REVEALING LAYERED MATHEMATICAL LEARNING GOALS THROUGH AN EXAMINATION OF MINDSET

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This exploratory case study investigated the role of mindset in the establishment of an elementary teacher's mathematical learning goals at different layers of her classroom and curriculum. Data from the critical case of a teacher displaying characteristics of the growth mindset and engaging in the processes of teaching change provided evidence for a unique goal structure that could prove useful to a variety of mathematics teachers and mathematics teacher educators. This layered goal structure featured goals at global, trajectory, and content levels that provided opportunities for further operationalization of the teacher's mindset.

Keywords: Instructional Activities and Practices, Research Methods, Teacher Beliefs

Introduction

In bridging the perceived divide that exists among the theories, research, and practices of mathematics education, we must begin by addressing ideas that are shared and fundamental to each of these facets of the discipline in a way that leverages the unique strengths of each. One such idea involves the mathematical learning goals established by teachers as they interact with learners across the days, weeks, and months that constitute the academic year. As others have observed, this is perhaps the most fundamental idea shared between the unique faces of our discipline, as "until learning goals are expressed clearly, further analyses are impossible" (Hiebert, Morris, Berk, & Jansen, 2007, pp. 50-51).

A growing body of literature documents that a teacher's establishment and sharing of appropriate learning goals is an essential component of learning mathematics in the classroom (National Council of Teachers of Mathematics [NCTM], 2014). The specific challenges that are experienced by both teacher and learner are defined by these learning goals (Hiebert & Grouws, 2007), and the degree to which these challenges are overcome is greater in classrooms in which these goals are clearly and explicitly defined for all involved (Haystead & Marzano, 2009; NCTM, 2014). Despite the array of knowledge regarding the value of mathematical learning goals, their genesis and interaction with an individual's beliefs about the teaching and learning of mathematics are difficult to measure. Additionally, theories that describe these goals in terms of teaching are in notoriously "short supply" (Hiebert & Grouws, 2007, p. 373). The research reported here attempts to bridge this gap by examining the influence of a teacher's mindset, operationalized through the tenets of self-regulation theory, on the mathematical learning goals she pursues in the classroom. In doing so, it establishes a crossroads between two important theoretical perspectives and the daily operation of the elementary mathematics classroom and promotes the synergy among these factors that is the theme of this year's conference.

Purpose

A complete model of mathematics teacher development must describe the teachers' motivations and dispositions for their teaching as well as the influence of these factors on areas such as the teacher's implementation of learning activities, interactions with students and the classroom environment, and interpretations of professional development experiences (Opfer & Pedder, 2011; Wagner & French, 2010). The principal purpose of this study was to explore one of these motivational factors, the teacher's mindset, within the contexts of the teacher's professional

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development experiences and classroom practices. However, as the study evolved, it became apparent that the teacher's mindset linked inexorably to the mathematical learning goals she established in her classroom and the manner in which she operated on and monitored progress towards these goals. These premises led to the primary research question of the study reported here: How do characteristics of the growth mindset influence the mathematical learning goals established by a mathematics teacher as she engages in professional development and mathematics teaching? To address this question, the influence of mindset on the teacher's learning goals as she observed, interpreted, discussed, adapted, planned for, implemented, and reflected on a demonstration lesson was examined.

Theoretical Framework

The unique strength of the theoretical framework of a research study is in its ability to provide an underlying structure for the research that allows the researcher to anticipate, understand, and attempt to explain the phenomena under consideration. Additionally, this framework shapes the research design process, and in a single-case study supports the analytic generalizations that are the primary product of the research (Yin, 2014). With this perspective in mind, two important theoretical constructs guided this study: the model of implicit theories, commonly referred to as mindset, provided the primary theoretical lens for the study, while tenets of self-regulation theory operationalized these mindset constructs. The remainder of this section contains descriptions of these theoretical elements.

The Model of Implicit Theories

Situated in their prior research on goal orientation and behavior, Dweck and Leggett (1988) described the social-cognitive model of motivation and personality that developed into the implicit theories framework. In this model, the authors posited that an individual's implicit assumptions about the nature of an ability lead directly to the type of goals he pursues regarding that ability and the behaviors he exhibits when faced with challenges to that ability (Dweck & Leggett, 1988; Dweck, Chiu, & Hong, 1995). These mindsets and their associated goal pursuits thus created "a framework for interpreting and responding to events" (Dweck & Leggett, 1988, p. 260) that promoted observable behavioral patterns when the ability under consideration is challenged. Two implicit theories, the *entity theory* and *incremental theory*, exist in this model.

