ELEMENTARY MATHEMATICS TEACHER AGENCY: EXAMINING TEACHER AND ECOLOGICAL CAPACITY

Phi Nguyen
University of Missouri
phinguyen@mail.missouri.edu

Sheunghyun Yeo
University of Missouri
sheunghyunyeo@mail.missouri.edu

Wenmin Zhao
University of Missouri
wz2mb@mail.missouri.edu

Corey Webel
University of Missouri
webelcm@missouri.edu

We investigated how 53 elementary teachers interpreted the impact of the contexts in which they work on their mathematics instruction, and what those interpretations reveal about the agency individual teachers were able to achieve. Latent class analysis revealed two distinct classes, with teachers in one class perceiving that their contexts had a greater and more supportive impact than teachers in the other class. Interviews of four elementary mathematics specialists then revealed that the extent to which agency was achieved depended on not only their evaluations of the constraints and affordances of their contexts, but also their past experiences and future goals.

Keywords: teacher agency; policy; elementary mathematics specialists; latent class analysis

Although decades of policy have sought to limit teacher agency through, for example, highly prescriptive curriculum and accountability regimes (e.g., Biesta, 2010), discourses in mathematics education have emphasized how teachers exert agency in their specific enactments of broader policy (National Research Council, 1997; OECD, 2005). Theories of agency suggest that mathematics teachers have always interpreted and responded to policies, even those designed to limit agency, based on their experiences and frames of references (e.g., O'Day, 2002; Osborne et al., 1997; Zancanella, 1992). Discourses focused on agency, however, raise questions about what it might mean for teachers to be agents and the extent to which teachers can achieve agency. In this paper, we share a mixed methods study that investigates how elementary mathematics teachers achieve agency in their unique contexts. In particular, we focus on how elementary teachers interpret the impact of the contexts in which they work on their mathematics instruction and what those interpretations reveal about the agency they are able to achieve.

Theoretical Framings & Related Literature

We view agency as a temporal process informed by the past (iterational dimension), oriented towards the future (projective dimension), and achieved in the present (practical-evaluative dimension) (Emirbayer & Mische, 1998). In other words, teachers build upon past experiences and understandings to refashion and appropriate patterns of behaviors. Motivated to create a future that is different from the past and present, teachers generate possible trajectories of action. Although agency is tied to the past and future, it can only be achieved in the present as teachers make judgements based on evaluations of the constraints and affordances of their contexts. An implication is that, in response to present problems, teachers who are able to draw upon a greater repertoire of past experiences or form a wider range of alternative futures might achieve greater levels of agency (Priestley et al., 2015).

However, agency is not simply a quality of teachers; it is a dynamic interplay between both individual efforts and ecological conditions (Biesta & Tedder, 2007). Carried out in concrete situations, agency is achieved as teachers engage with their ecological contexts. Teachers may

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achieve agency in one situation but not another, and that may depend on the availability of social, cultural and economic resources.

Prior studies on teacher agency have highlighted the importance of both teacher capacity and ecological capacity. Regarding the former, research suggests that teachers' experiences and beliefs play an important role in the achievement of agency (Sloan, 2006; Vähäsantanen, 2015). A wide range of past experiences may enhance agency by allowing teachers to see alternatives to the present, while strong beliefs about student learning enable teachers to develop a broader set of aspirations (Priestley, 2011; Priestley et al., 2012). In contrast, when teachers' discourses and goals are framed in terms of policy (e.g., meeting accountability expectations), projective elements of agency are reduced because teachers' potential to envision alternative futures is narrowly defined by the constraints of policy (Biesta et al., 2015).

Regarding the latter, research suggests that the ecological contexts in which teachers work influence the extent to which teachers are able to achieve agency. Teachers' evaluation of the professional obligations of their contexts may limit the actions they take towards projected goals (Priestley et al., 2012). For example, teachers working in contexts where standardized outcomes are highly valued may feel pressured to forgo ambitious instructional practices for those that are better suited for meeting accountability expectations (e.g., those focused on developing procedural fluency). However, access to ecological resources, such as professional relationships with administration and other teachers, may foster agency by supporting teachers to develop their practice, take risks, and see alternative futures (Coburn & Russell, 2008; Priestley et al., 2013).

