

DIMENSIONS OF SUCCESSFUL ELEMENTARY MATHEMATICS TEACHERS' EFFECTIVENESS DURING PROFESSIONAL DEVELOPMENT

Susan Swars Auslander
Georgia State University
sauslander@gsu.edu

Kayla Myers
Georgia State University
kmyers@gsu.edu

Gary Bingham
Georgia State University
gbingham@gsu.edu

Carla Tanguay
Georgia State University
ctanguay@gsu.edu

Carrie Tahlor
Gwinnett County Public Schools
carrietahlor@gmail.com

This 5-year mathematics professional development project involves 27 elementary teachers being prepared and supported as Elementary Mathematics Specialists (EMSs) through completion of a university's K-5 Mathematics and Teacher Supporting & Coaching Endorsement programs, as well as participation in Professional Learning Communities and individual mentoring. Across the project, data are gathered to examine changes in mathematical content knowledge, instructional and coaching practices, beliefs, and teacher leader skills of the EMSs. Described here are Year 1 data from the participants, who have been identified as successful, experienced teachers, focusing on specific aspects of teacher effectiveness. The findings illuminate their classroom instructional practices, including those that are learner-centered and equitable, along with their early histories as learners of mathematics.

Keywords: Instructional Activities and Practices; Teacher Knowledge; Teacher Beliefs; Equity, Inclusion, and Diversity

Purpose of the Study

This study's context is a 5-year mathematics professional development project involving 27 elementary teachers who are prepared and supported as Elementary Mathematics Specialists (EMSs). They complete a university's K-5 Mathematics and Teacher Supporting & Coaching Endorsement programs and participate in Professional Learning Communities and individual mentoring. Across the 5 years, data are collected to examine how the intentional and continuous project components affect the mathematical content knowledge, instructional and coaching practices, beliefs, and teacher leader skills of the EMSs. Described here are specific data collected in Year 1, with these questions guiding the inquiry:

- To what extent do experienced, successful elementary teachers implement instructional practices that foster standards-based learning environments in mathematics?
- What are the relationships between these instructional practices and their mathematics content knowledge and beliefs?
- What are their early histories with mathematics as learners?
- What are their views on equitable mathematics instruction and their own enactment of equitable teaching practices in mathematics?

Perspectives

Teachers should implement effective and equitable instructional practices in mathematics (NCTM, 2014) that support *standards-based learning environments* (SBLEs). They should use instructional tasks with high levels of cognitive demand that support students' reasoning and problem solving, and facilitate productive discussions that elicit student ideas, attend and

respond to student thinking as it unfolds during a lesson, and use that thinking to guide instructional decisions. These practices place children's thinking and learning at the center of classroom activity and instructional decision-making, leaning heavily on developed teacher identity and agency, and provide fruitful opportunities for students to develop positive identities as mathematics doers and learners (Aguirre, Mayfield-Ingram, & Martin, 2013). Teachers must navigate many constraints when it comes to implementation of these learner-centered practices, including those that are contextual and their own divergent past experiences as a learner of mathematics (Bartell, Cho, Drake, Petchauer, & Richmond, 2019).

Teachers' content knowledge and beliefs are also related to their support for children-centered learning environments. Teachers require deep and broad knowledge of mathematics to be effective in their teaching (Hill, 2010), including *specialized content knowledge* characterized as "mathematical knowledge needed to perform the recurrent tasks of teaching mathematics to students" (Ball, Hoover Thames, & Phelps, 2008, p. 399). This depth of understanding equips teachers to navigate children's mathematical thinking during instruction, including misconceptions, and the continuous decision-making processes required for responsiveness to this thinking. Also, teacher beliefs shape classroom instruction. Two important teacher beliefs constructs include pedagogical beliefs (i.e., beliefs about teaching and learning) and teaching efficacy beliefs (i.e., beliefs about capabilities to teach effectively and influence student learning).

Methodology

The design of this study includes a descriptive, holistic singular-case approach (Yin, 2014). The case is experienced elementary teachers who have been identified as effective teachers of mathematics and teacher leaders; all were employed in one urban-situated school district and teaching in high-need schools with diverse student populations. Multiple sources of data, both quantitative and qualitative in nature, were collected to form the descriptive findings.