Incremental theories. The model described individuals espousing an incremental theory as those who view attributes as malleable, with the potential for the related ability to grow over time. Subscribers to this *growth mindset* often establish learning goals that focused on improvement of the ability in question (Dweck, 1986; Dweck & Leggett, 1988; Elliott & Dweck, 1988). When faced with challenging situations related to this ability, individuals with growth mindset characteristics display adaptive, mastery-oriented responses characterized by engagement with the challenges and resilience to failure (Elliott & Dweck, 1988).

Entity theories. Individuals assuming an entity theory tended to view attributes as fixed, uncontrollable entities, for which ability depended on factors over which the individual had no control. Those with these *fixed mindset* characteristics adopted performance-oriented goals to gain positive judgments for skills they had already mastered or to avoid negative judgments regarding talents they had yet to acquire (Dweck, 1986; Dweck & Leggett, 1988; Elliott & Dweck, 1988). When faced with challenges, these individuals displayed helpless responses characterized by lowered performance and avoidance of challenges (Elliott & Dweck, 1988).

Generalization of the model. Although the tenets of implicit theory advanced through research regarding characterization of an individual's own intelligence (Dweck & Leggett, 1988), the authors soon generalized the model to other attributes and domains. Additionally, they predicted that for any

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attribute of personal significance, "viewing it as a fixed trait will lead to a desire to document the adequacy of that trait, whereas viewing it as a malleable quality will foster a desire to develop that quality" (Dweck & Leggett, 1988, p. 266). Applications of this prediction culminated in the validation of a simple instrument used to assess an individual's implicit theories for a variety of attributes (Dweck et al., 1995). Additional evidence supported the notion that the model holds for generalization to other traits, such as the character and attributes of other people (Erdley, & Dweck, 1993), or mathematical ability (Lischka, Barlow, Willingham, Hartland, & Stephens, 2015; Willingham, 2016; Rattan, Good, & Dweck, 2012).

Self-Regulation Theory and Mediated Pathways of the Growth Mindset

Burnette, O'Boyle, VanEpps, Pollack, & Finkel (2013) conducted a large-scale meta-analysis examining the relationship between implicit theories and self-regulation theory. Their analysis revealed a strong alignment between three key processes of self-regulation theory and the constructs of mindset. Goal-setting processes encompassed the performance versus learning goal orientations; goal-operation processes associated helpless and mastery responses; and goal-monitoring processes aligned the dichotomy of expectations of success and negative emotional responses. More specifically, the results described the relative strength of association for these mediators of incremental theory on an individual's goal achievement across a wide range of abilities, disciplines, and context (Burnette et al., 2013).

These findings aligned with prior research showing that an incremental theory regarding an ability associated with an affinity for learning goals, mastery strategies, and expectations of success regarding that ability, and negatively associated with the pursuit of performance goals, helpless responses, and negative emotions regarding that ability (e.g., Blackwell, Trzesniewski, & Dweck, 2007; Dweck & Leggett, 1988; Dweck et al., 1995). However, this analysis also revealed significant findings regarding the positive strength of association between mastery-oriented responses and expectations of success with goal achievement and the negative relationship between negative emotions regarding an ability and goal achievement. The most significant findings resulted from considering the mediated paths between an incremental theory and goal achievement. For instance, examination of these pathways revealed that the incremental theory's avoidance of negative emotions is more strongly associated with goal achievement than its expectations of success (Burnette et al., 2013).

Methodology

The unique strength of a well-designed qualitative research study is in its ability to answer specific research questions while at the same time testing the boundaries of those questions to discover significant relationships as the research evolves (Yin, 2014). When guided by a well-grounded theoretical framework, this approach allows important and perhaps unanticipated findings to emerge. The remainder of this section describes the design and contexts of the study, which allowed the meaningful goal structures found in the participant's classroom to surface.

