HIGH SCHOOL MATHEMATICS TEACHERS' ORIENTATIONS TOWARD ENGAGEMENT

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The purpose of this research study is to characterize secondary teachers' orientations toward mathematics engagement. Results indicated that these 16 high school mathematics teachers tended to emphasize a cognitive dimension for engagement in their orientations, usually intertwined with an additional dimension (affective, social, or behavioral). Understanding teachers' thinking about engagement is a critical step toward helping teachers improve their practice to support their students' engagement in mathematics learning.

Keywords: High School Education; Teacher Beliefs; Instructional Vision; Affect, Emotion, Beliefs, and Attitudes.

In this study, we describe how high school mathematics teachers think about mathematics engagement. Teachers' efforts to engage students during their instruction are likely to be informed by their thinking about mathematics engagement. Understanding mathematics teachers' orientations toward engagement at the secondary level is particularly important because students' motivation and engagement has been found to decline over time as students move through levels of education. For instance, Chouinard and Roy (2008) found that students' self-efficacy, enjoyment, and sense of the utility of mathematics decreased as they move through middle school and into high school, and students became more disengaged over time in high school.

Students' motivation and engagement is malleable, socially situated, and influenced by teachers' instructional practices in the moment and by the classroom climate (Anderson, Hamilton, & Hattie, 2004). Teachers' instructional practices can impact students' motivation and engagement, and engagement is an important step on students' path toward learning mathematics. We conjecture that understanding high school teachers' orientations toward engagement is essential for supporting teachers to create secondary mathematics classrooms that disrupt declines in students' motivation and engagement.

Mathematics Engagement

Engagement in school manifests as students' expression of affect, beliefs about themselves, sense of belonging, and observable behaviors in the school setting (Jimerson, Campos, & Greif, 2003). Engagement is thus a complex meta-construct that simultaneously accounts for cognitive, affective, and behavioral dimensions (Fredricks, Blumenfeld, & Paris, 2004). Middleton, Jansen, & Goldin (2017) extended these dimensions to add a fourth with respect to mathematics learning: social engagement. Mathematics engagement is an interactive relationship between students and the subject matter, and it is manifested in the moment through expressions of behavior and experiences of emotion and cognitive activity; engagement is constructed through opportunities to do mathematics, as situated in both current and past experiences (c.f., Middleton, Jansen, & Goldin, 2017).

For students to learn mathematics, they must be engaged with experiences that support learning. In a study of almost 4,000 middle school and high school students in Western Pennsylvania, researchers

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found that higher levels of cognitive, behavioral, emotional, and social engagement predicted students' course grades in mathematics (Wang, Fredricks, Yea, Hofkens, & Linn, 2016). According to Greene (2015), it is well-established in prior research that motivation constructs such as students' self-efficacy support students' engagement in ways that lead to learning. However, it is possible that some teachers might speak about engagement in ways that are not always connected to learning, instead more connected to students' behaviors.

Teachers' thinking about students' mathematics engagement

Very few prior research studies have been conducted on secondary teachers' thinking about mathematics engagement, but some relatively recent research from Australia provides insights. Skilling, Bobis, Martin, Anderson, and Way (2016) conducted interviews with 31 secondary mathematics teachers from ten schools. Their results indicated that teachers in their study tended to describe students' engagement in terms of students' behavioral, affective, or emotional engagement; they spoke less often and less extensively about students' cognitive engagement. About one-third of these teachers reported an instrumental orientation, such that they strove to provide students with examples of how mathematics was a part of their lives outside of school. Some of these teachers also emphasized a relatedness dimension of engagement as they reported making efforts to build relationships with students to promote engagement. Their stance, which we also adopt, was that multi-dimensional orientations toward engagement would be more productive for teachers to hold.

Bobis, Way, Anderson, and Martin (2016) investigated changes in teachers' thinking about engagement, particularly among teachers who initially thought about engagement in terms of students' behavior primarily. After professional development, these teachers began to view engagement as more multi-faceted, beyond behavior management, and more than whether students were on-task. For the purposes of this study, we view behavioral engagement as the least productive dimension of engagement, because students could be on-task but not intellectually connecting with mathematics. We view cognitive engagement a potentially productive dimension, as it focuses is on students' mathematical thinking and learning.