Participants were 27 elementary teachers in a large, urban school district in the southeastern USA. Their schools (n=22) served 91% students of color and 69% students eligible for the free/reduced lunch program. The participants identified as 24 females and 3 males and 70% teachers of color. They are a highly educated group, with 100% having a master's degree and 33% holding an educational specialist degree; further, they are experienced teachers, on average having 10.5 years of teaching experience. Teaching positions vary widely and include: three kindergarten, one first grade, two second grade, five third grade, one fourth grade, seven fifth grade, four STEM/Math Specials, one English to Speakers of Other Languages, one Special Education, one Early Intervention Program, one Accelerated Content, and two Dual Language Immersion.

The teachers had recently been selected to participate in a federally-funded, 5-year professional development project focused on developing EMSs. EMSs are generally considered to be teachers, teacher leaders, or coaches with the expertise to support effective elementary mathematics instruction and student learning (Association of Mathematics Teacher Educators, 2013). The project's recruitment efforts had concentrated on the highest need elementary schools in the district, as determined by free/reduced lunch program rates. The teachers were chosen based on criteria that identified them as successful, experienced teachers of mathematics and teacher leaders. Their application materials and interviews were reviewed for meritorious professional achievement, academic accomplishment, knowledge of mathematics, commitment to teaching mathematics, and evidence of/desire for teacher leadership. These criteria, plus

consideration of race/ethnicity, gender, grade level, and school site with the aim of assuring participation of underrepresented groups and diverse school sites and grade levels, informed the selection of the 27 teachers in the project.

Quantitative data were collected from all participants via a classroom teaching practices observation protocol (i.e., Standards-Based Learning Environment Observation Protocol [SBLEOP], Tarr et al., 2008), *specialized content knowledge* assessment (i.e., Learning Mathematics for Teaching [LMT], Hill, Schilling, & Ball, 2004), background and practices survey, and two belief surveys (i.e., Mathematics Beliefs Instrument [MBI], Peterson, Fennema, Carpenter, & Loef, 1989, as modified by the CGI Project; Mathematics Teaching Efficacy Beliefs Instrument [MTEBI], Enochs, Smith, & Huinker, 2000). Qualitative data were gathered through individual interviews of all 27 participants, as well as three focus group interviews with nine participants in each group. The interview protocol includes questions related to their histories with mathematics and their mathematics instructional practices, particularly equitable mathematics instruction. Data were collected using virtual means at the start of the professional development project. This collection occurred during the COVID-19 health pandemic, and all teachers were providing instruction via different hybrid models with a mix of face-to-face and virtual delivery. Both descriptive and inferential statistics were used for analysis of the quantitative data. Relationships between scores from the different instruments were analyzed using Pearson Correlation. Analysis of the qualitative data involved constant comparative methods (Lincoln & Guba, 1985).

Results

Table 1 displays data from the SBLEOP used to assess the extent to which participants enacted learner-centered SBLEs during their classroom observations. The SBLEOP evaluates specific classroom events on a scale of 1-3, with higher scores indicating more alignment with a SBLE. For example, across the SBLEOP rubric criteria a score of 2 indicates partial evidence of a classroom event (e.g., “students had *some* opportunity”, “the teacher *sometimes* encouraged students to orally explain how they arrived at an answer”, and “different perspectives or strategies were *occasionally* elicited from students”). Shown are the mean scores on eight classroom events, or dimensions of facilitating a SBLE, and the overall mean score across classroom events. Lesson structures were somewhat consistent across all observations per school district guidelines, with teachers beginning with an activation activity, followed by a whole group mini-lesson and gradual release model, and ending with small group instruction based on ability grouping.

With an overall mean score of 1.5, the participants’ implementation of SBLEs was less than partially evident. Teachers were rated the highest on the *Mathematical Connections* indicator, suggesting that they were observed making some connections among mathematical topics during the lesson, though those connections were not typically discussed in detail. *Conceptual Understanding* (i.e., how the lesson fostered the development of conceptual understanding) was the next highest rated indicator. Both of these mean scores, though comparatively higher than other events, still fall below a 2. Teachers scored the lowest on the indicators *Making Conjectures* (i.e., observed opportunities for students to make conjectures about mathematical ideas) and *Reflecting on Reasonableness*, suggesting that teachers were rarely asking students whether their answers were reasonable and when students gave incorrect responses, another student was asked to provide a correct answer.

