Explaining differences in one teacher’s instruction across multiple tracked fifth-grade classes

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Explaining differences in one teacher’s instruction across multiple tracked fifth-grade classes

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Abstract
In this article, we describe the case of “Keri,” a fifth-grade teacher who had completed an Elementary Mathematics Specialist (EMS) certification program. Drawn from a larger study investigating the knowledge, beliefs, and practices of EMSs, Keri’s case was unique in that she was teaching mathematics to four classes in a departmentalized structure, where students were placed into different classes according to perceived mathematics ability. Observations from the larger study revealed that Keri’s instructional practices did not align with her reported beliefs and knowledge. To explore this deviation, we conducted a case study where we observed Keri’s instruction across multiple classes and used interviews to explore reasons for Keri’s instructional decisions in terms of her perceived professional obligations. We found that Keri did employ practices that were aligned with her reported beliefs and knowledge such as pressing students for mathematical justifications, but only in her “higher ability” classes. Interview data suggested that Keri’s decisions were driven by a strong obligation to individual students, overriding other obligations. We describe implications of these findings, including the limitations of teacher assessments and surveys as proxies for teaching quality, and discuss recommendations for approaches to teacher development that account for teachers’ perceived obligations.

KEYWORDS
classroom discourse, elementary, inquiry/discovery, mathematics, teacher knowledge

1 | INTRODUCTION

Teaching requires specialized forms of knowledge, commitments to particular principles and values, and skills for enacting specific practices (e.g., Franke et al., 1997; Ball et al., 2004; Lampert et al., 2013). This can lead to an exclusive emphasis in teacher education and professional development on knowledge, beliefs, and skills, based on the assumption (or hope) that a teacher who can enact high-quality practice will do so. But teaching also takes place in particular contexts where entrenched norms and expectations already exist (Herbst & Chazan, 2003; Hiebert, 2013). These expectations are often unchallenged; teachers tend to graft new knowledge, beliefs, and skills onto their current assumptions, impacting how these are carried out in practice (Thompson & Zueli, 1999). Hence, teachers sometimes fail to enact new practices, not because they lack knowledge or skill, but because their decisions...
are constrained by perceived obligations as professionals or tacit assumptions about teaching gleaned from prior experiences (Herbst & Chazan, 2003).

In this article, we describe such a case. By all measures, the fifth-grade teacher Keri (a pseudonym) was capable of the kind of ambitious mathematics instruction advocated for by the National Council of Teachers of Mathematics (2000, 2014). She had recently completed a 24-credit-hour graduate program for elementary mathematics specialists (EMSs). Like many EMS graduates, Keri demonstrated relatively strong mathematical knowledge for teaching (MKT) and expressed positive beliefs about promoting student agency and discussion in the learning of mathematics, developing conceptual understanding through problem solving, and using multiple solutions and representations (Webel et al., 2018). However, observations of her instruction did not reflect these priorities, but instead revealed an environment focused on answer-getting, where students were relatively passive recipients of information.

In addition to this discrepancy, Keri’s case was interesting because, unlike most fifth-grade teachers who teach all subjects, Keri taught mathematics to four different classes, where students were placed into classes according to their prior achievement in mathematics.

We wondered whether the instructional quality would differ across the four classes and how Keri might justify instructional choices that led to these differences. Our research questions were:

1. What are the differences in Keri’s instructional practices across her four sections?
2. What do Keri’s justifications for her instructional decisions across her four classes reveal about the way she interprets and prioritizes her professional obligations?

2 | LITERATURE REVIEW

2.1 | Personal resources, professional obligations, and teacher decision-making

Research has revealed links between teachers’ knowledge, beliefs, and practice (Campbell et al., 2014; Copur-Gencturk, 2015; Hughes et al., 2019). However, research also shows cases where individual teachers’ instructional decisions do not appear to reflect their expressed goals or take advantage of their mathematical knowledge for teaching (MKT; e.g., Hill et al., 2008; Raymond, 1997; Webel & Platt, 2015). For example, Hill et al. (2008) found that some teachers with high levels of MKT received lower ratings of instructional quality than would be expected based on overall patterns in the data and vice versa. Using case studies of individuals, the researchers explained these deviations, in some cases, in terms of teachers’ beliefs about how mathematics should be learned.

Focusing solely on individual teachers’ identities, beliefs, and knowledge to explain their instructional decisions, however, does not take into account the fact that to be a teacher is to take up a role that comes with boundaries, expectations, and particular ways of enacting the role (Buchmann, 1986). Herbst and Chazan (2011, 2012) use the term “practical rationality” to describe how personal resources like beliefs and knowledge act as filters for professional norms and obligations, which can help explain teacher decision making (e.g., Lande & Mesa, 2016; Milewski et al., 2021). They identified four obligations: the obligation to serve as a representative of the mathematics discipline; the obligation to students as individuals; the obligation to the class as a community; and the obligation to the teaching institution. These professional obligations are attached to the role of teacher, in contrast to beliefs, knowledge, and skill, which are characteristics of individual teachers. They represent concerns that teachers, because of their position, are not free to ignore (e.g., a teacher would not likely continue in their position if they persistently disregarded institutional expectations such as what content to cover in their class or parental expectations about how their child is to be treated).¹ Understanding how teachers prioritize and respond to these obligations can help explain why teachers may act in ways that do not align with their espoused beliefs and goals, such as relying on direct instruction and emphasizing formal vocabulary to avoid student confusion (a legitimate obligation to individual students) despite valuing student agency and shared mathematical authority (e.g., Webel & Platt, 2015).