Our study builds upon existing research by examining how elementary mathematics teachers - a group not yet investigated in the research on teacher agency - are able to achieve agency in their unique ecological contexts. We expand beyond the individual case study methodology commonly used in studies on teacher agency to also include quantitative analyses of surveys reporting the extent to which teachers evaluated their contexts as impacting their mathematics instruction. Specifically, we investigated the following questions: 1) how do elementary mathematics teachers interpret the impact of their ecological contexts on their mathematics instruction? and 2) what do different interpretations reveal about the agency individual teachers are able to achieve? Though the practical-evaluative (present) dimension is foregrounded, the judgments mathematics teachers make about the affordances and constraints of their contexts are influenced by the projective (the instructional goals teachers have for the future) and iterational dimensions (the past experiences they draw upon to achieve those goals).

Methods

Study Context

This study originates from a larger multi-year project focused on the beliefs, knowledge, practices, and student achievement for certified elementary mathematics specialists (EMSs) (McGatha et al., 2017). Among 55 participating teachers, there were 24 EMS and 31 comparison teachers that were recruited from the same schools (or districts) and same grade levels as the EMS teachers. A variety of data were collected for the larger project, including teacher surveys, measures of teacher knowledge, and observations of teachers' instructional practices. In addition, eight EMS teachers were selected as case study participants and each participated in five semi-structured interviews that were audio-recorded and transcribed.

Data & Participants

For the present study, we focused on a set of items from the teacher survey that asked participants about the impact of 14 items on their mathematics instruction. The 14 items were: 1) current state standards; 2) district curriculum frameworks; 3) district and/or school pacing guides; 4) state

testing/accountability policies; 5) district testing/accountability policies; 6) textbook/program selection policies; 7) teacher evaluation policies; 8) students' motivation, interests, and effort in mathematics; 9) students' reading abilities; 10) community views on mathematics instruction; 11) parent expectations and involvement; 12) principal support; 13) time for you to plan; 14) time available for your professional development (see Figure 1 for survey directions). These items were completed by 53 teachers (23 EMS and 30 non-EMS). In addition, we analyzed the interviews of four case study EMS teachers: Amy, Denise, Emma, and Mary. Selection of the cases is further discussed in the Data Analysis section.

What is the extent of the impact of each of the following on your mathematics instruction?					Indicate the nature of the impact			
No impact (1)	Some impact (2)	Great impact (3)	Not applicable (4)	Don't know (5)	Mostly inhibits effective instruction (1)	Mostly supports effective instruction (2)	Both inhibits and supports effective instruction (3)	Not applicable (4)

Figure 1: Survey Directions

Amy and Denise taught at the same school in a district with five K-4 elementary schools. Part of the instructional day at this school included a math intervention time where students engaged in Rocket Math, a fluency program, with the stated goal of improving state standardized test scores. The district's curricular program was Math in Focus and teachers were provided a pacing guide that suggested how much time to spend on each topic.

Emma and Mary taught at different schools within a district that served 13 elementary schools. The district's curricular program was Go Math and, as in Amy and Denise's school, teachers were provided a suggested pacing guide. The district administration also encouraged teachers to engage students in weekly problem solving, though this was taken up by teachers in various ways, which will be further discussed in the cases of Emma and Mary.

Data Analysis

Using the 14 survey items described above, we employed latent class analysis (LCA) with the poLCA package in R (Linzer & Lewis, 2011) to identify groups of teachers who perceived different impacts of their ecological contexts (i.e., the 14 items) on their mathematics instruction. To create binary variables for LCA, we first created a holistic score for each item combining 'extent' and 'nature' of impact (e.g., great impact and mostly inhibits =1; great impact and mostly supports =5). Based on exploratory factor analysis, we consolidated the 14 items into 6 factors. These were named by their 'type': standards (items 1, 2), textbook/pacing guide (items 3, 6), accountability policies (items 4, 5, 7), students/community (items 8, 9, 10, 11), principal (item 12), and time (items 13, 14). To dichotomize each factor, we calculated the average score of the items and coded "supportive" (average > 3) as 2 and "inhibitive or mixed" as 1. Then we conducted the LCA analysis using the factor scores for each participant. After 100 iterations of 2-class and 3-class models, we selected the 2-class model because both the Bayesian information criterion (BIC) and the Akaike information criterion (AIC) were minimized (2-class: BIC = 422.575, AIC = 396.961; 3-class: BIC = 443.926, AIC = 404.520).