Teachers' orientations

The term "orientation" is usually not defined explicitly in research literature on teaching and teacher education. Researchers' use of the term seems to imply that an orientation is a constellation of beliefs (e.g., Ambrose, 2004) or a set of perspectives and dispositions (Remillard & Bryans, 2004). It is particularly compelling to consider the root idea of "orienting," as these ways of thinking about teaching and learning can provide a direction for teachers' decision making. In this study, we define teachers' orientations toward mathematics engagement to be the set of teachers' beliefs about what it means for students to interact with mathematical tasks and each other productively during mathematics class, and together this set of beliefs provides direction for how teachers would enact instruction to engage their students.

By "beliefs," we mean what a teacher holds to be true. Beliefs are different from knowledge in that they are personal truths (Rokeach, 1968), and they have stronger, more affective components than knowledge (Nespor, 1987). Beliefs must be inferred by what a person says or does; they cannot be directly observed (Pajares, 1992). According to Rokeach (1968), ''All beliefs are predispositions to action'' (p. 113). Similarly, Aguirre and Speer (1999) explain that beliefs are "conceptions, personal ideologies, world views and values that shape practice and orient knowledge" (p. 328). Following Leatham (2006), we assume that teachers' beliefs are sensible to them, so we do not attempt to investigate whether teachers' actions appear consistent with their beliefs from a researchers' perspective.

Our stance toward teachers' orientations reflects that beliefs can cluster together within a system of beliefs. Green (1971) writes of beliefs having varying levels of psychological strength, some beliefs in a cluster are more central and others are more peripheral. Our investigation of teachers' orientations toward engagement targets the cluster of beliefs about the meaning of mathematics engagement, identifying which are more central in their belief clusters.

This study was guided by the following research question: *What are secondary teachers' orientations toward mathematics engagement?* We investigated dimensions of engagement that teachers reported when talking about engagement in interviews about their teaching practice.

Methods

This exploratory study was conducted during the second year of a three-year NSF-funded project designed to investigate engagement in high school mathematics classrooms. In Fall 2018 and Spring 2019, project team members interviewed 16 teachers in two states (one in the Southwestern region of the United States and one in the Mid-Atlantic region). Schools in these areas of the country use different curricular approaches: integrated mathematics in the Mid-Atlantic and topics-based courses in the Southwest. The three Mid-Atlantic schools implemented a block schedule with approximately 90-minute class periods. In the Southwest, the class periods were approximately 50 minutes long.

We gathered data from six schools (three from each state). In the Mid-Atlantic, the schools' demographics ranged from 9-30% low income, 24-57% white, 27-46% Black, 7-24% Latinx, and 5% or less Asian-American, Native American, or mixed-race students. In the Southwest, the schools' demographics ranged from 85-94% low income, 2-5% white, 1-15% Black, 74-96% Latinx, and 5% or less Asian-American, Native American, or mixed-race students.

Teachers were recruited for this study by soliciting nominations from district curriculum supervisors and mathematics coaches. The 16 participating teachers averaged 10.8 years of teaching experience, ranging from 1 to 27 years. Twelve teachers had earned a Master's degree. They self-identified their races as follows: 14 white, one Asian-American, one Hispanic/Latinx. They self-identified their genders as eleven female and five male.

Data Collection

Each teacher completed a baseline survey online at the start of each course. Survey items were open-ended, such as: *In your own words, what does "engaging students with mathematics" mean?* Interviews took place at the end of the semester in the Mid-Atlantic region, where schools had block scheduling, and it was at the end of the academic year in the Southwestern region. Interviews lasted from 35 minutes to about an hour and 15 minutes. Prior to the interviews, we video recorded classroom observations between two and four times per class period; observations targeted a lesson activity that the teacher conjectured would be likely to engage students. Interview questions included: *What are some of your favorite strategies you use to engage students? Why do you use these?* and *Can you tell me about a time when you have successfully engaged students with mathematics?* During the interview, we also asked teachers to elaborate on their definition for engagement on their baseline survey. Additionally, the interviews incorporated a video viewing session protocol; we showed teachers a video clip of their lesson, and we asked them to reflect on their students' engagement and their approaches to engaging them.

Data Analysis

The goal of our analysis was to describe the orientations each teacher used to conceptualize students' mathematics engagement. We compared descriptions of orientations to map a framework of ways in which mathematics teachers think about engagement along six dimensions identified in the engagement literature. Any of these dimensions could be either central or peripheral in a teacher's orientation, or in the constellation of beliefs the teacher held about mathematics engagement.

