Complexity and Proximity: Framing School Mathematics Challenges Inside and Outside Metropolitan Areas

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Abstract: We investigated the mathematics-related challenges identified by 50 mathematics leaders across one state, how the leaders framed those challenges, and whether their framings differed across different communities. Challenges were most often framed around standardized test outcomes (as opposed to students' experiences or equity), and this was especially the case among leaders outside of metropolitan areas.

Introduction

Beyond the few pockets of success that have been achieved in enacting high-quality, equitable mathematics teaching (e.g., Boaler & Staples, 2008; Steele & Huhn, 2018), we have, in the U.S., been largely unsuccessful in effecting change in how we do school mathematics at any significant level of scale. Much of what research in the learning sciences and mathematics education (and their overlap) has yielded about supporting mathematics learning has had little influence in many school settings. One change effort in U.S. education that *has* been remarkably "successful" are accountability reforms centered around state standardized testing. This "success" has not been with respect to the ostensible goals of ensuring that all U.S. children—and those historically marginalized in particular—have positive learning opportunities and outcomes (Au, 2016), but rather in shifting discourses and building infrastructure around problems manufactured by setting standardized measures of proficiency (Kitchen, Ridder, & Bolz, 2016). Many of the ways that states and school districts have responded to accountability pressures run counter to the vision for mathematics learning and teaching rendered by the last three decades of research in mathematics education (e.g., NCTM, 2014), and differentially affect different communitis (Davis & Martin, 2008). Still, those responses structure the current policy climate in which teachers and others work to achieve particular goals—however narrowly defined—for students' mathematics learning and therefore require our attention if we hope to improve mathematics instruction at a wider scale. As McKenney (2018) argued, "substantial social, historical, and economic factors can render our best research efforts inconsequential if we do not also attend to the factors that shape those settings" (McKenney, 2018, p. 2).

One such "factor" that we are interested in—and one that is of central importance to design-based research and research-practice partnerships—are the ways that those in positions of authority in school districts view and define the problems on which they focus improvement efforts. In this paper we report on our investigation of the mathematics-related challenges identified by 50 mathematics leaders across one state, how the leaders frame those challenges, and whether their framings differ across different communities.

Framing problems of practice

Our analysis is rooted in an assumption that the discourses that district leaders employ to define challenges and strategies for addressing those challenges contribute to maintaining or transforming institutional cultures (Bertrand, Perez, & Rogers, 2015). We view this as a matter of *framing* problems of practice, and are interested in particular in what Benford and Snow (2000) characterized as *diagnostic framing*—describing a problem's underlying causes—and *prognostic framing*—identifying viable solutions or responses to a problem. Across these dimensions, we are interested in the complexity with which district leaders frame problems. In some ways, particularly given the current outcomes-focused climate in the U.S., this complexity is related to what Jackson, Cobb, Rigby, and Smith (2018) identified as different *orientations* among district leaders in how they respond to accountability policies. Rather than taking an instructional *management* orientation, which leads to simply re-configuring human resources in order to produce higher test scores, the leaders with whom they partnered adopted instructional *improvement* orientations, through which they focused on supporting teachers' learning and growth.

Guiding our analysis were the following research questions: 1) What mathematics-related problems of practice do leaders identify and how do they frame them? and 2) In what ways, if any, do leaders' frames differ with respect to community context? In the next section we describe our methods for identifying and interviewing relevant leaders in a statewide sample of 50 school districts in Missouri, and our analysis of those interviews.

Methods

Setting

We conducted our study in Missouri, a state located in the middle of the U.S. and home to more than 6 million people (the country's 18th most populous). As shown in Figure 1, on opposite borders are the state's two urban centers—Kansas City to the west and St. Louis to the east, with their surrounding metropolitan areas, approximately 2.1 million and 2.8 million people, respectively. At the other end of the density spectrum, about a quarter of the state's population live in rural communities. As is typical, perspectives, practices, and access to resources often differ across the state's different communities.

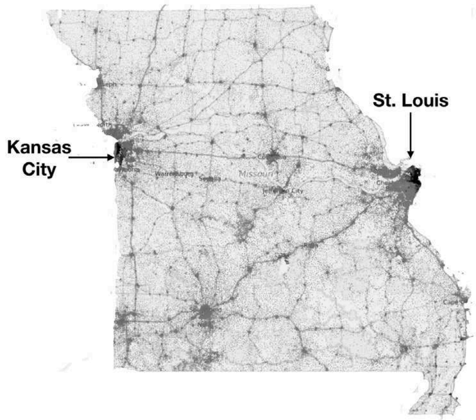

Figure 1. Missouri population density (with the two urban centers noted).