This way of describing individual teachers as taking on a role is reminiscent of Gee’s (2000) discussion of “institutional identity,” in which aspects of one’s identity² are granted by a set of external authorities which make up an institution. Occupants of professional roles may more or less actively fulfill those roles, and have more or less room to negotiate how they meet the obligations that come with their role. However, they are not “free agents” who can ignore their professional obligations to follow their individual beliefs or preferences. Practical rationality helps tease apart how different teachers navigate

¹Note that the specifics of the obligations may vary from community to community; for our purposes the important aspect is that they originate from external sources and are attached to the professional role.

²In Gee (2000), the term identity does not refer to an internal state of being, but rather a part or role that is performed in society. It is largely related to how one is seen and recognized by others as “a certain kind of person.”
relatively similar sets of obligations, and reveals that “an instructor’s role includes obligations that they do their best to fulfill, but that these obligations may be constrained and influenced by each other, the environment in which faculty work, and the individual” (Lande & Mesa, 2016, p. 201).

The role of teacher is also situated within nested environments—society, the institution of the school, and the specific working environment that is made up of interactions the individual has with elements of the institution, including other actors such as colleagues, administrators, and students (Lande & Mesa, 2016), and each of these adds layers of obligations and expectations. Each environment has what Gee (2000) describes as a Discourse: a way of being a certain kind of person. Gee stresses that even identities that seem to be attached to individuals regardless of environment, when viewed through a wide enough lens, can be seen as attached to the social time and place in which the Discourse is enacted. In the United States, for example, public schools are required to submit scores on mandated state tests, and performance on those tests is used to judge school quality in a variety of contexts, including by legislators, parents, and community members. Pressure to perform well on these tests is placed on school administrators, which trickles down to teachers, and then to students. Administrators in the state where our study was conducted, especially those in non-metropolitan areas, largely describe their “most salient mathematics-related problems” in terms of improving student achievement (Munter et al., 2021). Zooming out even further, we can observe that this culture of increasing individual performance is embedded in a society that places high value on individual freedom, meritocracy, and independence, even as inequitable access to educational resources is built into the design of the educational system (Rooks, 2017). The Discourses attached to these societal values and institutional realities of schooling, as well as many others, create possible ways of being an elementary teacher of mathematics. Acknowledging these layers of context can help us understand the decision making of teachers as not merely functions of individual preference, but as individual ways of prioritizing and navigating the norms and obligations of the teaching role.

The practical rationality framework encourages us to see teacher actions not in terms of a “lack” of knowledge, beliefs, or skill, but in terms of knowledge about what to do in a specific context in order to meet a set of obligations, some of which may be in conflict with others (Herbst & Chazan, 2011). For example, in any given lesson the institutional obligation to stay on pace with a curricular guide may conflict with a disciplinary obligation to develop mathematical meaning for a particular concept, both of which may conflict with an interpersonal obligation to provide a positive and healthy learning environment for all students. In the face of these competing obligations, teachers must act, and the justifications they provide for their actions reveal how they navigate and prioritize these obligations to make decisions. In this article, we are interested in how Keri justifies her decisions with regard to the different learning experiences she provided across her four tracked classes.

3 | METHODS

3.1 | Context

3.1.1 | Situating Keri’s case within the larger study

Keri’s case was part of a broader National Science Foundation (NSF)-funded project addressing the impact of EMS certification and departmentalization3 on teaching and student learning. EMSs are professionals who have completed graduate programs that aim to develop mathematical knowledge for teaching in specific content domains, as well as leadership skills (de Araujo et al., 2017). The larger study included 55 teachers, 24 of whom were EMSs who had completed 24 graduate hours of coursework aligned with the Association of Mathematics Teachers’ Standards for Elementary Mathematics Specialists (2013). Teachers who graduated from Keri’s program have generally shown higher MKT than their peers and were more likely to enact practices advocated by the National Council of Teachers of Mathematics (Webel et al., 2018). From that group of 24 EMSs, we selected four of the cases where teachers had departmentalized assignments to document how aspects of each context affected teachers’ practices within that assignment (Yin, 2014). Keri was a unique case, not just because of her teaching context (departmentalization with explicit tracking by mathematics ability), but also because the patterns in her data from the larger study deviated from many of her EMS peers.

3.1.2 | The case of Keri

Keri taught at a suburban school located outside of a large city in the Midwestern United States. Roughly 600 students in Kindergarten through Grade 6 were enrolled

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3Departmentalization is a structure in which a single elementary teacher is responsible for teaching mathematics to multiple classes of students who rotate through her classroom during the course of the day (Brobst & Markworth, 2019; Webel et al., 2017).
at Keri’s school, nearly half of whom qualified for free and reduced-rate lunches (a statistic used in US school-funding formulas as a proxy measure for poverty). Keri taught mathematics to four classes of students, where class placement depended largely on students’ scores on end-of-unit assessments. Students with the highest scores were placed in what was referred to as the “Green” class, while students with the lowest achievement were placed in the “Red” class. The other two sections, “Yellow” and “Orange,” represented students with “middle” levels of achievement. This structure is sometimes described as ability grouping, “streaming,” “setting,” or “tracking,” though Keri did not use these terms. Research suggests that tracking can increase achievement gaps (Slavin, 1987; Steenbergen-Hu et al., 2017) and teachers in such settings can exacerbate existing societal inequalities by providing different kinds of learning experiences in different classes (Gamoran, 1992; MacQueen, 2013; Oakes, 2005).

The study took place during Keri’s second year as a fifth-grade mathematics teacher. Prior to teaching fifth grade, Keri was a Title 1 mathematics teacher at the same school, where she worked with small groups of first through sixth-grade students. Keri was recruited according to protocols approved by a university Internal Review Board and agreed to the analysis of her interview transcriptions and classroom observations.

