# Conceptualizing STEM Majors' Developing Agency and Autonomy in Undergraduate Mathematics

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**Abstract:** This poster describes an ongoing and iterative research effort aimed at conceptualizing the interrelated constructs of mathematical agency and autonomy in the context of undergraduate mathematics. We offer an illustrative dialogue between data from student interviews and reflection logs and our emerging definitions of agency and autonomy. We close with our provisional working definitions.

## Introduction

In the U.S. context, the transition from computationally-focused introductory-level mathematics coursework to proof-intensive upper-level coursework substantially changes what is expected of students and their mathematical work. A subset of the authors previously conducted a small-scale longitudinal study to investigate students' experience(s) as they navigated this transition at a large public U.S. university (Bae et al., 2018). Our initial study considered student experience along the dimensions of (1) students' perceptions of differences between prior and current mathematics learning experiences, (2) students' ways of experiencing and organizing their learning activity in and out of class, (3) students' subjective sense of success and understanding, and (4) students' emerging sense for the nature of mathematical proof (Smith & Star, 2007). The goal of this poster is to provide an overview of our steps toward conceptualizing two central and interrelated constructs of mathematical agency and autonomy in the context of our new longitudinal study of student experience in tertiary mathematics.

## Research setting

The data for our study was collected at a large public U.S. university where students, both mathematics majors and minors, first encounter formal training in mathematical proof in a semester-long, problem-based Introduction to Proof (ITP) course. In the ITP course, project data collection involved a baseline interview, a task-based interview, and a series of homework reflection logs from each of the 15 participants in the first cohort. Both the mathematics majors and minors in our study subsequently enroll in two or more advance, proof-based mathematics courses to satisfy their major or minor requirements. While our longitudinal study involves following students into these subsequent courses, thus far, we have only collected data from our first cohort in during their experience in their initial ITP course. Participants were selected to represent a broad spectrum of gender, ethnicity, and major/minor.

## Conceptualizing agency and autonomy

Our initial framing of mathematical agency and autonomy, based on our survey of the literature in mathematics education, described mathematical agency as dependent on autonomy. We followed Yackel and Cobb's (1996) analysis in seeing intellectual autonomy as both a *state of awareness of one's intellectual capabilities* and a *willingness to act on them in engaging in challenging mathematical work*. Where Yackel and Cobb conceptualized intellectual autonomy solely within the social practices of mathematics classrooms, we needed our constructs to apply also to in–class and out–of–class mathematical activity, as college students have great freedom to act (or not) in ways they see as productive. Indeed, one key developmental task for college students is deciding how and why to deploy out–of–class time and activity productively. Our initial conceptualization of the relationship between agency and autonomy was that when students choose act in particular ways out of their sense of autonomy, they are exercising agency. In order to operationalize our constructs, we chose a grounded approach, in which the entire team coded for evidence of agency and autonomy participant-by-participant, to allow us to discuss patterns in our coding and revise our working definition for our constructs before moving to the coding of the data for the next participant. Through the iterations of our definition, three observations crystallized. First, although agency may be an ability or capacity to act, claims about agency seem most cogent when they can be supported by evidence of choosing to act (and that, to us, choosing not to act is a form of acting). Second, participants chose to act, or purposefully acted, when confronted with a challenge. Third, it became clear that we

 

needed a way to describe a spectrum of participants' agency and autonomy, as opposed to describing them as qualities that participants either had or did not have.

With this in mind, when analyzing an initial subset of interviews with four of our participants (Benjamin, Eva, Falon, and Kaleb) from our first cohort for agency, we looked for participants acting to address challenges arising in the context of their ITP course. Among our participants, a number of common challenges emerged: intellectual, interactional, affective, institutional, and personal. We recognize that these challenges intersect one another, yet we have found these broad categorizations to bear merit. By far the most prominent of the challenges, was the intellectual challenge reported by students. For example, Benjamin reported *"I've never struggled with math like this before, so this is a very new area, and this is uncharted territory for me, so, I don't know if I'm just being lazy, or if I don't understand. I don't know."* In the face of this challenge, Benjamin looked for help in two ways. First, he went to the Mathematics Learning Center (MLC) for around an hour every week. The MLC is a room staffed by teaching assistants of the course for nearly 12 hours per week in which students can ask for help or simply go to work on homework. It is also noteworthy that he decided to work with anyone working on a similar problem, not just people he already knew or was comfortable with. Second, as he could not make it to his instructor's regular office hours, he scheduled two other office hours with the instructor. Unique to Benjamin, among our four coded participants in the initial analysis, was the fact that his help network did not include friends. On the contrary, Eva, Falon, and Kaleb all formed friendships and frequently consulted their friends when confronting challenging homework problems.

A contrasting example of acting in the face of challenges, this time an interactional challenge (being linguistically isolated in a group where mathematical activity was primarily taking place in a language she did not share) came from Falon, describing her decision to change groups in class: *"I sat somewhere else. I felt really nervous about it. I think it was like the second week of classes. We sort of have those informal assigned seats and I was like, 'I'm definitely stealing somebody's spot in this group but I got to do it. I can't be stuck in a group where I can't communicate. Otherwise I'll fail this class."* To contrast our emerging sense for mathematical agency with our emerging sense of mathematical autonomy, consider the following reflection in the first homework log of Kaleb: *"I did the entire assignment in one sitting over 3 or 4 hours and got to the last question and was stuck. I gave up on it after looking it over and playing with it for about 5 minutes and left frustrated. I looked on Pizza to see if anyone had asked about that question. I saw an instructor's hint for where I should go, but I didn't really do anything. A few hours later I looked at the hint again. I realized that the instructor had done more than I thought was necessary so I followed their path for half of the problem and finished it up in my own way. It took 20 minutes to figure out what I had to do, but it took another 40 minutes to an hour to plan and formally write this proof. Overall, the problem was a huge challenge and it took a little over 2 hours to do."*

## Discussion and conclusions

Following our initial analyses, our provisional working definitions for agency and autonomy are:

- Mathematical agency is the capacity to take considered action in the face of challenges related to mathematical work (as evidenced by taking such actions).
- Mathematical autonomy is a sense of ownership over one's mathematical reasoning which may involve active resistance to endorsing, following or replicating the reasoning of mathematical authorities (i.e. mathematical texts, course instructors, or peers recognized as mathematical authorities).

We currently see agency and autonomy as contextually-bound and existing on a continuum, allowing wider possibilities for understanding growth and change. That is, individual students do not either have agency and autonomy or not, but rather, students' observed agency and autonomy is something that can change in response to context and over time. Accordingly, though both constructs have an individualistic sense to them, our initial analyses have led the team to think about what could come from deliberately experimenting with social-interactionist lens in our analyses.

## References


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