12/02, she stated in a colloquy style, "if it has to do with arithmetic I feel like I'm just . I feel like . I can do it. like I. Maybe they don't take me as like serious so when I have the answer they're like "whatever like it's probably wrong." but I usually do get the right answer and I feel like "hah" like "told you."'"

Unlike Melissa, Bettie did not attend to her groupmates. In fact, during the early interview, she thought her group had only four, instead of five, members, of whom she knew only Jeremy by name. During group work, she mostly worked alone, reading from the textbook and writing on her notebook. During the SCNI interview on 10/15, she confessed, "when I hear people talking and I don't understand I just zone them out because it confuses me more so I just like keep do . I just keep looking on my own." Later on in the same interview, she reiterated and generalized her group disposition, "that's basically all I do [in group work]. like when I'm in class. I just listen to what [my groupmates] are saying and look at the book . cause if I don't understand it then . when they're like talking . I don't know. so I just zone people out . until I look at it myself because . otherwise it just confuses me more." During group work, Bettie took up a group disposition geared towards building her own understanding of the mathematics. In effect, her dominant participation role was "seeking explanations" (compare graphs in Figure 2, Figure 3 and Figure 4). In the interviews, Bettie reported an individualized disposition of seeking to understand mathematical concepts. When she was stuck on homework, Bettie affirmed during the early interview on 9/22, "I go online […] yeah I work alone […] most of the time […] I just like to read over because I like to understand things cause like it's really frustrating when I'm just like copying work I have to really just like understand what I'm doing and why I'm doing it so I kind of just like to work alone because it takes me a pretty long time to figure out a problem."

Conclusion

Both women, Melissa and Bettie, were not recognized as reliable resources by their groupmates. However, this stigma was more detrimental to Melissa than Bettie. Due to Melissa's group and individualized helping dispositions, the developmental path of her mathematical identity led her to take on the role of helping others to find answers to problems. This path was blocked twice throughout the semester. Melissa could overcome the first barrier, i.e. her perception that her groupmates are more resourceful than she, but struggled with grabbing her groupmates' hearing. In contrast, the developmental path of Bettie's mathematical identity went through coping with her slow learning processes in group. She was oriented towards understanding the mathematics, the disposition of which made her immune to others' recognition of her abilities.

Throughout the analysis, we showed that individualized dispositions undergirded all observed group dispositions. Dispositions that students carry from other contexts into the classroom are more significant for identity development than it is commonly being thought of.

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