The Study's Design

Overview. An exploratory, holistic single-case design (Yin, 2014) supported consideration of how characteristics of the growth mindset influenced an elementary teacher's mathematical learning goals. The study focused on Gale Martin, a second-grade teacher, deemed significant as evidence from her engagement in an ongoing professional development project, Project Influence, indicated that she represented the critical case of a teacher displaying strong growth mindset characteristics and engaging in the processes of teaching change. Over the course of four months of the fall of 2015, the researcher interview and observed Ms. Martin as she engaged in activities including the planning, delivery, and assessment of classroom instruction, classroom teaching, assessment, a demonstration

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lesson, and other professional development activities.

Data collection. The data collected throughout the study focused on how Ms. Martin's mindset characteristics influenced her other experiences, beliefs, and practices. More specifically, the researcher collected data regarding Ms. Martin's mindset and beliefs regarding the teaching and learning of mathematics, her described and observed mathematics teaching practices, and her adaptation of a demonstration lesson for use in her classroom. Data sources for the study included historical records of her mindset and beliefs, semi-structured interviews, classroom observations, artifacts of the observed and enacted demonstration lessons, reflective journal entries, and artifacts from Ms. Martin's lessons. The researcher collected this data across four stages, including a participant selection process, baseline classroom observations, Ms. Martin's engagement in the demonstration lesson through her professional development project, and her adaptation and enactment of the demonstration lesson in her own classroom.

Data analysis. The researcher then organized this body of data in chronological fashion, corresponding approximately with the data collection stages described above, and completed a simple time series analysis (Yin, 2014). A holistic analysis of themes, "not for generalizing beyond the case, but for understanding the complexity of the case" (Creswell, 2012, p. 101), was performed for the first stage of data through open coding and reduction of these codes into themes consistent with the theoretical framework. The themes emerging from the stage one analysis guided interpretation and coding of the stage two data, after which the stage one codes were revisited for completion. The researcher repeated this process through all four stages of data in order to produce a comprehensive set of themes to guide a written case description.

Research Contexts

The participant. The researcher selected Ms. Gale Martin, a Caucasian female in her mid-thirties, as the critical case for the study. Rationales for this selection included historical survey data indicating persistent growth mindset characteristics, a positive record of changes in beliefs regarding the teaching and learning of mathematics, and observational records indicating a change in classroom teaching practices consistent with the mindset and belief data. Ms. Martin was an elementary mathematics teacher in her second year of teaching second grade and her fifteenth year of teaching elementary school who taught in a rural elementary school of approximately 330 students in a southeastern state. Prior to teaching second grade, Ms. Martin had taught one year of kindergarten, two years of third grade, and 10 years of fourth grade, providing her some perspective in the mathematical content requirements of several elementary grades. During the course of this study, Ms. Martin was also engaged in her third year of ongoing professional development for mathematics teaching.

The demonstration lesson. As part of the study, Ms. Martin observed a second-grade demonstration lesson conducted by the faculty of Project Influence with a lesson goal of "engaging students in thinking about subtraction with regrouping, while potentially representing the process symbolically" (Demonstration Lesson, October 28, 2015). The lesson involved students interacting with the following task in a problem-solving format.

> On Thursday, Tara was at home representing numbers with base-ten blocks. The value of her blocks was 304. When she wasn't looking, her little brother grabbed two longs and a flat. What is the value of Tara's remaining blocks? Use pictures, words, and/or symbols to describe how you solved the problem.

During the lesson, students worked in pairs to solve the problem and participated in extensive mathematical discussions across pairs, small groups, and the whole group under guidance of Project Influence's expert teacher. Approximately 30 kindergarten to second grade teachers observed the

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demonstration lesson, and demographically, the county, school, and class were extremely similar to those of Ms. Martin.

Results

The unique strength of a teacher's classroom practices exists in their ability to mediate the outcomes of students' learning (Hiebert & Grouws, 2007). During the course of this study, Ms. Martin's students consistently displayed a sense of ownership of their mathematical ideas, communicated their thinking about these ideas to one another and Ms. Martin, explored relationships across their curriculum, and achieved lesson goals with varying degrees of success. This section contains a portion of the results of this study related to different goal pursuits Ms. Martin utilized to facilitate these outcomes.

Overarching Goals

Ms. Martin professed to believe that a focus on student thinking and ownership of their mathematical ideas was one of the most essential elements of her classroom environment, and one that allowed students to learn mathematics effectively. She described her thoughts on the matter, referring to how a student from the previous year's class was ultimately able to be successful in learning mathematics in her class.