Each interview transcript had three sections, and we applied four levels of analysis to the transcripts. The interview's three sections were: (a) teachers' definitions for mathematics engagement, (b) teachers' strategies for engaging students, and (c) teachers' reflections on students' engagement during a classroom video episode. Interviews were transcribed prior to analysis. Each interview was coded independently by two researchers. All disagreements were resolved.

We operationally defined a teacher's orientation to be composed of dimensions of engagement that they reported in the three sections of the interview. Each transcript was analyzed at four levels: (1) we applied descriptive coding techniques (Saldaña, 2013) to identify the dimension(s) of mathematics engagement to which each teacher was oriented [see Table 1].

Table 1: Indicators for Dimensions of Mathematics Engagement

Dimension of Engagement	Indicators of Engagement that Teachers Described
Affective	Students' emotional responses, interest, attitudes, and expressions of values.
Cognitive	The process of students coming to understand, learn, and make sense of mathematics.
Social	Students interact with one another for the purpose of learning mathematics.
Behavioral	Observable actions of students, including whether or not they were on task.
Relatedness	Enactments of interpersonal care or personal connections between the teacher and students and among students.
Instrumentality	Students see mathematics as useful and relevant to their lives.

(2) We analytically identified the centrality of the dimensions in each interview section based on the teacher's use of repetition, level of detail, and emphasis terms. Central dimensions had two of these three features (repetition, detail, or emphasis). Peripheral dimensions did not. (3) We analytically determined the degree to which a dimension was central to a teacher's orientation by identifying whether the dimension was central to the teacher across more than one section of the interview. (4) Finally, we applied axial coding across each teacher's interview (Saldaña, 2013) and compared teachers' central dimensions to identify categories of orientations.

Results

In Table 2, we summarize the central and peripheral dimensions of mathematics engagement reported by these teachers at the case-level, or across the interview for each teacher. Central dimensions are labeled with a shaded 1 and peripheral with an unshaded 2. Zero indicates no evidence of this dimension in teachers' responses.

Table 2: Teachers' Orientations toward Mathematics Engagement

Teacher	Cognitive	Affect	Social	Behavioral	Instrumentality	Relatedness
Elise	1	1	1	1	0	0
Ken	1	1	1	2	2	1
Chloe	1	1	2	1	2	0
Addie	1	1	2	2	2	0
Jessica	1	1	2	2	0	0

Nancy	1	1	0	2	1	1
Jimena	1	2	1	2	2	2
Julie	1	2	1	2	0	2
Nicole	1	2	2	1	2	2
Peter	1	2	2	1	0	0
Colton	1	2	2	2	1	2
Tori	1	2	2	2	1	0
James	1	2	2	2	0	2
Rachel	1	2	2	2	0	0
Anne	2	1	2	2	1	2
Craig	2	2	0	1	2	0

All of these secondary mathematics teachers expressed a multi-faceted orientation toward mathematics engagement--they all spoke about engagement with at least four dimensions, either at the central or peripheral level. Table 3 (below) shows four prevalent orientations that teachers reported.

Table 3: Four Prevalent Orientations Toward Mathematics Engagement among Secondary Teachers

Orientations toward mathematics engagement	Summary of each orientation
Cognitive-Affective	Support students' learning of mathematics while cultivating enjoyment, interest, and a desire to learn mathematics.
Cognitive-Social	Learning mathematics is a process of coming to know mathematics through discourse.
Cognitive-Behavioral	For students to be actively involved in mathematics learning, teachers must manage students' behavior.
Cognitive-Instrumental	Opportunities to learn are enhanced by connections between school mathematics and students' lives.

All but two of these teachers (87.5%) reported a central cognitive dimension in their orientation such that engagement involves students thinking mathematically or making sense of mathematics. This is important because previous research indicates that mathematics teachers tend to think about engagement in terms of its behavioral dimension primarily, unless they had had support from professional development (e.g., Bobis, Way, Anderson, & Martin, 2016; Skilling, Bobis, Martin, Anderson, & Way, 2016). Our findings illustrate counter evidence, indicating that secondary teachers can strongly consider learning processes when they talk about mathematics engagement.