3.1.3 Patterns in Keri’s quantitative data

For the larger study, we collected information about Keri’s beliefs about mathematics teaching and learning through surveys completed at the beginning, middle, and end of the year. Items were drawn from the 2012 Mathematics Teacher Questionnaire (Banilower et al., 2013), the Integrating Mathematics and Pedagogy (IMAP) survey (Ambrose et al., 2003), and a set of beliefs and attitudes questions developed by White et al. (2005). Keri’s responses generally indicated a strong belief in “reform” practices, such as having students explain and justify solutions, use multiple representations, and compare their solution methods. She responded with an average of 4.75 out of 5 on the Horizon composite scale (Banilower et al., 2013) assessing such practices, while the average for all of our participants was 4.29 (see Appendix A for the full set of items in this scale). She also showed appreciation for student sense-making in her survey responses. For example, when asked to sort tasks based on their level of difficulty for students, she selected a contextual problem as the easiest and a strictly symbolic problem $1/5 \times 1/8$ as the most difficult, writing, “I think kids are able to perform the [symbolic] operation and think it is the easiest, but they really struggle to make sense of it.” This view, that students can generally make sense of contextual quantitative situations more readily than they can grasp symbolic representations, is a key belief measured by the IMAP survey. Overall, our survey instruments portray Keri’s views as well-aligned with an inquiry-based approach to instruction that was similar to her EMS peers (Webel et al., 2018).

The larger study also provided indicators of teacher knowledge through scores on four subtests of the Learning Mathematics for Teaching (LMT) assessments, a multiple-choice instrument designed to measure the kind of knowledge that teachers must employ during effective mathematics teaching (Schilling et al., 2007). The LMT features tasks where the teacher must interpret student solutions, evaluate intuitive and non-standard strategies, and generate mathematical judgments about elementary mathematics concepts, and it predicts effective teaching practices (Hill et al., 2008) and student learning (Hill et al., 2005). Keri’s scores on the four LMT measures were above average in the full sample, and close to average among the other Elementary Mathematics Specialists in the project, suggesting a relatively high level of MKT (Table 1).

Finally, for the larger study, Keri’s teaching was observed three times over the course of the school year using a protocol adapted from Tarr et al., 2008; see Table 2; the full protocol is provided in Appendix A. The protocol includes indicators aligned with NCTM recommendations (National Council of Teachers of Mathematics, 2000, 2014), such as opportunities for students to propose/critique mathematical justifications, teachers’ use of student thinking to inform instruction and facilitate discussions, the use of multiple solution strategies and representations, etc.

Unlike her survey responses and LMT scores, Keri’s percentile ranks on the observation protocol, shown in

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Z-scores for Keri on the Four LMT subtests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtest</td>
<td>Percentile rank among the full sample ($n = 55$)</td>
</tr>
<tr>
<td>Geometry</td>
<td>65th</td>
</tr>
<tr>
<td>Probability</td>
<td>63rd</td>
</tr>
<tr>
<td>Algebraic reasoning</td>
<td>59th</td>
</tr>
<tr>
<td>Number and operations</td>
<td>65th</td>
</tr>
</tbody>
</table>

$^4$In the United States, schools with high levels of low-income students receive federal funding to hire additional teachers or instructional aides (United States Department of Education, 2015).
belief survey responses indicated a strong belief in such practices and her LMT scores indicated that Keri had the authority with students. This was surprising, given that her junction with the middle three interviews5 (see the timeline response to student thinking, and to share mathematical approaches might reveal about these apparent discrepancies.

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Table 3, put her in the lower range of our participants, especially among other teachers in our study to ask student to use multiple solution methods or representations, to ask them to justify their reasoning, to adjust instruction in response to student thinking, and to share mathematical authority with students. This was surprising, given that her belief survey responses indicated a strong belief in such practices and her LMT scores indicated that Keri had the knowledge needed to enact them.

This combination of data—relatively strong knowledge and student-centered beliefs but relatively low observation scores—heightened our interest in Keri’s case. We knew from our early case study interviews that Keri was teaching multiple sections, and we also noted that the observations had occurred in her lower (Red and Yellow) classes. We became curious to compare her teaching across her sections and see what her explanations of different teaching approaches might reveal about these apparent discrepancies.

### 3.2 | Data collection

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<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasoning about mathematics (R)</td>
<td>R1. Students were afforded opportunities to formulate and investigate conjectures about mathematical ideas</td>
</tr>
<tr>
<td></td>
<td>R2. Students created and defended mathematical justifications</td>
</tr>
<tr>
<td></td>
<td>R3. Mathematical authority was shared by members of the classroom community</td>
</tr>
<tr>
<td>Using student thinking in instruction (ST)</td>
<td>ST1. Evidence of student learning was used to adjust instruction</td>
</tr>
<tr>
<td></td>
<td>ST2. Students’ statements about mathematics were used to advance discussions</td>
</tr>
<tr>
<td>Focus on sense-making (SM)</td>
<td>SM1. Multiple (alternative) solution strategies were discussed</td>
</tr>
<tr>
<td></td>
<td>SM2. The enacted lesson developed mathematical knowledge in meaningful ways</td>
</tr>
<tr>
<td></td>
<td>SM3. Connections between multiple types of representation were made</td>
</tr>
</tbody>
</table>

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### 3.3 | Data analysis

#### 3.3.1 | Observations of teaching

To analyze Keri’s instruction across her four classes (RQ1), we examined the field notes created during the full-day observations by the second author. The third author initially conducted the analysis of these field notes by creating a description of the activities and analytic notes based upon the eight indicators that were used in the larger study (see Appendix A). Instructional interactions recorded in the field notes were coded for aspects of instruction such as opportunities to justify reasoning, the sharing of mathematical authority, patterns of questioning and uptake of student ideas, and

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5At the time of interview 2, Keri had been teaching math to all four classes in the fifth grade for 2 weeks. We chose to only observe her original two classes (Yellow and Red) during interview 2 and then observe all four classes during interviews 3 and 4.
opportunities for conceptual sense-making (as opposed to a procedural focus). The lesson descriptions and analytic notes were subsequently reviewed for accuracy by the field researcher.

