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Call for Manuscripts

The editors of the ***NCSM Journal of Mathematics Education Leadership (JMEL)*** are interested in manuscripts!

The editors are particularly interested in manuscripts that bridge research to practice in mathematics education leadership. Manuscripts should be relevant to our members' roles as leaders in mathematics education, and implications of the manuscript for leaders in mathematics education should be significant. At least one author of the manuscript must be a current member of NCSM. Categories for submissions include:

- **Case studies and lessons learned** from mathematics education leadership in schools, districts, states, regions, or provinces
- **Research reports** with implications for mathematics education leaders
- **Professional development** efforts including how these efforts are situated in the larger context of professional development and implications for leadership practice
- Other categories that support the NCSM vision will also be considered.

Submission Procedures

Each manuscript will be reviewed by two volunteer reviewers and a member of the editorial panel. Each manuscript will be reviewed by two volunteer Each manuscript will be reviewed by two volunteer Each manuscript will be reviewed by two volunteer Each manuscript will be reviewed by two volunteer Each manuscript will be reviewed by two volunteer reviewers and a member of the editorial panel. Manuscripts should be emailed to the Journal Editors, currently Drs. Erin Lehmann and Paula Jakopovic, at **ncsmJMEL@mathedleadership.org**.

Submissions should follow the most current edition of APA style and include:

1. A Word file (.docx) with author information (name, title, institution, address, phone, email) and an abstract (maximum of 120 words) followed by the body of the manuscript (maximum of 12,000 words)
2. A blinded Word file (.docx) as above but with author information and all references to authors removed.

***Note:** Information for manuscript reviewers can be found at the back of this publication.

NCSM

Inquiries about the ***NCSM Journal of Mathematics Education Leadership*** may be sent to:
Paula Jakopovic at ncsmJMEL@mathedleadership.org

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NCSM–Leadership in Mathematics Education
PO Box 3406
Englewood, CO 80155
Email: office@ncsmonline.org • ncsm@mathforum.org

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NCSM Vision

NCSM is the premiere mathematics education leadership organization. Our bold leadership in the mathematics education community develops vision, ensures support, and guarantees that all students engage in equitable, high quality mathematical experiences that lead to powerful, flexible uses of mathematical understanding to affect their lives and to improve the world.

Purpose Statement

The purpose of the NCSM Journal of Mathematics Education Leadership is to advance the mission and vision of NCSM by:

- *Strengthening mathematics education leadership through the dissemination of knowledge related to research, issues, trends, programs, policy, and practice in mathematics education*
- *Fostering inquiry into key challenges of mathematics education leadership*
- *Raising awareness about key challenges of mathematics education leadership in order to influence research, programs, policy, and practice.*

Comments from the Editors

Erin Lehmann, *University of South Dakota*
Paula Jakopovic, *University of Nebraska at Omaha*

"Powerful leaders are those who have the courage to take the step and embark on the journey" (Blankstein et al., 2016, p. 1).

As we publish this issue it seems to be an appropriate time to reflect on the "new normal." In some ways, schools have picked up where they left off, with face-to-face instruction resuming and teachers and leaders refocusing their energies on promoting high quality, equitable mathematics instruction. There are also reminders that, in some ways, the face of education has been indelibly changed by the pandemic. Teachers and leaders everywhere are grappling with increased socio-emotional needs of students as well as managing their own mental well-being. These issues provide an invaluable reminder of the importance of promoting self-care, empathy, and kindness in our roles as mathematics leaders. This focus helps us as we strive to support our teachers and students as they both adapt and rise to the challenges ahead. It is through our mathematics educational leadership networks and community that we can continue to uplift and support one another in fostering positive change.

In the current issue of *JMEL*, the authors offer approaches for both instructional leaders to support mathematics teachers, as well as for districts to support the development of administrators and mathematics instructional leaders. "Humanizing mathematics" can help to ensure that students see themselves as mathematically capable and develop deep mathematical understanding (NCSM, 2021). When teachers begin by identifying and leveraging the strengths of their students, they can foster asset-based learning approaches in the classroom (Kobett & Karp, 2020). Similarly, when mathematics leaders can help teachers utilize a strengths-based approach to examining work, it can not only support students' learning, but also that of classroom teachers. This is the focus of the first article, titled, "Beyond Right or Wrong: Supporting Teachers in Strengths-Based Approaches to Examining Student Work." In this study, Zimmerman and Wilson facilitated structured interviews with six experienced mathematics educators focused around examining student work from a strengths-based perspective. They identify six questions that participants attended to, examining first the mathematics, then student thinking, and finally the subsequent instructional decisions they would take as a classroom teacher. Additionally, they offer examples of how mathematics leaders might utilize these questions to guide professional development to help teachers increase their mathematical content knowledge (Hill et al., 2004).

