

Student Agency and Identity in Reading Didactical Mathematics Texts

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Reading didactical texts, such as textbooks, requires particular sets of literacy practices. Researchers have proposed that these practices are related to aspects of identity and agency, and have described aspects of these constructs separately. In this study, we examine the interactions between students' agency and their macro- and micro-identities. We present data from two undergraduate students reading a section of a calculus textbook and explore the ways the interactions between the students' identity and agency shape their reading activity.

Keywords: Agency, Identity, Literacy, Textbooks

Didactical texts—that is, media such as textbooks and instructional videos—play an important role in college mathematics instruction. Many students are asked to read mathematics textbooks or watch instructional videos (e.g., Butler, 2019; Shepherd & van de Sande, 2014; Weinberg et al., 2022), and these texts constitute an important resource for student learning outside of in-person instruction.

Disciplinary texts have long been viewed as requiring particular sets of skills and literacy practices to read productively (e.g., Moje, 2007; Shanahan & Shanahan, 2008). Fang and Schleppegrell (2010) described their grammatical resources, Lee and Spratley (2010) described discipline-specific reading actions, and others (e.g., Morgan, 1998; Rezat & Rezat, 2017) have contrasted aspects of genres in mathematics texts with those of other disciplines. In addition, Shanahan et al., (2011) demonstrated that mathematicians, chemists, and historians enact distinct literacy practices when reading texts from their own disciplines.

Some studies of mathematics disciplinary literacy have focused on the identities of the readers (e.g., Wiesner et al., 2020) and the relationships between these identities, the text, and the discipline itself (e.g., Fulmer et al., 2022; Weinberg et al., 2022), while others have explicitly incorporated functions of agency into this exploration (e.g., Fang & Schleppegrell, 2010). Both identity and agency have been widely studied in mathematics education research. A close examination of theoretical descriptions of these concepts suggests that they are intertwined—for example, Boaler and Greeno (2000) suggested that “positional identity” is related to the enactions of these positions; Barton and Tan (2010) alluded to the “intersecting roles” of agency and identity; Cobb et al. (2009) suggested that identity is related to “the ways that students are able to exercise agency” (p. 44); and Hitlin and Elder (2007) stated that agency is grounded in ideas of “the self.” Although some studies (e.g., Fulmer et al., 2022; Louie, 2020) have explicitly discussed the entanglement of agency and identity, few have explored their interaction in depth.

Our current research has two goals. First, we want to understand students' mathematical identities, agency, and potential interactions between these aspects. Second, we are curious about the extent to which students' agency and identity manifest themselves in the ways they read and attempt to learn from mathematics texts.

Theoretical Framework

Agency

Agency is generally described as an ability make independent choices and act on those

choices (e.g., Anderssen & Norén, 2011), although Gresalfi et al. (2009) point out that agency exists in moments of action rather than being a permanent characteristic of a person. Some researchers (e.g., Barton & Tan, 2010; Emirbayer & Mische, 1998) regard these actions as existing in a structure-agency dialectic (Bourdieu, 1977), so that the structures promote and constrain particular types of action and the actions, in turn, influence the structure.

Many mathematics education researchers cite Pickering's (1995) notion of a "dance of agency" (e.g., Boaler & Greeno, 2000; Brown, 2018; Cobb et al., 2009; Grootenboer & Jorgensen, 2010; Sengupta-Irving, 2016; Wagner, 2007) involving human agency—individuals' acts of creating ideas and making choices—and the agency of the discipline, which refers to established mathematical practices. In this notion of a dance, disciplinary norms are the product of collective human activity and that activity is, in turn, constrained by the norms; thus, this dance mirrors the more general agency-structure dialectic.

Barton and Tan (2010) point out that disciplinary norms aren't immediately affected by individual acts of agency and, thus, Pickering's perspective doesn't allow researchers to account for more localized entailments of position and power. They called for a formulation of agency that attends to its "socially transformative" nature (p. 191) and integrates context, position, knowledge, and identity. Similarly, Fulmer et al. (2022) worked to bridge Pickering's formulation of agency with a more "emancipatory theory of constructing knowledge" that attends to the "interplay of autonomy, identity, power, and knowledge" (p. 632).