### 3.3.2 Interviews

To analyze the perceived obligations that drove Keri’s instructional decisions (RQ2), we isolated instances in the interview transcripts where Keri discussed specific actions or practices related to providing different learning experiences for students, and then grouped these according to themes that emerged from the data. The five most prevalent actions were: the general use of perceived ability to group students into different classes, the process of assessing and assigning students to the different classes, the use of different teaching methods or assignments in each class, planning across the four classes, and using within-class ability grouping. For each action, we looked at Keri’s justifications for three types of indicators of obligation (see Webel & Platt, 2015). The first indicator was the presence of a justification for the instructional action using words like “so,” “so that,” “because,” or a response to a “why” question from the interviewer. A second indicator was the presence of evaluative statements about the action, such as “I hate giving quizzes at the beginning of the week”, a statement which suggests that the action (giving quizzes) is driven more by a sense of obligation than desire. Third, we coded for any modal modifiers used in the description that can indicate stance toward an action (e.g., “will” versus “probably” or “need to” versus “could”). These features provided evidence about the extent to which Keri perceived an obligation to engage in a particular action; additionally, we used the specifics of her comments to identify the most likely obligation driving her decision making. See Appendix C for examples of different codes and the indicators of obligation.

### 4 RESULTS

#### 4.1 Differences in Keri’s mathematics teaching across her four sections

Table 4 shows the activities in each class for each observation.

On the day of Interview 3, Keri’s lessons involved reviewing for an upcoming test on the concept of fraction multiplication. On the day of Interview 4, Keri introduced the concept of volume and connected it to previous lessons on perimeter and area. For the test review lesson, the Red, Orange, and Yellow classes were all organized...
into multiple teacher-assigned stations at which different activities, such as review games and teacher-supported work, were conducted. For the volume lesson, the Red class was the only class that worked in teacher-assigned stations for their work following the lesson. The regularly assigned co-teacher was present for both of the observed lessons in the Red class. On both occasions, students in the Green class either worked in a whole class setting or in self-assigned partner groups.

### TABLE 4 Description of Keri’s lessons in each class during observations associated with Interviews 3 and 4

<table>
<thead>
<tr>
<th>Class</th>
<th>Observation for Interview 3</th>
<th>Observation for Interview 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Students divided into 3 stations: (a) Order Up: cut and paste matching activity of symbolic fraction multiplication problems with answers (e.g., (\frac{1}{2} \times \frac{2}{5})), (b) Work w/teacher: symbolic fraction computation and simplification, plus story problems, students work on whiteboards; (c) Work w/SPED co-teacher: story problems, multiplication of fraction by fraction and fraction by whole number</td>
<td>Students begin with a warm-up, a bare numbers double digit multiplication problem (23 (\times) 56). The co-teacher re-writes the problem from horizontally to vertically on the board. The teacher announces that they will be doing volume today and volume of composed figures tomorrow. They watch a YouTube music video that is focused on using the formula to find the volume of a rectangular prism as the number of cubic units that it can hold. The teacher elicits the students’ math noticing from the video. They split into three groups to work with teacher, co-teacher, and student teacher, in which they practice calculating volume using the formula. Discourse patterns are almost all IRE (Initiate-Respond, Evaluate). Students make it through 2 rotations of the stations</td>
</tr>
<tr>
<td>Orange</td>
<td>Students divided into 2 stations: (a) Bump: roll dice to get a symbolic fraction multiplication problem (whole number by fraction less than 1, denominators up to 10), compute and place tokens on answer,..., (b) End of chapter review with entire group at “VIP” table working with teacher</td>
<td>Students begin with the same warm-up as the Red class, 23 (\times) 56. They watch the same video, process in a similar manner with the teacher eliciting their math noticings from the video. The teacher asks many short answer questions, followed by some practice calculating volume in which teacher leads students step-by-step similar short-answer questions. One task requires students to find a missing side length in a rectangular prism with given volume, and the teacher discusses “inverse operations”</td>
</tr>
<tr>
<td>Yellow</td>
<td>Students divided into 3 stations: (a) Bump: roll dice to get a symbolic fraction multiplication problem (whole number by fraction less than 1, denominators up to 10), compute and place tokens on answer,..., (b) Error analysis of work 3 symbolic problems, (c) Work w/teacher on contextual problem solving, where students were encouraged to find “keywords” to determine what operation to use</td>
<td>During the warm-up of a bare numbers double digit multiplication problem (54 (\times) 23), students are working individually and the teacher checks their answers as she goes about the room. They watch the same video, process in a similar manner, and then engage in solving volume problems. This lesson is very similar to the lesson in the Orange class</td>
</tr>
<tr>
<td>Green</td>
<td>She begins with a warm-up that uses similar numerals, adding decimal concepts to what the other classes did (0.23 (\times) 5.6). Then, without using the video or discussing volume, she gives them 5 min to come up with a formula and definition for perimeter, area, and volume. Each discussion leads to multiple versions of a formula along with discussions about the range of figures to which the formula might apply. They do a problem similar to the Orange and Yellow groups with the volume known and a missing dimension. Then they self-select partners to complete the 3-part task, “Design a Cracker Box,” an open-ended task that involves testing different designs for maximizing volume</td>
<td></td>
</tr>
</tbody>
</table>

#### 4.1.1 Quality of discourse

We saw considerable differences across the classes in both of the observations in terms of the quality of spoken discourse. In the Red, Orange, and Yellow groups, Keri’s questioning largely followed an Initiate-Respond-Evaluate (IRE) pattern (Mehan, 1979), often using a verbal fill-in-the-blank style in which she frequently answered the question herself after a brief pause or elaborated on
a short response instead of pressing students for more detailed ideas. For instance, in the Red class Keri asked the question, “Area measures the what?” as she visually swept her marker up alongside the area covered by a rectangle drawn on the board. She then modeled the placement of cubes in the same rectangle and counted them to find the area. All of this was done with minimal student input. In the Orange and Yellow classes, the dialog showed more student involvement, but Keri generally funneled students toward using the “length times width” formula for area.