> [The student] was able to share her ideas, because she heard somebody else share their ideas. So just building that community of "I am my own person in here, and that's okay. I can show you how I know something. It's just not Ms. Martin's way. I can have my way. So and so can have their way. Yeah, Ms. Martin shows us things, but if I don't see it the way Ms. Martin shows us, then I can still use my way." (Selection Interview, September 9, 2015)

Ms. Martin credited this student's willingness to value and share her own ideas to the fact that she first heard another student share their thinking and the community norms of her classroom.

This relationship between students' willingness to communicate their ideas and their increasing level of understanding of mathematics appeared to be one of the motivating beliefs behind much of Ms. Martin's thoughts regarding the teaching and learning mathematics. She spoke directly to the notion that understanding mathematics and communicating about mathematical ideas were inescapably linked.

> That's why I always tell them, "If you can explain, you can go home and teach mom or teach brother or come to me and show me and explain it in your own words, I think that's how you understand it." That's why I like for them to do a lot of talking, obviously, because I want them to share their ideas with each other and understand it, especially in kid terms. Because there are times when I have said something and a kid will say it differently, and I feel like we've said it the same way. If a kid says it, [other] kids are like, "Oh yeah, that makes total sense." (Selection Interview, September 9, 2015)

It appeared that Ms. Martin believed that this focus on student thinking and communication was essential to student learning and could help to reconcile differences between adult's and children's ways of thinking about and describing mathematics.

Lesson Goals Within a Learning Trajectory

Ms. Martin also spoke explicitly about her learning goals for her implementation of the demonstration lesson and how she believed these goals related to her students' past and future study of mathematics. In describing these learning goals, she referred directly to her students' current understanding of strategies for operating with two-digit numbers, a topic which directly preceded her implementation of the demonstration lesson.

> I would think that my students need to be able to represent the two-digit number in various ways to subtract. . . . I feel like the goals [for the demonstration lesson] are kind of the same, we're just kind of changing, we're moving from two-digit numbers to three-digit numbers. I feel like our goal is the same, can they look at these numbers and understand that I need to maybe represent the number in a different way in order for me to subtract. I guess that really works for this whole unit. (Planning Interview, November 10, 2015)

In this quotation, Ms. Martin established the specific mathematical goals for her enactment of the demonstration lesson as extending students' ability to represent numbers in a variety of ways into using these representations with purpose in the form of regrouping for subtraction. This was a substantial change from the goal of the lesson she originally observed.

Additionally, she described how this goal connected to her students' recent areas of study and her future goals for the semester.

> To me, it's definitely understanding that not only can we represent numbers in different ways, but we can do that when we are subtracting as well. I see where we were several weeks ago where we were really focused on the place value and representing those numbers in different ways. I really hope that they can see the tie-in with that to the subtraction. I really think if they make that big connection, then once we get to the algorithm of regrouping this will be no issue. (Planning Interview, November 10, 2015)

With these words Ms. Martin confirmed the goals described in this section and explained the connections among these goals, her emphasis early in the semester on representations of number and place value, and the future objective of having her students symbolically represent operations and utilize algorithms.

Reinforcing Goals Within a Lesson

The previous section presented explicit examples of Ms. Martin's lesson goals and her willingness to change the goals of a lesson she had observed to suit her lesson and trajectory needs. In addition to these planned changes, Ms. Martin also displayed the ability to adjust her classroom instruction to reinforce the goals she had established for her students. In closing her implementation of the demonstration lesson, Ms. Martin placed a final question on the board, which she read aloud with her class.

> All right, here is your last question. Let's read it together. Guys, listen, we've got five minutes, and this is our last thing. Ready? [Read aloud and recorded on the whiteboard] How could you represent 407 so that 3 longs could be taken away? Write a sentence explaining how you know. . . . You have to write a sentence, but I don't mind if you use a drawing to show it as well. (Classroom Observation, November 13, 2015).

As the demonstration lesson Ms. Martin observed ended with students reflecting on what they had learned from solving the original task, this extension question provided a substantially different close to the lesson that was more aligned with Ms. Martin's lesson goals.

In an interview after this lesson, Ms. Martin's overall assessment of the lesson was that it had been successful and that the majority of students had developed further understanding of the need to represent numbers in different ways in order to support operations such as subtraction.