We draw on Barton and Tan's (2010) formulation of agency in which "Agency is at once the possibility of imagining and asserting a new self in a figured world at the same time as it is about using one's identity to imagine a new and different world" (p. 193). Agency is grounded in the individual's perception and enactment of control and choice. Thus, moments of agency can be identified by either affective or enactive dimensions. In the former, the participant expresses a perception of their ability to make a choice or feels in control of a situation; in the latter, the participant takes an action (or describes acting) in a way that clearly demonstrates a choice they have made. These feelings and actions exist within a set of locally negotiated and constructed interactional roles and structures that entail a status quo, so actions that run counter to the status quo are evidence of agentic moments.

Identity

Identity has been theorized in many ways within the discipline of mathematics education. Darragh (2016) distinguished between two broad perspectives in which identity has been framed. In the first perspective, identity is presented as a stable construct that you acquire over time. For example, Aguirre et al. (2013) describe mathematics identity in terms of "dispositions and deeply held beliefs" about participating in mathematical contexts. This perspective aligns with the structure-agency dialectic in which identities are described in relation to a socially established notion of "what it means to know and do mathematics" (Cobb et al., 2009, p. 44). Wood (2013) describes these long-term stable constructions as *macro-identities* and points out that their scale makes them difficult to use to examine relationships with moments of learning or to describe the multiple, dynamic identities a student might simultaneously inhabit.

The second perspective frames identity in terms of activity. For example, Boaler and Greeno (2000), citing Holland et al. (1998) described positional identity as "the way in which people comprehend and enact their positions in the worlds in which they live" (p. 173). This perspective focuses on interactions in which people "convey positions or identities for themselves and all others involved in the interaction" (Wood, 2013 p. 778) in a way that draws on the socially constructed context. Wood (2013) refers to the narratives that individuals construct to make

sense of these interactions as micro-identities. This focus on positioning enables researchers to describe relationships between enactments of identity and moments of learning, and to consider students' sense of self as potentially multiple and divided.

In our research, we examine both students' macro- and micro-identities. The former enables us to consider the students' perceptions of themselves in relation to long-term narratives (e.g., "I feel like I'm good at calculus"), whereas the latter lets us resolve apparently conflicting identity-related narratives (e.g., "I'm not good at derivatives of trig functions") and to relate aspects of identity with the meanings they construct as they attempt to learn from a didactical mathematics text. Thus, statements in which students describe their self-perception provide evidence of identity, and the interactions—or described interactions—between students and other participants in their socially-constructed worlds also can be evidence of their identity.

Methods

Materials

Examining literacy practices for didactic mathematics texts required using text materials for which the participants would have the necessary background knowledge, yet could engage in the reading process for the purpose of learning a new concept. We selected Newton's method for finding roots as the target concept since it only requires knowledge of derivatives and tangent lines and is not always taught in first- or second-semester calculus. Our materials consisted of four pages from a standard calculus textbook (Stewart, 2016) that introduced Newton's method, provided examples of using Newton's method, and included exercises at the end of the section.

Participants

We sent invitations to participate in the study to two groups of students at our institution: (1) all students who had declared either a major or minor in mathematics and hadn't yet completed a course in numerical analysis; and (2) all students who had been enrolled in first-semester calculus the previous semester and earned at least a C-. All participants who replied and were available during the times the researchers were able to conduct the interviews were included in the study. This resulted in five math majors/minors and five non-math majors/minors. For the current study, the restricted length of the conference paper format led us to randomly select two student participants for analysis: one math major and one non-math major/minor. We expected that such a pairing would allow us to identify similarities and differences in their identities and the ways they reported interacting with pedagogical situations and didactical texts.

Data Collection

Each student participated in a 75-minute interview, conducted by the first author, who is a professor in the mathematics department. They were asked about their positionality with respect to calculus, college, learning, and textbook-use (e.g., "how would you describe your relationship with calculus?"). Then they described their knowledge of calculus and worked on a problem using linear approximation to estimate the value of a function at a point.