In the Green class, Keri gave no definitions during the introductory lesson on volume; instead, students were given 5 min of talking to a peer in order to construct a definition for perimeter, area, and volume. Students were asked to share out to the class and the teacher used discourse moves that oriented them to each other’s thinking, such as “does anyone want to add to that?” She also asked questions that pointed to the generalization of ideas such as “What kind of shape would that [formula] work for?” These kinds of moves were only made in the Yellow and Green classes, and in the Green class, she pushed students for justification for why the generalization would only work “with a quadrilateral.” In the Yellow class, the teacher asked a more specific question, “Would this formula work for a hexagon?” She accepted the student response of “no” and used the specific example of a hexagon to write a new formula on the board. In effect, the Yellow class version of this episode emphasized specific formulas for different shapes rather than a more general conception of area.

4.1.2 | Quality of mathematics

Differences in the quality of mathematics were particularly salient in the field notes from the day of Interview 3 when the students were all preparing for the same test. In the Red and Orange classes, groups of students worked with the teacher on fraction multiplication story problems and participated in a fraction multiplication game that included symbolic and pictorial representations. In the teacher-guided group, Keri defined “proper” and “improper” fractions and gave instructions on what to do with them, emphasizing the difficulty students were having with “simplification.” Keri also emphasized correct execution of mathematical procedures, saying there was “no need to find common denominators when multiplying” and informing students that “of means multiplying.” In the Yellow class, students examined sample work in an “error analysis” activity where they identified and explained errors and computed the correct solution. While students were asked to share a strategy for reworking each of three problems after they identified the error, all of the solutions provided for analysis were non-contextual and involved the improper execution of a standard algorithm rather than sense-making about a concept or situation (e.g., $7/9 \times 6/9 = 42/9 = 46/9 = 42/3$).

In the Green class, the test review was driven primarily by student thinking. This was the only class in which we were able to code field notes for evidence of students engaging in extensive reasoning about mathematics. Before the test review, Keri introduced a scenario about downloading music and asked students to come up with their own mathematical question and answer it with justification, an activity that was only used in the Green class. While much of the questioning during the test review followed a directive pattern and seemed largely focused on steps in the solution process, there was much more student dialog in the Green class, including deliberate teacher-led discussion about the benefits of multiple strategies. Instead of simply computing the answer to a question at the end of a word problem, some exercises did not require an answer at all. Instead, students answered a series of True/False questions about the given contextual situation. In each of these problems, the students were asked to provide justifications for why the statement was true or false.

4.2 | Summary of findings from observations

Our observations of Keri’s teaching across her four classes revealed differences in patterns of student participation, teacher uptake of student ideas, and sense-making. In the Red, Orange, and Yellow classes, the patterns positioned the teacher as the purveyor of mathematical ideas and the primary evaluator of student performance. They showed preferential treatment of procedural performance over connections between multiple strategies and representations, consistent with observation scores from the main study. In contrast, Keri’s instruction in her Green class was more inclusive of student voice, afforded students opportunities to provide justifications, and had more intentional emphasis on the use of multiple solution strategies through a variety of contextual situations. Dialogue in the Green class included more peer-to-peer interaction and tended to focus on the construction of ideas and definitions rather than modeling and evaluating algorithmic procedures.

4.3 | Keri’s explanations for her instructional decisions

Our analysis of Keri’s interviews revealed that, by far, the most common source of obligation for all five of the
instructional actions we identified was the obligation to meet the instructional needs of individual students (as opposed to institutional, disciplinary, or interpersonal obligations). This obligation was often used to justify teaching decisions that created different kinds of learning opportunities across her classes.

4.3.1 | Separating students by ability

The first theme relates to Keri’s statements about the use of ability and/or “need” as a primary criterion in determining what kinds of learning opportunities students should be provided. She discussed this in all five interviews, and her statements often included justifications, positive judgments, and modality. For example, she described ability grouping as an improvement upon the previous structure where each class had “a very wide range” of students: “Once we differentiated those groups, it was just so much better for them and for me because the kids who were my struggling learners they had a voice, they weren’t as afraid to ask questions.” This quote includes both a justification (“because the kids who were my struggling learners, they had a voice”) and a positive judgment (“so much better”) that connected ability grouping to Keri’s obligations to individual students—particularly students who were “struggling learners.” Not only did Keri convey that students benefited from being in classes with others of similar ability; she also thought that different groups of students learned best from different styles of instruction. In Interview 3, she said, “I teach so much different to one group than I do to the other, I mean my teaching style is different, their learning style is different, so it changes.” These comments help to explain why we saw such variation in instructional quality across our observations of Keri’s four classes.

4.3.2 | Assigning students to leveled classes

When addressing the practice of assessing and moving individual students between sections, Keri at times focused on benefits to students at the “higher” end of the ability spectrum:

So, being able to move them and give them a challenge has been really good, because I’ve seen a huge growth just in taking those kids into a more challenging group and seeing what they can do with less support. It’s been pretty awesome, because they get bored... They’re capable of doing it on their own and they want to.

In this excerpt, Keri again makes positive judgments (“has been really good”) and justifications (“because I’ve seen a huge growth”) about the practice of moving certain students from a “low” class into a “high” class. She sees this as enabling her to challenge these students by giving them “less support,” which is consistent with the types of tasks and questions that we saw her providing the Green class.