We selected two teachers from each latent class: Amy and Emma from the first class and Denise and Mary from the second class. As described earlier, Amy and Denise taught at the same school and Emma and Mary taught in the same district. These teachers were selected because they worked in similar ecological contexts and, comparing across the two classes, we were able to explore how they interpreted the impact of their contexts on their instruction differently and how those interpretations

influenced their achievement of agency. These four teachers participated in five semi-structured interviews that elicited their vision and goals for teaching mathematics, supports available for and challenges anticipated in enacting that vision, the resources available for teaching (e.g, curriculum materials), the influence of state-mandated standardized assessments, and their understanding and implementation of mathematics teaching standards. Our analysis attended explicitly to how the iterational (e.g., prior experiences; understanding of math standards), projective (e.g., vision and goals for teaching) and practical-evaluative (e.g., resources, supports, and challenges for enacting vision; influence of standardized assessments) dimensions informed how each teacher was able to achieve agency.

Results

Classes of Impact on Mathematics Instruction

The LCA analysis revealed two distinct latent classes: SUPPORTED (Ecological Factors Supported Instruction) and MIXED (Ecological Factors Inhibited and Supported Instruction). Teachers in SUPPORTED (45% of teachers), on average, perceived that their ecological contexts had a greater and more supportive impact on their mathematics instruction than those in MIXED (55% of teachers). For example, teachers in MIXED had a 0% probability of reporting that accountability policies (state testing, district testing, and teacher evaluation) supported their mathematics instruction, compared to an 87% probability among teachers in SUPPORTED. The three factors that had the greatest difference in perceived support between the two classes are accountability policies, standards, and principal support. Figure 2 shows, for each class, the probability of a teacher reporting that a particular factor supported their mathematics instruction.

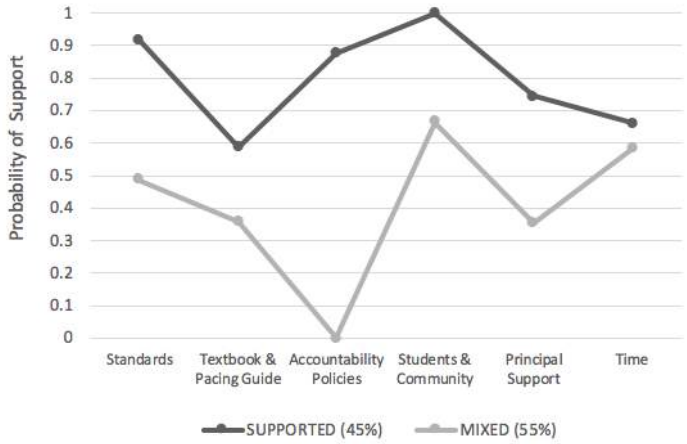

Figure 2: Conditional item probability plot for two classes

Cases of Amy and Denise (Same School)

Amy was an instructional coach for several years, and after completing an EMS program, returned to the classroom as a third-grade teacher. Illustrative of the SUPPORTED class, Amy conveyed little concern with regard to the district's accountability policies and pacing guide. For example, Amy perceived that the only stress regarding state testing was that "the computers didn't work the way they were supposed to." Amy's evaluation may explain why she did not use the test preparation materials like her partner teacher did:

> When my kids started doing that packet and I watched them, I'm like, "This is crap. I am not doing this. Stop…" The conversations were so much better than making them do 25 problems on their own. And my partner did it the traditional way…My principal is cool with

> it. He was like, "I don't want you to spend the whole month prep on it. They don't need it. They can think and that's the main thing."

This agentic activity - deciding not to engage students in test preparation materials - was supported by Amy's principal, who accepted her justification that her students were able to think and reason mathematically. Amy's decision to engage in mathematical conversations rather than practice problems also reflected her vision of mathematics instruction and her goals for student learning. Making specific references to the Standards for Mathematical Practice, Amy explained, "…it's so important for kids to be able to interchange numbers and to problem solve. And I think, honestly, the math practice standards are probably something that gets skipped over so much, and those are so important…Like taking a problem, making sense of it."

Drawing upon her goals and vision for mathematics learning, Amy was also able to achieve agency when she decided to devote extra time for Calendar Math in place of Rocket Math: "I kinda talked to my principal about it. I would like next year, instead of doing the Rocket Math, it's so very, it's a basic, it's a procedure, is what it is.…instead of doing Rocket Math with the group, I would like to teach Calendar [Math] to my second group. Because I add so much." Perceiving support from her principal, Amy saw Calendar Math as an alternative future to Rocket Math that better reflected her vision for instruction by developing a deeper understanding of mathematics concepts and providing students opportunities for reasoning and sense-making.

Amy's achievement of agency drew to a large degree upon her capacity to enact her goals for student learning and develop a wide repertoire for maneuvering her school context. In other words, she was able to draw upon her past experiences and imagine alternative futures to test preparation and Rocket Math. Supported by resources (e.g., the principal), and unconstrained by accountability policies, Amy was able to achieve a relatively great deal of agency.