The second article, "Influencing Elementary Principals' Leadership Self-efficacy for Mathematics: A Professional Development Case Study," Gomez Johnson and Jakopovic present findings from a study centered around principal professional development. Often, principals feel undertrained in content specific instructional strategies, which can negatively impact their confidence leading professional development and change efforts in their buildings. Utilizing Bandura's four sources of self-efficacy as a framework, the authors examine the impact of a districtwide, year-long professional development model on principals' self-efficacy as mathematics instructional leaders. The authors identify three key findings as to aspects of the professional development model that positively impacted principals' self-efficacy, and present implications for other mathematics instructional leaders.

In both articles, the authors highlight the importance of situating students, teachers, and leaders as mathematically competent. Both articles identify the need to engage in open minded dialogue to further mathematical and pedagogical understanding, and to reflect upon the learning process and how it can positively impact future practice. As mathematics leaders, how do we frame our interactions with teachers and students from an assets-based perspective? How do we support the mathematics instructional capacity of both teachers and other leaders through our work? We hope that these articles help to inspire you as you engage in the essential work of supporting high quality mathematics instruction. ✪

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Beyond Right or Wrong: Supporting Teachers in Strengths-Based Approaches to Examining Student Work

Stacey C. Zimmerman, *Western Carolina University*
P. Holt Wilson, *University of North Carolina Greensboro*

Abstract

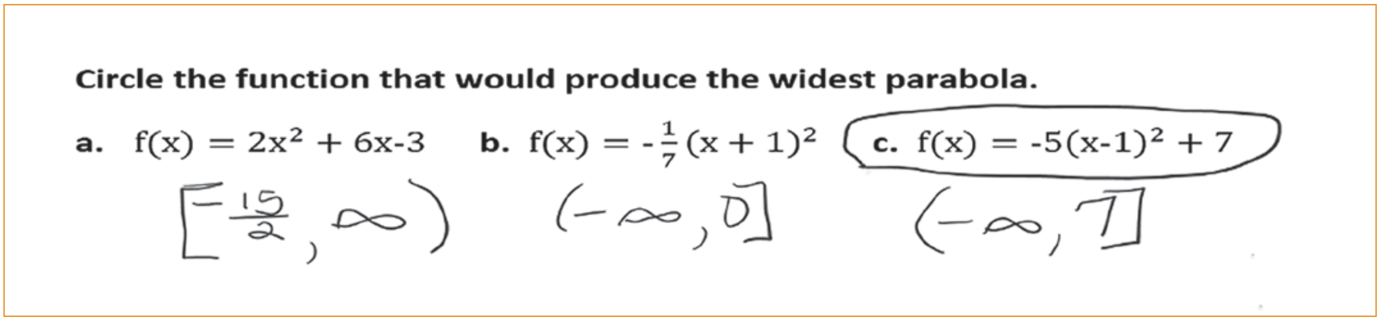
Recognizing the strengths of students through their written work takes time, practice, and intentionality. In this article, we detail a set of questions that can be used to purposefully engage with student written work in a strengths-based way. Derived from the exploration of experienced mathematics educators' mathematical knowledge for teaching quadratic functions, the questions place value on student thinking while providing the opportunity for teachers to enhance and extend their own mathematical knowledge for teaching. Mathematics leaders can use these questions to facilitate meaningful learning experiences for teachers, professional learning communities, and large group professional development activities.

When you look at the student work presented in Figure 1, what do you see?

Living in a world of high-stakes testing, from end-of-course assessments to college admissions tests, it is not surprising that teachers often focus on correctness when examining student work. Even with numerous years of teaching experience, sometimes a quick glance at the work in Figure 1 may simply reveal an incorrect response. However, what if we were to look a little closer and purposefully seek to understand the mathematical ideas demonstrated in the student's work, what would we see?

Purposefully seeking the mathematical understandings embedded in students' written work is key to taking a strengths-based approach to examining written work. A strengths-based perspective on teaching and learning emphasizes the "positive aspects of student effort and

FIGURE 1. *Student Work Sample 1*



achievement" (Lopez & Louis, 2009, p. 1). When examining student work from this perspective, the student is valued by recognizing what the student knows and has demonstrated while not ignoring what has not been recorded. It requires moving beyond simply identifying what is right or wrong. A strengths-based approach allows teachers to recognize where support is needed and determine ways to build upon the student's understandings (McCarthy et al., 2020). While this may require a degree of intentionality, we agree with Philipp (2008) that "we best help a learner by starting where he or she is and building upon his or her current understanding" (p. 23). Hence, paying attention to and building upon students' ideas can lead to more effective instruction and increased student learning (Bishop et al., 2014; Fennema et al., 1996; Kobett & Karp, 2020).