She also described the process of looking over assessment results to determine which students should switch to which classes: “there was a lot of movement across all four groups, and even at the end of this quarter now we are going to kind of look at our groups and have discussion...let’s take a look at the data that we have right now and decide. There are a few kids that we need to move for sure.” Here Keri describes a sense of obligation (“there are a few kids that we need to move”) for ensuring that students are placed in the appropriate group. For Keri, these placement decisions seemed to be based on an obligation to individual students—finding out whether a student was in the “wrong” class, and moving them into the appropriate class.

4.3.3 | Planning for instruction

Keri also invoked obligations when making statements about planning. In particular, she often talked about planning different kinds of activities for each section:

My [Red class] I felt like we needed more building blocks for them. My [Yellow class] that I had today, I was trying to get more from them just to kind of see more of what they knew and try to get them to kind of problem solve and figure some more things out on their own, so, I asked them a lot more questions. And they had some different higher-level thinking problems that I didn’t really, necessarily touch on with the other groups because I didn’t feel like I wanted to confuse them with that yet.

This elaboration on how she taught each class differently shows specifically how and why some classes were expected to complete “higher level thinking problems” while other groups got more “practice with understanding the concept.” Again, this seems motivated by her perceptions about what students need—more “building blocks” for some students, more problem solving for other students. We also see an obligation to avoid confusion, which can constrain teachers from using more ambitious practices (Webel & Platt, 2015).
4.3.4 | Specific teaching practices in different classes

Finally, Keri made statements about her teaching practices in certain classes that provided additional insights into why each of her sections was taught differently. For example, when describing her Green class, she noted that she would probably skip going over a task with those students “because I think that they can persevere, they can deduce, they can figure that out on their own. I know that sounds – but they can.” Here we see evidence that Keri was aware that sentiments about students’ ability can be perceived negatively (“I know that sounds—”) but nevertheless was basing her instruction on her higher expectations for the students in the Green class. In contrast, she said, “I will scaffold those lessons [with the other two classes].” When asked if she would use more “modeling” for the Red and Orange groups, Keri replied, “For sure,” indicating a strong stance toward teacher demonstration in the “lower” classes, which is consistent with what we saw in our observations.

Overall, we see many of Keri’s decisions that resulted in different teaching practices in different classes were driven by an obligation to 1) determine what students need and can do, and then 2) deliver instruction matched to those needs and abilities. That is, for students who lack confidence or reasoning ability, Keri described providing more “scaffolding” and creating a “safe” environment for them, while she allowed students with stronger reasoning ability more opportunities to explore their own solutions for problems.

5 | DISCUSSION

5.1 | Obligations and instructional practice

Our analysis revealed that, first, the quality of teaching on the days we visited was different across Keri’s four sections. The instruction in her Green class was more focused on developing students’ conceptual understanding, whereas the instruction in other classes was more focused on memorization of procedures. Like other research on tracked classes, these patterns are likely to exacerbate existing inequities over time because they provide richer learning opportunities to those who are already high achieving (Oakes, 2005).

Keri’s instructional patterns in her Orange, Yellow, and Red classes would likely not have been predicted by looking at her survey and assessment responses, where she displayed a commitment to student agency, a focus on the development of conceptual understanding, and a relatively strong understanding of children’s mathematics. This echoes some of the cases described by Hill et al. (2008), where teachers’ mathematical knowledge for teaching did not align with the quality of their instruction, as well as Webel and Platt (2015), where teachers’ practice appeared to conflict with their stated goals and commitments. Those and other studies point to external influences, including curricula, norms, and obligations, that can affect how teachers put their expertise and beliefs into practice (e.g., Amador, 2016).

Keri’s responses to interview questions suggested that her decisions about providing differing instructional approaches were driven by an overriding obligation to individual students, which was operationalized by Keri as a practice of separating students into smaller and smaller groups where instruction could be more precisely targeted. This practice failed to appreciate that students of various abilities can learn from each other by sharing and discussing their different ideas (Boaler & Staples, 2008; Linchevski & Kutscher, 1998; Murata, 2013). Moreover, by endorsing the separation of the lowest achieving students into a class that received lower quality opportunities to learn, Keri neglected interpersonal obligations, which emphasize the teacher’s commitment to all students, who “need to share resources such as time, physical space, and symbolic space in socially and culturally appropriate ways,” and disciplinary obligations, which say that “the mathematical knowledge teachers teach needs to be a valid representation of the mathematical knowledge, practices, and applications of the discipline of mathematics” (Herbst & Chazan, 2012, p. 610). In the lessons we observed, the students in Keri’s Red class did not have the same access to resources and opportunities for learning (interpersonal obligation), and also did not have access to the same kinds of mathematical practices (disciplinary obligation), as students in her Green class.

We do not know why Keri prioritized her obligation to individuals so strongly, but we want to acknowledge the possible connections to the norms and obligations within the institution of schooling (such as the emphasis on student performance on end-of-year state standardized tests) and wider society in the United States (such as the emphasis on individual achievement and meritocracy). These institutional and societal values are consistent with a focus on improving the performance of individual students, especially on the procedural skills that state assessments tend to measure. That is, the way Keri was enacting her role as the teacher was entirely consistent with prevalent Discourses about how to be a good mathematics teacher, how to be a member of the educational system, how to prepare future citizens of the United States, etc., even as it appeared to conflict with her stated/measured beliefs about good mathematics teaching.
5.2 | The role of personal resources

Part of the power of the practical rationality framework is that it enables us to see teachers’ actions not as resulting only from a lack of knowledge or misguided beliefs, but as reasonable responses to professional pressures that are common to the role (Herbst, 2010). In Keri’s case, her obligation to individual students is legitimate, and indeed she must attend to the learning needs of individuals. But her personal resources, including her views about ability grouping, influenced how she responded to that obligation. Other teachers might respond to the same obligation differently, or might prioritize interpersonal obligations rather than individual obligations, resulting in more equitable practices (such as encouraging students to share their strategies and explicitly assigning competence to low-status students; Jilk, 2016). Practical rationality emphasizes that even though they might prioritize obligations differently, teachers are not free to ignore them; therefore, the adopting of different practices would require Keri’s to see how those practices would enable her to better meet (all of) her professional obligations.