At the same school as Amy, Denise taught fourth grade. The interviews took place during her fifth year of teaching. Illustrative of the MIXED class, Denise associated a great deal of stress and risk with the district pacing guide, which she described as constraining what and how she teaches: "I think it'd be more free on your pacing of how you teach and then you can do fun projects but it's like, 'oh, we can't do that cause it's gonna take a week to do that. And it's gonna put us behind,' and so to me I always feel like it goes back to that pacing guide." In this excerpt, Denise attended to how the pacing guide constrained her agency to engage her students in fun projects and hands-on activities. Such learning opportunities figured prominently in Denise's broader description of her vision for mathematics teaching and learning:

> I want them to have, to know the vocabulary, to be able to use it and just, and that just comes with understanding. I'd see like presenting the lesson but then we have our hands-on activity, like we're doing things together like as we're working though the lesson and understanding concepts, they're doing it with me or they have their boards and they're writing it out.

Unlike Amy, whose vision emphasized sense-making and engaging in mathematical practices, Denise viewed mathematics learning as participating in interactive activities to practice vocabulary and procedures after teacher demonstration.

Denise also felt pressured by state tests, stating "I think that's the pressure that's put on you to do well because that's what's reflected in the school on the state test." She saw students' standardized performance as reflecting on her performance as a teacher, which is a stark contrast to Amy who only described stress related to the computer testing system. Influenced by her evaluation of the pressures of her ecological context, Denise engaged in substantial test preparation, stating "I'll go back and like go lower so that way we can walk our way up but going back in that re-teach piece like a month - like with review, of course we review before the [state standardized] test but it's like being better about, okay, you did fractions last month, let's do like a bell ringer right now." In this, Denise

describes that she prepares for the state test by reteaching previously taught content, sometimes starting at a "lower" level. She even wishes that she had more time throughout the year to spiral back on prior knowledge.

Denise acted similarly in response to students' lack of advancement in their Rocket Math fluency program. She said that:

> I pulled back from that [fluency] because it wasn't working. It's like for some of them - don't get me wrong. Like my lower kids though it wasn't working for them because it's like part of it they don't put in the work… it's like you get to the sixth time they're not passing it and then it's like okay, so let's go back re-teach.

Denise's solution to the perceived problem of low math fluency was to reteach and review. By blaming students for their lack of effort, she also engaged in deficit discourses about students ("my lower kids…don't put in the work") that relieved her of responsibility for student learning. These cases illustrate that her agency was constrained by a lack of past experiences and beliefs that would allow her to imagine alternatives to reteaching and reviewing.

Constrained by the pacing guide and accountability policies of her ecological context, Denise seemed to enact a self-limiting form of agency framed by short-term goals and discourses focused around achievement and fluency. And without a range of past experiences or ambitious instructional goals to draw upon, Denise's repertoire for maneuvering her context was limited.

Cases of Emma and Mary (Same District)

Emma and Mary both taught fourth grade, but at different elementary schools within their district. A representative of the SUPPORTED class, Emma perceived that her context's accountability policies positively impacted her mathematics instruction. Though she acknowledged stress and pressure associated with standardized testing, she perceived that her context supported her in meeting such accountability expectations. For example, she explained that the curriculum was aligned with state standards, that instructional coaches taught students test-taking strategies, and that the district's weekly problem solving provided test preparation throughout the school year. For Emma, such policies supported her instructional goals, which were focused on achievement and proficiency: "My goal, always talk to them about improvement. That no matter where you start--for example, I had a student last year that started at common assessment for the first quarter at 19%, and then she got to 45%."

Emma's beliefs and goals for student learning are reflected in her understanding of problem solving. She explained that problem solving included highlighting and underlining key words to figure out which operation to use. Emma described that in her class,

> We would give a problem at the beginning of the week, and then the same type of skill problem at the end of the week…During the problem-solving time we would meet with that group that was struggling. Then, the last day of the week we would do it again and see how they improved.

For Emma, "problem solving" did not primarily involve making sense of problems and reasoning about numbers and concepts, but rather practicing and acquiring answer-getting skills.

Though Emma perceived that her ecological context supported her mathematics instruction, she seemed to enact a form of agency limited by her goals and conceptions of proficiency and achievement. Specifically, Emma did not achieve agency in ways that afforded students opportunities to meaningfully engage in conceptual understanding of mathematics, as her repertoire of iterational beliefs and projective futures was constrained.