Focusing on the mathematical ideas present in student work not only benefits the student, but it has the potential to benefit the teacher (Wilson et al., 2013). As teachers engage with their students' written work, they may enhance and extend their own mathematical knowledge for teaching. Mathematical knowledge for teaching, or MKT, is the phrase that is commonly referenced to describe the knowledge used and needed by those providing mathematics instruction (e.g., Ball et al., 2008; Hill et al., 2008). It describes the knowledge that teachers rely upon to convey mathematical concepts to students in ways that are meaningful and useful. Over the last few decades, researchers have sought to identify, describe, categorize, and connect MKT to student learning. Through this work, researchers have linked increases in teachers' MKT to improvements in the quality of their instruction (Hill et al., 2008) and their students' achievement (Hill et al., 2005). With the importance of MKT recognized through research, it is understandable that "all teachers need continuing opportunities to deepen and strengthen their mathematical knowledge for teaching" (Conference Board of the Mathematical Sciences, 2012, p. 68). Utilizing a strengths-based approach to engage with student work can provide an opportunity for teachers to deepen and strengthen their MKT.

Student work can be a powerful mechanism for facilitating mathematics teacher learning (Kazemi & Franke, 2004). However, moving from an evaluative, diagnostic, or formulative approach to one that highlights students' strengths may require some guidance, particularly in an era of high stakes testing and accountability. Through our research with six accomplished mathematics educators committed to the idea that all student written work is valuable and worthy of careful review (Zimmerman, 2020), we surmised a set of questions that focus on a student's strengths and can guide the examination of student work. In the following sections, we first provide a brief overview of the study and then detail six questions that math leaders can use with teachers to focus on the assets and strengths that students bring to instruction. We then use the context of a professional learning community of teachers to illustrate the ways mathematics leaders might use the questions to support teachers in taking a strengths-based approach to mathematics teaching and learning.

Learning from Experts

Though MKT for elementary and middle grades teachers is an established area of research, studies of secondary mathematics teachers' MKT are less common (Howell, 2012; Howell et. al., 2016). To that end, we designed a study to explore and document the MKT for quadratic functions that accomplished mathematics educators use when examining student work (Zimmerman, 2020). Six mathematics educators (two high school teachers, two university teacher educators, and two university mathematicians) with considerable experience and recognized expertise were purposefully selected and invited to participate in the study. Combined, the participants had over 170 years of teaching experience, served as teacher leaders for their state and local school districts, amassed numerous awards and recognition at both the local and state level, regularly participated in and led multi-year professional development activities focused on teacher learning, and actively engaged in mathematics education research. Through a series of semi-structured interviews, the participants engaged with student work that represented various quadratic function concepts. In these individual interviews, each participant was presented with pieces of student work and simply asked to "think-aloud". By thinking aloud, we were able to capture each participant's initial thoughts and reactions to the student samples. Through phases of thematic analysis and iterative pattern coding, we identified six themes that were representative of the participants' demonstrated MKT.

Results from the study characterized the participants' MKT for quadratic functions as a dynamic relationship between their knowledge of mathematics and the ways they used this knowledge to make connections to related mathematical concepts, interpret and conjecture about student understanding, and consider how they might support students in continuing to learn. Further, as the participants used their mathematical knowledge to consider student learning and their teaching, they deepened their own understandings of quadratic functions.

Characterizing the participants' MKT was possible because they engaged with student work in ways that focused on the mathematical ideas demonstrated by the student. While the participants were aware of the study's purpose to explore MKT for quadratic functions, their engagement with student work focused on what students knew as opposed to what they did not know, and the participants used these strengths as a resource from which they might build future instruction. The participants moved beyond attending to correct or incorrect solutions to see information conveyed by students through writing as useful and powerful. For example, consider an excerpt from "Kurin's" interview discussion of the student work depicted in Figure 1:

> I think the width of a parabola is not that well defined without something to reference to. So, I would want to look at all 3 graphs together. Knowing about the different kinds of shifts and changes to functions based upon where you put coefficients, I would say it is the middle one, $f(x)=-1/7(x+1)^2$. So, I think maybe for this question I might say "circle the function that would produce the widest parabola at the same height" or maybe "at the same y-value." Will a student understand what I mean when I add that to it? Now, this student is not connecting what you want the student to connect to in terms of the widest parabola. When they report back the range, you know they are looking vertical instead of looking horizontal. I would ask the student to graph all three functions together and then point out to me in their picture, where they are looking to determine the widest parabola. Then I would just reorient them to the horizontal width instead of vertical. I think this is a place where a tool like DESMOS really comes in handy, where you can graph several of that same function family and change a single coefficient.