> I'd say three-fourths of the classroom. . . were [able to address the exit ticket]. I could pick out maybe five or six that were not. I think, for the most part, they were able to. . . . They understood that you had to represent a number a different way in order for them to subtract, which leads to

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the whole idea of the algorithm and regrouping. I feel like the trajectory is on target and moving towards the overall goal. (Reflection Interview, December 21, 2015)

This description further illustrates Ms. Martin's commitment to her lesson goal and her ability to adapt her instruction to continue to reinforce her student's progress towards this goal based on ongoing classroom assessment.

Discussion and Conclusion

Utilizing the self-regulation constructs of goal setting, goal operating, and goal monitoring to observe Ms. Martin's operationalization of her mindset in the classroom proved extremely effective. Perhaps one of the most important results of this framework was the revelation of three distinct layers of goals under which Ms. Martin operated throughout the semester. Although hierarchical language describes these goal structures in the following paragraph, this language relates only to the relationships among the goals themselves and not the value Ms. Martin ascribed to these goals as she spoken of them with equal importance (see Figure 1).

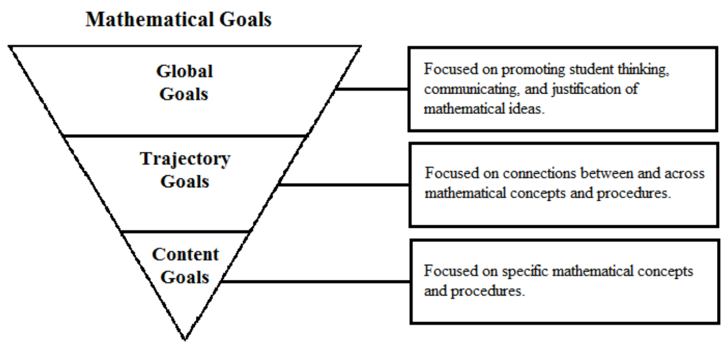

Figure 1. Ms. Martin's Layered Mathematical Learning Goals

At the highest layer, Ms. Martin established *global goals* that spanned the length of the school year. These goals tended to focus on widely applicable student mathematical practices such as thinking independently about mathematical ideas, communicating these ideas to others, justifying this thinking, and critiquing the reasoning of others. In an intermediate tier, Ms. Martin described *trajectory goals* that involved assessing and moving students along an evolving mathematical trajectory by helping them connect various mathematical concepts and representations throughout the semester. She spoke of these goals at the level of sequences of lessons and classroom activities, units of instruction, and conceptually related mathematical topics. These goals appeared to be more fluid than the global goals and evolved as the semester progressed based on her students' current understanding. At the lowest level were Ms. Martin's *content goals*, which aligned roughly with her learning goals within a lesson or brief sequence of lessons and could be adapted as needed within an individual lesson or student encounter.

These layered goals also offered a variety of opportunities to observe Ms. Martin engaging in goal operating and goal monitoring practices on a daily basis. In general, her goal operating practices aligned with utilizing specific instructional strategies to advance individual students, small groups, or the whole class towards her goals for them at different layers. Additionally, she focused heavily on her students' use of mastery strategies throughout her interactions with them. Ms. Martin's general goal-monitoring strategies focused on making students' mathematical thinking visible to her and the students' peers. She then used this thinking as evidence for assessment as she compared students' progress to her learning goals, for facilitation of group discussions, or for discussion and critique from the students' peers.

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The most directly useful aspect of Ms. Martin's case for the classroom mathematics teacher is likely the fashion in which she operationalized her mindset through her goal-related practices. Although all classroom teachers may not operate under the tenets of a growth mindset on a daily basis, many of these goal-related practices can be easily adapted to any classroom. Setting goals that support student interactions about mathematics and that focus on mathematical concepts and strategies that transfer are broadly useful. Operating toward these goals by interacting with students via advancing, redirecting, and facilitating strategies appears to require little adaptation to the questioning approaches many teachers already use. Goal-monitoring practices such as focusing on student thinking and evaluating student progress against a mathematical learning trajectory align well with globally accepted assessment practices. These findings, which are useful to a variety of elementary mathematics teachers and mathematics teacher educators, represent the intersection the study's theoretical framework, research design, and observations of classroom practice, and would not be possible without the convergence of these facets.

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