Teachers consistently paired statements about cognitive engagement with statements about one or more other dimension. Affective, social, and behavioral engagement, and instrumentality were viewed as critical contributors to students' efforts to grapple with and understand important mathematical concepts and procedures. Rather than speaking about goals for cognitive engagement and then speaking about other facets separately, teachers' responses concurrently emphasized the role of affect, social or behavioral dimensions in supporting cognitive engagement. In particular, when speaking about strategies and practices that contribute to students' math engagement, these facets were reasoned as important for helping students engage in learning the mathematics productively.

Relatedness and instrumentality were the dimensions reported least by these teachers, but these dimensions were still a part of most of these teachers' orientations. At least half of the studied teachers mentioned relatedness and instrumentality in at least one of the sections of the interview at some level (either central or peripheral). It is interesting to note that these dimensions displayed the most variability in teachers' responses. Half of the teachers in the sample did not mention relatedness as somewhat central to their conceptions of engagement, and six did not mention instrumentality.

Cognitive-Affective Orientation toward Mathematics Engagement

Six secondary teachers reported a cognitive-affective orientation toward mathematics engagement (Jessica, Addie, Chloe, Elise, Ken, Nancy). They said that students are engaged when they invest their thinking in order to learn (cognitive) and their investment will increase if they enjoy the experience and feel a desire to learn (affective). Addie wrote that engagement is "Where students are excited to learn the beautiful world of mathematics." (baseline survey) "I think it's taking where students are at, because that's where they're comfortable, and then expanding their knowledge in different ways that aren't necessarily lecture based in order to get students really interested in mathematics." (22-25, interview). When Addie spoke about engagement in terms of learning (cognitive), she also wrote about affective experiences of excitement, beauty, comfort, and interest. Nancy said, "I feel like engagement is having them be actually, like, cognitively thinking about the mathematics that are happening and not just copying down the notes… it's about having them actually think about it… having, like, some sort of level of fascination or even just curiosity, or seeing a goal with it. Just, kind of, finding a purpose in it." (39-46, interview). Nancy valued fostering curiosity (affective) so that students engage in deep mathematical thinking (cognitive). The teachers spoke about productive opportunities for students to understand mathematics in ways that also provided powerful opportunities for students to develop strong relationships with the discipline of mathematics.

Cognitive-Social Orientation toward Student Engagement

Four teachers (Julie, Jimena, Elise, and Ken) reported a cognitive-social orientation toward engagement. They described engagement as investing thinking in order to learn (cognitive) through a process of coming to understand mathematics through discourse (social). (We note that some teachers, such as Elise and Ken, were examples of more than one of these four orientations, because their orientations contained more than two dimensions.)

Julie's baseline assessment provided a concise example of a cognitive-social orientation. She wrote, "Engaging students with mathematics means finding ways for students to think about and discuss mathematics in a way that deepens their understanding." Thinking (cognitive) and discussing (social) were integral to Julie's view of engagement.

These teachers tended to characterize cognitive engagement as a process of grappling with mathematics. For instance, Elise said, "I want them to say, 'What am I doing that's not making sense?' Or, 'What pieces could I be missing that are not connecting?' I want them to ... if they find an answer, interpret that answer. Is it a useful answer? Does it answer the problem you're trying to figure out? Does the answer make sense?" Similarly, Julie said, "So I like to ... from time to time, after we've done a concept, to kind of pose a question that forces them to really, first of all, think on their own. Can they generate their own thought? But then to have those discussions with their peers to see, 'Well, what do you think about that? I didn't think about it. How can we maybe expand on each other's ideas to see different ways of viewing the same kind of problem?' " (27 – 39, interview) These teachers talked about learning and understanding in ways that involve making sense, interpreting their work, and wrestling with concepts as they talk them through with peers.

Cognitive-Behavioral Orientation to Students' Engagement

A cognitive-behavioral orientation toward mathematics manifested in four teachers' talk (Nicole, Peter, Chloe, and Elise). They reported that they wanted students to be actively involved in the learning process (cognitive), but they also reported having to manage behavior so this would happen (behavioral). On his baseline survey, Peter wrote, "Engaging students means that all students are working on what are supposed to. All students are actively participating in their own learning, with no exceptions. Engaged means 'doing.'" Elise spoke about engagement challenges as being about the range of ways students engage behaviorally and cognitively.