As it is, Keri did not seem to see how her focus on meeting individual needs compromised other obligations. She would not likely have described herself as having lower expectations for students in her Red and Orange classes; she did not seem to recognize the overall lower quality of learning opportunities she provided for her “low” students or acknowledge the potential long-term consequences of these decisions. But these findings align with research on tracked classes, which often shows lower quality learning opportunities for students in lower tracks (Belfi et al., 2012; Gamoran, 1992; MacQueen, 2013; Oakes, 2005; Slavin, 1987). And while practical rationality allows us to see Keri’s instructional decision-making as a reasonable way to address her obligation to individual students, it makes us wonder how highlighting other obligations (disciplinary, institutional, and interpersonal) might support deeper self-examination of practice for teachers like Keri.

5.3 | Significance of Keri’s case

We were able to see the effects of Keri’s obligations to individual students play out in her classroom because she taught four classes and worked in a context that allowed her to enact, to some degree, her goal of differentiated classrooms. While her context is somewhat unique for an elementary school teacher, the way in which her obligations affected her instructional decisions is probably not. It is possible that other knowledgeable teachers make similar decisions in their classes based on a prioritization of individual student needs and, because of this, rarely demonstrate capacity for more ambitious forms of instruction.

Keri’s case also contributes to literature on the relationship between mathematical knowledge for teaching and mathematics teaching practices (Hill et al., 2008). In particular, Keri had relatively strong MKT, but the quality of instruction between her classes differed based on the perceived needs of each group of students. Using broad measures such as the LMT assessments and surveys can obscure more nuanced influences on teaching practice and may also lead to the assumption that the capacity to enact particular forms of practice will generally result in those forms of practice. Rather, this study helps show how teachers’ choices are not determined only by their general knowledge or beliefs, but are also influenced by the obligations they prioritize at the moment.

These findings should interest administrators and professional development providers, particularly if efforts to improve instruction are focused primarily on developing MKT or beliefs. We think it is valuable to recognize that Keri is responding to a set of obligations in a particular way, because any change to her beliefs (and ultimately, her practice) cannot come at the expense of meeting her professional obligations—she is not free to stop caring about the needs of individual students. She will likely need to see how other obligations are compromised by her current instructional decisions, and she will need to see how a different set of practices will enable her to better meet these obligations. As an example of an alternative that still attends to the needs of individuals, teachers like Keri could be encouraged to assign random groupings of students to encourage collaboration, sharing of strategies, and the development of positive mathematics identities (Webel et al., 2021).

6 | CONCLUSION

Keri’s case shows a teacher justifying different teaching approaches across her classes nearly exclusively through references to obligations to individual students. The needs of individual students, and the idea that a teacher’s primary obligation is to target instruction to the individual, overshadowed other obligations and permitted Keri to use less ambitious teaching practices for whole classes of students. Ironically, Keri’s intense focus on meeting individual needs appeared to be the primary thing that prevented her from providing what all students need—access to consistently rich learning opportunities. These findings align with other research on tracked classes and problematize approaches to teacher development that ignore existing norms and expectations. We hope that the contradictions and conflicts described in this article aid in the design and development of programs to support teachers, taking into account not only
knowledge and general beliefs, but also the ways that teachers perceive and respond to their professional obligations.

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REFERENCES


APPENDIX A
Reform oriented teaching practices scale from the Horizon 2012 survey (Banilower et al., 2013)
How often do you do each of the following in your mathematics instruction in your class? (a) Never; (b) Rarely (e.g., a few times a year); (c) Sometimes (e.g., once or twice a month); (d) Often (e.g., once or twice a week); (e) All or almost all mathematics lessons.

- Have students consider multiple representations in solving a problem (e.g., numbers, tables, graphs, pictures)
- Have students explain and justify their method for solving a problem
- Have students compare and contrast different methods for solving a problem
- Have students present their solution strategies to the rest of the class
### Appendix B