Interviews were conducted during a time that the state had experienced shifts in its standards for K-12 mathematics (from Common Core to the Missouri Learning Standards) and its standardized testing. These policy shifts applied to all districts in the state, regardless of location or size. However, given that there are different kinds of communities across the state, with varying levels of resources, we assumed there could be differences in the problems district leaders identified and the ways in which they framed them. Therefore, we purposefully sampled a range of districts with respect to population and proximity to metropolitan centers, our process for which we describe next.

Sampling and participants

We classified each Missouri municipality in two ways—by proximity to metropolitan centers and by population size. For the former, we categorized municipalities within counties designated as "metropolitan statistical areas" (U.S. Office of Management and Budget, 2010) as "metropolitan" and all others as "non-metropolitan." For population size, we assigned four categories. We designated the state's two urban centers, Kansas City and St. Louis, as "urban." We distinguished between "large" and "small" using a 24,999 cutoff, which is the median of the U.S. Department of Agriculture's (USDA) "frontier and remote" cut points. And, finally, we applied the label of "rural" to only non-metro municipalities with a population less than 2,500 (a cut-off from the U.S. Census Bureau).

Table 1 presents the size range and the total, sampled, and interviewed numbers of Missouri municipalities in each of the six classifications. Within each classification, we randomly ordered the municipalities, selected the number listed in the "Sampled" column in Table 1 from the top of the list, determined the school district the municipality's residents attended, and invited one leader in that school district to participate in an interview.

Table 1: District sample and classifications

Classification	**Population Range**	**Total in State**	**Sampled**	**Interviewed**
Urban Metro	> 200,000	2	2	2
Large Metro	25,000 – 200,000	21	19	11
Small Metro	< 25,000	262	24	10
Large Non-Metro	25,000 – 200,000	6	6	5
Small Non-Metro	2,500 – 24,999	93	24	12
Rural Non-Metro	< 2,500	655	25	10
TOTAL	**----**	**1,039**	**100**	**50**

Of those initially sampled, we interviewed leaders in 50 school districts combined. In each case, we identified the district leader tasked with overseeing mathematics curriculum and instruction. In total, we interviewed four superintendents, 17 assistant superintendents of curriculum and instruction (or equivalent), 25 other district leaders in curriculum and instruction (18 of whom were in roles specific to mathematics—e.g., curriculum coordinator, instructional coach), and four secondary mathematics teachers. It is worth noting that smaller and/or nonmetro districts were less likely to have mathematics-specific district leaders or, in some cases, even leaders directly responsible for curriculum and instruction.

Table 2 lists average district enrollments and student demographics for 2017 (the year preceding most interviews) for each district classification. Districts that were metropolitan and/or larger had more racially and ethnically diverse student populations than districts that were non-metropolitan and/or smaller. Besides the two urban metropolitan districts, non-metropolitan districts, on average, had a larger percentage of their student population that qualified for free or reduced-price lunch than their metropolitan counterparts.

Table 2: Enrollment and demographic information across district classification

Classification	Avg. Enrollment	Avg. % FRL	Avg. % White	Avg. % Black	Avg. % Hispanic	Avg. % Asian
Urban metro	17,996	99.95	11.23	67.68	16.34	3.28
Large metro	13,975	44.64	56.59	27.65	7.86	2.59
Small metro	3,273	34.32	74.54	11.75	4.88	3.79
Large nonmetro	12,523	56.64	67.23	16.37	6.10	2.69
Small nonmetro	2,853	49.00	85.08	3.40	6.61	0.86
Rural nonmetro	1,067	54.61	91.10	0.46	3.39	0.64

Data sources and analysis

Interviewees participated in one semi-structured, approximately 45-minute, audio-recorded interview. The majority (45) were conducted in 2018, with five in 2017. As the focus of this analysis, in each interview we asked "are there currently any math-related challenges in the district that have been made an explicit focus?" with follow-up questions regarding perceptions of the source of the challenge (or problem) and how the district was currently addressing it.

All interviews were audio-recorded and summarized. We analyzed the summaries using qualitative analysis software to identify what each leader identified as the (a) primary problem of interest, (b) underlying causes of that problem, and (c) responses to the problem. With respect to the last, expanding on Jackson et al.'s (2018) characterizations, we assigned either a "strictly management" orientation or a learning orientation to each leader's framing. The former focuses exclusively on changing district programs and structures (e.g., adopting a textbook, changing course sequence) and the latter on supporting and developing staff (e.g., professional development, hiring instructional coaches), possibly in addition to more "management"- oriented initiatives. Each summary was analyzed and categorized by the second and third authors, who resolved all disagreements by coming to consensus through discussion. We then looked across all interview summaries to identify themes and patterns across the districts with respect to proximity to metropolitan centers and population.