> You have different levels of engagement. You have the kid that hasn't even attempted to pick up a pencil… the kid that looks like he's listening or she's listening, but hasn't even read the question or hasn't tried to understand the directions and the task. And then you have the kids like, 'Oh, I got an answer. I'm done.' … It's such a big spectrum of engagement and lack of engagement that you try to address every day. (50-59, interview)

Engaging their students cognitively and behaviorally was reported by these teachers as something they constantly worked to accomplish. For instance, Nicole talked about cold calling (behavior management) as a way to engage students to think about mathematics (cognitive engagement), as she said,

> I kind of force them to be a little bit more engaged for the Popsicle sticks. And then also, if they didn't know the answer, they had to listen to somebody else, and then they had to repeat it back. Like, [student] didn't know what to do, so somebody else gave the answer. And then, I made [student] repeat it so that he was listening, at least. I don't know if that's considered engagement, because to me, he's just listening, and he's just repeating. But, at least it's trying to get them to think. If I could see the rest of the class, I believe most of them ... No, probably 50% of them were actually engaged, because I'm hearing talking in the background. I don't know where that came from. (370-380, interview)

The teachers who intertwined behavioral engagement with cognitive engagement spoke about using classroom management practices to bring about productive behavior in hopes that it would lead to stronger intellectual investment among students.

These teachers spoke about the cognitive dimension of learning in ways that appeared to be more closely aligned with procedural fluency than conceptual understanding. When teachers articulated a cognitive-behavioral orientation, there was a focus on getting answers over sense making, modeling procedures through lecture, and guided practice of steps to solve a task. This perspective on cognitive engagement contrasted with teachers who reported a cognitive-affective, cognitive-social, or cognitive-instrumental orientation, which illustrated a focus on interpreting and understanding mathematics.

Cognitive-Instrumental

A cognitive-instrumental orientation toward engagement was illustrated by three teachers (Tori, Colton, and Nancy) who talked about opportunities to understand (cognitive) being enhanced by connections between school mathematics and students' lives (instrumental). Tori reported the following on her baseline assessment: "For me, engaging students with mathematics means using the real-world information to understand the concepts in mathematics, and hopefully apply what the students have learned to their personal lives and become lifelong learners of mathematics." Colton described engagement on his baseline survey as "Giving them something more to connect with." Nancy reported the power of connecting mathematics and students' lives. When discussing functional relationships, such as whether the relationship between time and location is a function, she said, "I think that part of the reason why it was so engaging is because some of those things allow them to challenge math. … I think it's cool when they can make that, like, real-world connection."

These teachers could leverage opportunities to connect with mathematics (instrumental) in ways that enhanced students' opportunities to understand mathematics (cognitive).

Discussion

We conjecture that quality mathematics instruction can be best supported when teachers go beyond a focus on behavioral engagement in their orientations. The secondary teachers in our study emphasized cognitive engagement primarily, with other dimensions serving as supports and influential catalysts for helping students engage cognitively. If teachers tend to prioritize cognitive engagement in their orientations, and if they hold multiple dimensions of engagement in their orientations, they are likely to have productive resources and strategies they can call upon to support their students.

Future research could investigate whether teachers' instructional practice varies depending on their orientations toward mathematics engagement. It is possible that a teacher who holds multiple dimensions toward mathematics engagement in their orientations is more flexible in their approach to engaging students. Alternatively, it may also be possible that teachers who hold only two dimensions – such as cognitive-affective, cognitive-social, or cognitive-instrumental – could effectively engage their students in mathematics learning. The necessary and sufficient conditions for improving student cognitive engagement through integration of two or more dimensions is an open question.

To support teachers in developing their orientations, we propose two goals for teachers' learning about mathematics engagement: (1) Teachers can strive to more fully enact their orientations toward mathematics engagement in their teaching practice; and (2) Teachers can work to enhance additional dimensions toward mathematics engagement in their orientations. Teachers' orientations reveal some insight about their instructional vision for engaging students with mathematics (Munter, 2014). With appropriate coaching support or collaborative inquiry with teachers who hold similar orientations, teachers may be able to approach enacting teaching in ways that more closely align with their orientations. Alternatively, teachers could learn to take up instructional strategies aligned with additional dimensions of engagement to further develop their practice.

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