#### Classroom learning environment measure (CLEM) protocol (adapted from Tarr et al., 2008)

<table>
<thead>
<tr>
<th>Element</th>
<th>1</th>
<th>3</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>Students were afforded opportunities to formulate and investigate conjectures about mathematical ideas</td>
<td>Students had few, if any, opportunities to investigate conjectures in the lesson</td>
<td>Students had opportunities to investigate conjectures offered by the teacher</td>
<td>Students had opportunities to formulate their own conjectures and investigate the validity of those conjectures</td>
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<tr>
<td>Students created and defended mathematical justifications</td>
<td>Students were afforded few, if any, opportunities to create or share mathematical justifications</td>
<td>Students' mathematical justifications were seldom challenged by the teacher or other students, or this generally occurred only when faulty reasoning was offered</td>
<td>Students' mathematical justifications were challenged by the teacher or other students. Students responded to questions or critiques of their reasoning</td>
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<td>Mathematical authority was shared by members of the classroom community</td>
<td>Students relied on the teacher as the primary authority and as the source of mathematical knowledge. The teacher solely determined the validity of mathematical contributions or prompted students to refer to the textbook</td>
<td>Students were encouraged to consider the validity of at least some statements but in a superficial way. The teacher at least initially withheld judgments about the mathematical validity of students' reasoning or answers but ultimately asserted authority</td>
<td>Students were responsible for discussing the validity of at least some statements. The teacher withheld judgments about the mathematical validity of students' reasoning or answers and instead prompted student involvement.</td>
</tr>
<tr>
<td>Evidence of student learning was used to adjust instruction</td>
<td>The teacher sporadically or superficially elicited evidence of student learning by posing questions, making observations, and listening to students' thinking. The teacher generally accepted student responses and moved on. Instruction did not appear to be directly adjusted based on student work, questions, and responses</td>
<td>The teacher elicited evidence of student learning by posing questions, making observations and listening to students' thinking, and generally used student responses to continue discussion. Although instruction generally did not appear to be adjusted based on student work, questions, and responses, there may have been at least one such instance</td>
<td>The teacher actively elicited evidence of student learning by posing questions, making observations, and listening to students' thinking. The teacher purposefully selected students to share their thinking and instruction appears to be adjusted in the moment based on student work, questions, and responses</td>
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<td>Students' statements about mathematics were used to advance discussions</td>
<td>The teacher poses questions generally with a specific response in mind. Students respond by stating facts, definitions, or procedures. Students' responses were not typically used to advance discussion. Connections between students' statements, or between students' statements and mathematical ideas were generally not made</td>
<td>The teacher directs classroom discussion by posing questions intended to lead students down a particular path of discussion. The teacher uses desired responses to advance classroom discussion, and either ignores or directly addresses other responses. Connections between students' statements, or between students' statements and mathematical ideas are sometimes made</td>
<td>The teacher facilitates classroom discussion by pressing students to communicate their thoughts clearly and expecting them to reflect on their thoughts and those of their classmates. The teacher uses particular contributions to advance discussion. Connections between students' statements, or between students' statements and mathematical ideas are evident</td>
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<td>Element</td>
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<td>Multiple (alternative) solution strategies were discussed</td>
<td>Different perspectives or strategies for solving problems did not surface or were not valued. If students volunteered alternate approaches, the teacher responded to the student directly and moved on. Generally, if a student offered a correct solution, the teacher accepted it and moved on.</td>
<td>Different perspectives or solution strategies occasionally surfaced but primarily occurred when another student had not yet mentioned a particular solution method. Multiple strategies are primarily seen as disjoint options for solving a problem, and class discussion focused on using prescribed approaches.</td>
<td>Students viewed problems from multiple perspectives. When appropriate, alternative entry points or solution strategies were solicited and discussed. Connections between the varying approaches were made explicit in class discussions.</td>
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<tr>
<td>The enacted lesson developed mathematical knowledge in meaningful ways</td>
<td>The focus of mathematical knowledge was on algorithms and procedures, formulas and definitions without meaning. Typically, information was presented to students without discussion of mathematical connections, development of concepts, or components.</td>
<td>The focus of mathematical knowledge was on algorithms and procedures, formulas and definitions with some attention to meaning. Information was presented with some discussion of mathematical connections, development of concepts, or components. Verification of new ideas tended to focus on how (but not why) the mathematics “works.”</td>
<td>The focus of mathematical knowledge was on algorithms and procedures, formulas and definitions with strong attention to meaning. Mathematical concepts were developed through the generalization of existing concepts with a primary focus on understanding their components, relationships among them, and why the mathematics “works.”</td>
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<td>Connections between multiple types of representation were made</td>
<td>The lesson generally did not emphasize multiple types of representation of mathematical concepts and procedures. The teacher primarily focused on singular (typically symbolic) representations of ideas and did not elicit, use, or make connections to other representational forms.</td>
<td>The lesson elicited multiple types of representation of mathematical concepts and procedures. Although different representational forms occasionally surfaced, there was little discussion about explicit connections among representations.</td>
<td>The lesson emphasized using and making connections among types of mathematical representation to deepen student understanding, support classroom discourse, and serve as tools for solving problems. When appropriate, students used, discussed, and made connections among contextual, visual, verbal, physical, and/or symbolic representational forms.</td>
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### APPENDIX C
Example of coding for obligations

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<tr>
<td>Ability grouping by class</td>
<td>...because I feel like a lot of kids, and I notice that's my favorite part about differentiating, is that they get more confidence, they're not afraid to raise their hand, they're asking questions, they know we're there to help, they're enjoying it, and last year that's something we saw is those kids that were really quiet and just weren't doing well and hated to do math, at the end of the year said they loved math</td>
<td>Students get more confidence</td>
<td>Students in lower groups need more scaffolding</td>
<td>They loved math (positive)</td>
<td>Individual students</td>
</tr>
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<td>Planning for different experiences across classes</td>
<td>I notice sometimes that I feel like I want to move faster with the green group because I don't want to bore them but it's not that they need me to move faster, it's just that they need more challenge once they get it</td>
<td>Don't want to bore students in Green class; they need more challenge</td>
<td>Students in lower groups need more scaffolding</td>
<td>Individual students</td>
<td></td>
</tr>
<tr>
<td>Use within-class ability grouping (extra support for some students before problem solving)</td>
<td>They did, but we actually set them up a lot more than the last class, because they needed more of that scaffolding. So, we had them already set up with the table, we discussed how to solve the problem. We did a little more support on theirs because our focus for them, knowing that they're not quite there yet, is let's get them here and then let them solve and do the actual work</td>
<td>Because those students will be challenging for teachers</td>
<td>“Got to” consider implications of putting “low” students in same class</td>
<td>Individual students</td>
<td></td>
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<tr>
<td>Assigning “low” students to the same class</td>
<td>Keri: So we decide [on student placement] as a team.... Interviewer: Okay. So the group of students that I saw first, in your first class, are they together the whole day? Keri: Yep. So we've got to think about that, too, because they're going to be a challenge in every class</td>
<td>Because those students will be challenging for teachers</td>
<td>“Got to” consider implications of putting “low” students in same class</td>
<td>Institutional (how teachers are affected) versus individual</td>
<td></td>
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