Next, the participants sat at a computer that displayed an electronic version of the textbook excerpt; participants were able to use the arrow keys to "turn" the pages. The participants were asked to read the textbook section for the purpose of learning about the concept of Newton's method. As they read, an eye-tracker recorded their gaze pattern. After reading the excerpt, the participants watched a recording of their eye movements, with a red dot on the screen indicating the area of the text they had been looking at each moment. As the recording played, the

participants were asked to describe what they were looking at and what they were thinking about; both the participant and interviewer were able to pause and resume the playback.

In the final stage of the interview, the text was segmented into conceptual chunks consisting of (1) an example to motivate Newton's method; (2) the derivation of Newton's method; (3) a description of instances when Newton's method would fail; (4) an example of using Newton's method to approximate the roots of a polynomial; (5) a description of the idea of precision in Newton's method; (6) an example using Newton's method to approximate the root of a number; (7) an example using Newton's method to approximate the intersection of two functions; (8) a description of the impact of choosing a first approximation; and (9) a collection of exercises; each chunk was further sub-divided into a graph (if present), an equation in a blue box (if present), and the rest of the text. The interviewer first asked the participant to describe the main ideas of the text, and then to describe what was being shown or described within each of the indicated conceptual chunks, figures, and boxed equations.

Analytical Methods

We divided the text into areas of interest that matched the conceptual chunks, graphs, and equations described above. Then we used the eye-tracking data to record which of these parts of the text the participants were looking at and how long they looked at each part. We used these data to construct a holistic description of each participant's reading activity.

We used thematic analysis (Braun & Clarke, 2006) to describe the participants' identities and agentive moves. After segmenting each interview transcript into talking turns, we identified turns where the participants demonstrated agency by (1) indicating that they felt they were making a choice and expressed a feeling of control, (2) describing a previous situation in which they felt they were making a choice, or (3) took action that appeared to run counter to the status quo; this identification process took into account the positionality of the participant within the relevant social structures—specifically, the context of mathematics classrooms, independently learning mathematics for a class, and the interview itself.

We then identified turns where the student described or enacted aspects of their identity by (1) describing a stable narrative about their self (i.e., a macro-identity), (2) describing their feelings about their self in the moment, and (3) enacting or describing behavior that reflected particular forms of interactional relationships within the relevant contexts. After identifying turns that reflected aspects of agency or identity, we generated themes inductively by looking for similarities and patterns among the turns. Throughout the identification process, we worked collectively to identify, discuss, and resolve differences in our interpretations.

Results

Non-Math Major [NMM]

Activity. NMM spent approximately 63% of his reading time looking at the three examples, with nearly half of that time on the first example. He spent approximately 31% of his time reading the expository text; nearly 1/3 of this time was spent looking at the equation in the blue box and the surrounding text. He spent only 2% of his time looking at the graphs. He generally read the text in order, but there were 12 instances of him either glancing forwards/backwards or skipping to a different conceptual chunk.

Identity. NMM described being a person who enjoyed both school (e.g., "I've always kind of liked school") and calculus ("it is interesting, but hard, and parts of it are easy and cool"). However, he simultaneously contrasted himself with "people who are quicker with math,"

suggesting a multi-faceted macro-identity. NMM's interaction with the textbook suggested a micro-identity as somebody who could make sense of mathematical concepts (e.g., "I was kind of just trying to see like, all right, like what's the point of this? Like where is this going?"). He had a strong image of himself as a mathematics student, describing himself as "a numbers person" and "not a graph person," distinguishing himself from other "people who like to look at the graphs rather than the numbers." Entailments of this macro-identity included "lik[ing] equations" and "seeing people do something" that he could repeat. At several points in the interview, he described his activity in a classroom, saying that he would (e.g.) "want to be prepared for [problems on an exam]"; this implicit interaction between himself and an instructor suggested his position in the classroom as a student.