Table 1. *Means on the SBLEOP*

Classroom Event	Mean Score (1-3)
Making Conjectures	1.3
Fostering Conceptual Understanding	1.7
Making Mathematical Connections	1.9
Connections with Daily Lives	1.6
Students Explaining Strategies	1.6
Valuing Multiple Perspectives	1.4
Using Student Statements	1.4
Students Reflecting on Reasonableness	1.2
All Classroom Events	1.5

The analysis of the quantitative data reveals several other key findings. Notably, the extent of teachers' implementation of SBLEs was related to the depth of their content knowledge and strength of their pedagogical beliefs, as the correlational analysis shows a significant positive relationship between scores on the SBLEOP and both the LMT and MBI. When it comes to content knowledge (LMT), the participants' understandings of number and operations were the strongest compared to the two other content areas measured (i.e., algebra and geometry). All three of the subscales evidence considerable variability in scores. Further, when considering beliefs about the teaching and learning of mathematics (MBI), they were largely uncertain about cognitively-oriented pedagogy. And, while they were confident in their capabilities to teach mathematics effectively (MTEBI), they were less confident that this effective teaching would influence student learning in positive ways.

The analysis of the individual and focus group interview data provides insights into the participants' histories with mathematics and how their early experiences as a learner shape their instructional practices. They also described views on equitable mathematics instruction and specific practices they use with their students to support access and equity. Participants expressed a variety of firsthand experiences involving marginalization as mathematics learners and doers, sometimes as early as kindergarten, and how those early occurrences shaped their mathematical teacher identity and trajectory. Participants recalled experiencing inequities, though they recognized not having that language or awareness at the time, and how finding that language and awareness in adulthood as teachers has impacted their practices and relationships with their students. Participants are committed to providing equitable instruction, and the interview data show a range of enactment of those equitable practices with a consistent focus on learning new and better ways to teach mathematics equitably.

Discussion

The quantitative findings give us a distinct picture of these participants, who have been identified as successful, experienced teachers, at the very beginning of a lengthy, rigorous professional development project. The details and nuances of this picture are provided by the interview data, telling a story of themselves historically as mathematics doers and learners, and how those impact their practices, especially in addressing issues of equity and agency. The project's continual data collection and analyses across 5 years provide a unique and exciting opportunity to follow the trajectory of the participants as teacher leaders in high-need schools serving student populations rich in diversity.

Acknowledgement

Support for this work was provided by the National Science Foundation's Robert Noyce Teacher Scholarship Program under Award No. 1950064. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

- Aguirre, J. M., Mayfield-Ingram, K., & Martin, D. B. (2013). *The Impact of Identity in K-8 Mathematics: Rethinking Equity-based Practices*. Reston, VA: National Council of Teachers of Mathematics.
- Association of Mathematics Teacher Educators. (2013). *Standards for elementary mathematics specialists: A reference for teacher credentialing and degree programs*. San Diego, CA: Author.
- Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, 59, 389-407.
- Bartell, T., Cho, C., Drake, C., Petchauer, E. & Richmond, G. (2019). Teacher agency and resilience in the age of neoliberalism. *Journal of Teacher Education*, 70, 302-305.
- Enochs, L., Smith, P., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics*, 100, 194–202.
- Hill, H. C. (2010). The nature and predictors of elementary teachers' mathematical knowledge for teaching. *Journal for Research in Mathematics Education*, 41, 513-545.
- Hill, H. C., Schilling, S. G., & Ball, D. L. (2004). *Developing measures of teachers' content knowledge for teaching*. Ann Arbor, MI: University of Michigan.
- Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. New York, NY: Sage.
- National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematics success for all*. Reston, VA: Author.
- National Council of Teachers of Mathematics. (2020). *Catalyzing change in early childhood and elementary mathematics: Initializing critical conversations*. Reston, VA: Author.
- Peterson, P. L., Fennema, E., Carpenter, T. P., & Loef, M. (1989). Teachers' pedagogical content beliefs in mathematics. *Cognition and Instruction*, 6, 1-40.
- Tarr, J. E., Reys, R. E., Reys, B. J., Chavez, O., Shih, J., & Osterlind, S. J. (2008). The impact of middle-grades mathematics curricula and the classroom learning environment on student achievement. *Journal for Research in Mathematics Education*, 39, 247-280.
- Yin, R. K. (2014). *Case study research: Design and methods*, 5th edition. Los Angeles, CA: Sage.