Unlike Emma, Mary perceived that her context negatively impacted her mathematics instruction. Representative of the MIXED class, Mary perceived that accountability policies and the pacing guide constrained her instruction, stating that

> Because you know you're behind in your timeline and you know that students are going to be assessed on all these skills and you worry...Do I really want them to be able to just know how to get the right answer from rounding, or do I want them to really understand the number sense behind it?

Mary's achievement of agency was constrained by the pressures of standardized testing, limiting her ability to maneuver between district policies and her own goals for student sense-making.

Though Mary's agency was constrained by her ecological context in some instances, she was able to achieve agency in others. For example, Mary was able to take up an informal leadership role in her building to present to peers about problem solving. In describing the goals of her presentation, she stated that:

> Just because you're getting the kids a word problem does not mean that they are participating in problem solving because I remember student teaching within the district six years ago and there was Word Problem Wednesday and the teacher did the word problem up on the board for the kids and then the kids did the word problem that was exactly the same but with different numbers.

In this excerpt, Mary achieves agency in challenging, in front of her peers, the view that word problems imply problem solving: in particular, if students are mimicking the teachers' solution, they are not truly engaged in problem solving. Ironically, Mary's counterexample of problem-solving describes Emma's approach. Drawing upon her experiences and goals for student learning, Mary was able to achieve agency in promoting a problem solving that emphasized student reasoning and sense-making.

Though Mary was able to build upon iterational and projective dimensions to achieve agency in some instances (e.g., promoting problem solving opportunities), her repertoire for maneuvering her ecological context was constrained by practical-evaluative dimensions in other instances (e.g., rushing to cover the assessed material). In other words, though she was able to imagine a sort of problem solving that aligned with her goals for student learning, her achievement of agency was constrained by accountability policies.

Discussion & Conclusion

Our study contributes to the research base on teacher agency by revealing how elementary mathematics teachers perceive and achieve agency differently, even though they may share some ecological conditions. Using LCA, we found two unique classes: teachers in SUPPORTED perceived that their contexts had a greater and more supportive impact on their mathematics instruction than those in MIXED. Interviews then allowed us to investigate cases where agency was achieved differently within and between these classes. Drawing upon the theoretical literature (Biesta & Tedder, 2007; Emirbayer & Mische, 1998), these cases revealed the temporal nature of agency; in particular, how teachers' evaluations of their ecological contexts' constraints and supports dynamically interacted with their iterational experiences and projected goals (see Table 1).

Table 1: Summary of temporal dimensions of four case study teachers

	SUPPORTED Class	MIXED Class
Same School	Amy (achieved great deal of agency) • Iterational: beliefs about student learning focused on sense-making and mathematical practices • Practical-evaluative: felt supported by principal & unconstrained by context • Projective: able to imagine alternatives to test preparation and Rocket Math	Denise (constrained and self-limiting form of agency) • Iterational: beliefs about student learning focused on fluency and achievement • Practical-evaluative: felt constrained by pacing guide and accountability • Projective: unable to imagine alternatives to reteaching for test preparation and fluency
Same District	Emma (self-limiting form of agency) • Iterational: beliefs about student learning focused on proficiency and achievement • Practical-evaluative: perceived context as supporting goals • Projective: unable to imagine problem solving that focuses on reasoning and sense-making	Mary (constrained agency) • Iterational: beliefs about student learning focused on sense-making and problem-solving • Practical-evaluative: felt constrained by pacing guide and accountability • Projective: able to imagine problem solving that aligns with goals and vision

Emma's case suggests that feeling supported by one's ecological context is not sufficient for achieving agency, especially when teachers – even certified EMSs - lack ambitious goals and visions for mathematics instruction. Foregrounding the iterational and projective dimensions of the cases of Emma and Denise raises an important implication for teacher education: the need for teachers to have strong professional discourses about mathematics teaching and learning beyond those framed by policy (Biesta et al., 2015). Attention to the practical-evaluative dimension reveals that Mary's agency was constrained by her context's accountability policies as they conflicted with her goals for student learning. Such factors were not as constraining for Amy as she had more personnel resources (e.g., principal) to draw upon. This suggests a second implication for policy: the need to build ecological capacity. Mary's case illustrates how a teacher - one with experiences and visions aligned with ambitious mathematics teaching - can achieve agency in some situations and not others, depending on the availability of social, cultural and economic resources (Priestley et al., 2013).

If policies are to promote teacher agency, our findings suggest a need for building both teacher capacity and ecological capacity. This includes not only attending to the repertoire of past experiences and future trajectories mathematics teachers are able to draw upon, but also the ways their ecological contexts constrain and support their mathematics instruction. And, in our view, mathematics educators are especially well positioned to advocate for such policies.

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