Agency. NMM described a lack of agency for reading mathematics texts, describing how he "steered away from" them and "found other textbooks easier to read." More locally, during the interview, he skipped some parts because he didn't "really understand the context." Although it is possible to view these decisions to avoid reading parts of the textbook, in the context of a mathematics classroom we interpret these as reflecting his feeling of a lack of agency.

Despite this feeling of a general lack of agency, NMM regularly offered critiques and evaluations of pedagogical aspects of the textbook (e.g., describing a figure as "a nice thing to include" and a paragraph as "important to add"), suggesting some feeling of agency. NMM regularly made choices about which parts of the textbook excerpt to read and when to read them (e.g., "I spent a second or two on these side graphs, but I wasn't really drawn to them"); if the status quo is to read all parts of the textbook in the order they are presented, then these actions reflect choice and control, and, thus, are agentic moves. Similarly, he made choices about what to write in his notes based on personal goals (e.g., "I kind of just wanted to give myself an example of how I would go about solving the problem like that"), reflecting feelings of agency.

NMM also demonstrated agency in relationship to the mathematical concepts described in the textbook excerpt. He felt capable of "figur[ing] out what [the equation] actually means" and looked for connections with other concepts he had learned (e.g., "it's kind of like with asymptotes..."). These agentic moves were underscored while he was working on the pre-reading problem, when he transformed symbols (e.g., "I converted [decimal numbers] to fractions because I feel like it's easier") and created his own examples (e.g., "I'm operating under the assumption that the equation $f(x)$ is equal to two x ") to help him solve the problem; this "tinkering" demonstrates moments of agency.

Intersection of Agency and Identity. We noticed several aspects of NMM's identity and agency that built on each other to significantly influence his reading activity and learning. First, his identity as an "equations person" and as a person who can understand mathematical concepts prompted him to focus on the equations that were presented in the excerpt and enabled an agentic relationship to (agentively) "figure out" what things mean. For example, he described his sense-making activity: "I like equations and stuff like that. I was immediately drawn to the $f(x)$ equation up there. I kind of just figured, like, well, that's an equation. How can I figure out what it actually means?" His identity as an "equations person" was related to his identity as not a "graph person," which, coupled with his agency to choose which parts of the excerpt to read and which to skip. For example, he described his choice to skim part of the excerpt: "I'm sure for other people who are more like graph-based learners, it [text describing one of the graphs] would be helpful. just for me as a learner, like I'm not going to look at that graph."

NMM's identity as a student and as an "equations person" was, similarly, coupled with his choices about which parts of the excerpt to focus on, and guided his notetaking. For example, he

described his rationale for taking detailed notes on the equations in one of the examples: “I kind of just wanted examples to look back on, like as if they were my notes for an actual test.”

Math Major [MM]

Activity. MM spent approximately 62% of her reading time reading the expository text, with roughly half of this time reading the paragraph that described the derivation of Newton’s method. She spent approximately 19% of her time reading the examples, with this time split roughly evenly between the three examples. She spent roughly 5% of her time looking at the equation in the blue box and only 2% looking at the figures. She generally read the text in order, but there were 7 instances of her either glancing forwards/backwards or skipping to a different conceptual chunk; when she was reading the paragraph describing instances where Newton’s method failed, she looked back and forth between the text and the figure 4 times.

Identity. MM described herself as a person who enjoyed math (e.g., “I was taking math courses for fun”) and, in particular, calculus, describing it as “my favorite form of like mathematics because I like solving the derivatives and the integrals and all that.” She described herself as “an audio-visual learner,” but didn’t elaborate. MM described her interactions and position in a math classroom in terms of her status as a student. In particular, she described not being able to fully understand concepts until “the professor goes over it” the next day and wanting to know “what they’d be asking” to guide her reading and learning from the textbook.

Agency. MM “felt confident for the most part” about reading and using textbooks and reported developing her own strategy for reading the textbook by “skimming it for important aspects” and then “go[ing] back to find the answer” to problems. MM regularly made choices about which parts of the textbook excerpt to read and when to read them. She regularly described “skimming” various parts of the excerpt, looking “more at the equations” than the diagrams, and “looking back” at previous equations and explanations when she felt confused.