Additionally, we performed basic regression models to examine relations between districts' average levels of proficiency on standardized state tests (taken from publicly available data) and the types of problems leaders identified. As an outcome variable we used the difference in each district's percent of students scoring "proficient" or "advanced" and the state average. We used the comparison to state average, rather than a straight percent proficient, to account for the changes in state testing between years alluded to previously. We constructed two models. In the first, we examined the relation between 2018 proficiency rates and whether leaders described the most common type of problem, student outcomes (see next section). In the second, we added 2017 proficiency rates in order to examine whether leaders' problem descriptions were related to change in student outcomes. In both models, we controlled for whether the districts were in metropolitan areas.

Results

Across the 50 interviews, four main types of problems were described: student outcomes (n=30), student experiences (n=6), equity (n=3), and unspecified (n=9), with two rural district leaders reporting no problems. Here we summarize how participants described those problems and the orientations through which they framed them.

Problems related to student outcomes

Of the 30 leaders describing outcome-related problems (10 metro, 20 nonmetro), 28 focused on externally-established indicators centered on state or national test scores and two focused on higher-level course taking patterns. Common causes of outcome-related problems identified by leaders included instructional quality, teacher retention, and a lack of curricular alignment—vertical (across grade levels), horizontal (across sections within grade levels), and/or to state standards. Leaders were roughly evenly split with respect to orientation. Those taking learning orientations described providing professional development (PD) to support teachers' content knowledge and/or instruction. Those taking strictly management orientations reported adopting new curriculum materials that better aligned with state standards, implementing student interventions, and/or changing mathematics courses/sequences. Leaders in non-metro districts were much more likely to frame outcomes-related problems with a management orientation: of the ten metro district leaders describing outcomes-related problems, only two took a management orientation, while 12 of 20 nonmetro district leaders did. Thus, not only were leaders in nonmetro districts more likely to identify outcomes-related problems, they were also more likely to take a management orientation in framing those problems.

Problems related to student experiences

Six leaders (5 metro, 1 nonmetro) centered students' classroom *experiences*—rather than outcomes—in describing problems and solutions. Five reported problems of student engagement and one reported a problem of a cohesive K-12 student experience. The five leaders describing goals for student engagement did so in a variety of ways: being excited about or enjoying mathematics; seeing its relevance/usefulness; and engaging through sense-making or personalization. All five reported pursuing pedagogical shifts toward either inquiry-based instruction, a "workshop" model, or instruction focused on problem solving and discourse. Interestingly, all five also cited teachers' mindsets about instruction as barriers to those goals. In response, three leaders reported pursuing learning-oriented solutions such as providing PD or teacher collaboration time, and two described management-oriented solutions such as adopting a new instructional program.

Problems related to equity

Leaders in the three districts (all metro) with equity problems reported addressing an "achievement gap" and/or a "wide range of student abilities and prior experiences," attributing causes to a systemic lack of resources that under-prepares marginalized students or outside learning opportunities that advantage certain student groups (e.g., early childhood education). All three framed their equity problems with learning orientations. Two described a goal of closing a mathematics achievement gap for particular groups (e.g., African American students; students receiving free or reduced-price lunch), both of whom described providing PD on instructional improvement and either changed the math courses/sequence or provided interventions to support particular student groups. To meet a range of student "abilities," the third district provided PD, though this followed a previous "management" approach of adopting an integrated mathematics sequence, which was subsequently abandoned due to community and parental pressure.

Unspecified problems

Nine leaders (5 metro, 4 nonmetro) discussed solutions and initiatives without clearly specifying the problem those solutions were intended to address. In other words, leaders in the unspecified category framed their problem as an absence of a solution. Solutions included promoting a particular instructional approach such as inquiry or differentiated instruction (n=3), pursuing vertical and/or horizontal curricular alignment (n=4), or instituting tracking, distinguishing between "college-bound" and "non-college-bound" students (n=2). Although the problems these initiatives were intended to address were not made explicit, some leaders did describe challenges they encountered as they pursued the initiatives. For example, some leaders pursuing instructional change said that teachers' and parents' mindsets about instruction and mathematics were barriers in achieving the instruction they envisioned. Those working on alignment described teachers' content knowledge, inconsistencies in the curriculum materials used, and teacher retention as barriers.

No problems

Leaders of two districts reported not having any problems related to mathematics. One described general problems with student attendance. The other discussed alignment to the state standards, though did not indicate what problem such alignment would address (likely because, as in every Missouri school district, it is an effort in response to new state policy).