MM also demonstrated agency in relationship to the mathematical concepts. She felt capable of solving calculus problems in general (e.g., “I like solving the derivatives and the integrals and all that”) and that she can do so “on [her] own.” She worked to resolve uncertainty by revisiting confusing sections of the text and constructing her own interpretations. For example, when she felt confused about instances where Newton’s method fails, she reported “just trying to make sense of that because the wording tripped me up” and went back to the first page “to try and double check.” As part of this process, she looked for connections with other concepts she had learned (e.g., “it’s kind of like Reiman sums, how it’s like the more, the smaller and smaller you make the rectangles the more accurate you’re going to get”).

Intersection of Identity and Agency. MM’s identity as a person who enjoyed calculus appeared to be closely connected to her sense of agency at solving calculus problems, noting that calculus is her “favorite form of mathematics because I like solving the derivatives and the integrals and all that.” Similarly, her identity as a confident textbook reader appeared to be connected to her having chosen a textbook-reading strategy.

MM’s identity as a student, coupled with her choices about which parts of the excerpt to focus on appeared to be connected. For example, she described her choices as guided by the obligations she would face as a student: “I like looking at the exercises just to like, get a sense of like what the problems are like or like what they’d be asking and how similarly they are structured to one another.”

There were several instances where MM moved on from a section of the text without understanding concepts. For example, she described her feeling when after reading the paragraph that described instances where Newton’s method would fail: “I think I understood it enough, but

at the same time, I think I was still confused that I was like—I'm just going to move on. Probably that would have been something if I were in class, like I would ask about the next day.” In this moment, MM appeared to have been weighing her options for action based on her assessment of her understanding. Her identity as a student allowed her to position herself with respect to the textbook, the mathematical concepts, and the (imagined) professor, and this position facilitated her choice for a course of action.

Discussion

Both NMM and MM shared aspects of their macro- and micro-identities, as well as their feelings and enaction of agency. Both students enjoyed calculus, and they both felt and demonstrated agency for figuring out mathematical concepts. They made connections between the text and their prior learning and made decisions about which parts of the text to read and when. In terms of their reading activity, both students chose the order in which to read the text components and neither student spent much time looking at the graphs.

The two students also exhibited some differences in their identities, agency, and reading activity. While MM felt confident about reading textbooks, NMM expressed a lack of confidence. In their reading, NMM spent most of his time examining the examples, while MM focused on the expository text, examined the exercises, and did look back and forth between one of the figures and the corresponding text.

For each student, their identity, agency, and activity intersected in different ways. NMM's identity as a student prompted him to seek out formulas he could use to solve problems on a test and to consider the examples as helping him build a library of problem types he could use as templates for later solving problems; his identity as an “equations person” and his sense of agency with mathematical concepts appeared to enable him to try to make sense of the equations. At the same time, being not a “graph person” led him to avoid examining the graphs, which potentially contributed to his occasional feelings of confusion, which, in turn, led him to skip particular parts of the text.

MM's identity as a student connected with her sense of agency differently than NMM. At first, her identity as a student appeared to guide her read the text to help her solve problems on a test. However, MM also worked to understand the expository text; this could be connected to both her identity as an effective textbook-user and her sense of agency for mathematical concepts. MM's student identity also appeared to be connected to her perceived choices when she encountered confusing parts of the text: rather than exhibiting a lack of agency, she formulated a course of action that involved utilizing the expertise of her (imagined) professor, and choosing a course of action that she felt would help her resolve that confusion.

Taken together, these data show students making agentic moves based on their stated and enacted identities and their relationship to both mathematics (as a subject) and the text. This demonstrates the flow between identity and agency, and vice versa. What we find particularly interesting is that the students in this study are bringing their humanity to the experience of reading the textbook—that they *do* have identities relative to the experience, and that there are many moments of agency that they experience. Thus, it is relevant that their identity and agency affect their reading activity, but the central take-away is not that there is a causal relationship between these two concepts, but rather these two aspects work together to shape the students' activity.

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