Relating problem descriptions to outcomes

Table 3 lists the results of our basic regression analysis of whether there was a relation between the most common problem of those just described—student outcomes—and the very object of those concerns. Controlling for whether districts were in metropolitan areas, when we examined percentages of students scoring "proficient" or "advanced" on 2018 state standardized mathematics tests compared to the state average, we found that outcomes-related framings were associated with lower rates of proficiency (and this was true for 2017 as well). Of course, it may be *because* of low test scores that districts focus on outcomes-related problems. Controlling for 2017 scores in Model 2, then, helps to see whether such a focus is related to change in proficiency rates. With that model, we found no relation between 2018 proficiency rates and the type of problem leaders described, meaning that framing outcomes-related problems was not associated with improved outcomes (although changes may be unlikely after just one year of new initiatives).

Table 3: 2018 difference from state average in percent proficient on standardized tests

	Model 1	**Model 2**
Variable	**Estimate (SE)**	**Estimate (SE)**
Intercept	8.65* (3.70)	1.29 (0.92)
Outcomes-focused framing	-9.93* (3.79)	-0.87 (0.96)
Metropolitan	-1.51 (3.73)	-1.39 (0.89)
2017 Difference from state average in percent proficient	---	0.97*** (0.03)

* $p < .05$; *** $p < .001$

Discussion and conclusion

That problems related to student outcome measures were the most common among the leaders we interviewed is perhaps not surprising given this century's accountability climate in U.S. public education and recent changes in standards and testing in Missouri. But we do wonder why leaders from non-metropolitan districts disproportionately described outcomes-related problems, and why leaders from smaller districts were more likely to take a strictly "management" orientation to addressing problems. One conjecture is that it might be related to resources and personnel. Larger districts are more likely to have an individual (or office) whose time is dedicated solely to overseeing districtwide mathematics curriculum and instruction. Given that mathematics is their explicit focus (and area of expertise), it could be that these individuals are more likely to frame mathematics-related problems with more complexity than are non-mathematics-specific leaders. Our data suggest, however, that it might not be simply a matter of size. Four of the ten (40%) small metro districts had personnel in mathematics-specific roles, whereas only one of the 22 small or rural non-metro districts had a leader in a mathematics-specific role.

One might interpret a relation between type of problem articulated and district responsibility as a potential confound in our analysis. We view the relation, however, as reflecting the reality of leadership work in different education systems related to size and resources. Specifically, the finding leads us to wonder whether, in districts where there is no leader charged explicitly with overseeing mathematics-related initiatives, identifying and addressing mathematics-related problems may receive insufficient attention, and problems may be framed with insufficient complexity. In particular, we wonder whether for those farther from metro centers, mathematics-related problems are, in effect, being framed "for them" by the system driven by standardized testing.

Regardless of the level of agency with which leaders who framed problems around outcomes were acting, the results of our quantitative analysis suggest that doing so is not associated with changes in the articulated problem. Leaders may be *responding* to disappointing scores on state standardized tests by framing problems around student outcomes (Model 1), but that framing may not (yet) be leading to improvements in the scores of concern (Model 2). To be clear, we do not invoke standardized test scores in our own analysis to assess which types of problem framings are "better." Our inclusion of this component is only as a consideration point for leaders and researchers potentially engaging in problems related to outcomes: if such framings are not, within their own logic, "successful" (i.e., associated with improved test scores), then there may be more productive problems to address in the design of mathematics learning environments.

Beyond—although likely related to—the particular problems leaders describe, we wonder what implications different orientations ("learning" or strictly "management") have for how districts address their problems. For example, all five leaders who reported problems of student engagement cited teachers' mindsets about instruction as barriers to their envisioned pedagogical shift. But only three took a learning orientation in addressing their challenges, while the other two framed their student experiences problem with strictly management orientations. In considering cases like this, we wonder whether changing programs and structures can effectively address problems if adults' perspectives and practices stay the same.

Given that what gets constructed as a problem is tied to eventual policy designs (Ingram & Schneider, 2005), and that school personnel in positions of authority are the most successful in influencing the direction of work (Penuel, Coburn & Gallagher, 2013), leaders' framings of mathematics-related challenges are particularly relevant to the work of learning scientists engaged in design-based research and research-practice-partnerships. Our findings suggest that *where* that work occurs matters. Whether it is initiated within or beyond metropolitan areas may have implications for the starting point, the problems of practice around which we design and partner, and the complexity with which they are framed. As such, we raise these questions for leaders' and researchers' consideration in relation to the problems they are currently wrestling with, and whether/how they may productively address equity and students' experiences in addition to outcomes.

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