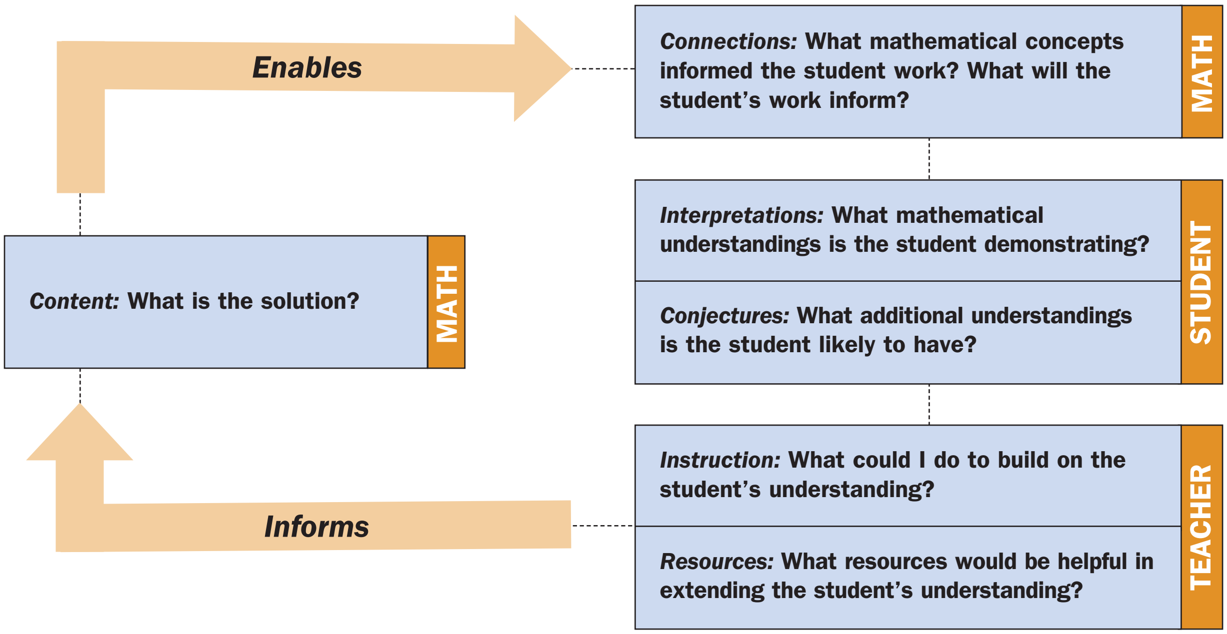
Intertwined with the solution to the problem, Kurin expressed concern regarding the problem itself. Kurin discussed possibly changing the wording of the problem and identified the range of a quadratic function as the mathematical idea represented in the student's work. Kurin conjectured that the student had a vertical perception of the functions graph and therefore used its range to identify the widest parabola. Kurin described how graphing might orient the student to width as a horizontal feature of parabolas. Rather than evaluating the response as incorrect or focusing exclusively on what the student did not know, Kurin identified the student's graphical understanding of the range of quadratic functions as a strength that they could use to reorient the student to determine the widest parabola.

Throughout the study, participants' discussions centered on student work and described how the understandings the students had recorded could be used in subsequent instruction. Their responses were not evaluative in nature but rather described a path for instruction that was based on what the student had demonstrated that they knew. The participants' strengths-based approach led them to identify the mathematical ideas embedded in the student work, recognize where support may be needed, and devise a plan to extend student understanding.

Similar to Kurin, other participants also tended to first discuss the mathematics of the problem before they engaged with the student's work. Then, their final remark focused on their role as a teacher and how they could support the student in continuing to learn. This pattern of focusing on the mathematics, then the student, and finally the teacher, was evident across all participants' interviews. They typically discussed the mathematics of the problem before deeply engaging with the student work. Once the student work was carefully analyzed, participants then turned their focus to what they might do to build from the student's understanding to further student learning.

Through our efforts to understand, describe, and categorize the participants' knowledge for teaching quadratics, we came to see the participants' responses as answers to six questions that embodied their strengths-based orientation to teaching and learning. It should be noted that the participants were not asked these six questions, rather it was their strengths-based responses that led us to the formulation of the questions. Summarized in Figure 2 (see next page), these questions related to the participants' MKT and the uses that we documented in our study. Each question had a focus on the mathematics of the task (math), the student's understanding (student), and the instructional steps that participants might take to build from the student's understanding (teacher). In what follows, we describe each question and offer examples of how they describe the work of our participants when examining student work. We then discuss how

FIGURE 2.
Participants' MKT Uses, Questions, and Question Focus



mathematics leaders might use these questions to support teachers in approaching student work from a strengths-based perspective.

Six Strengths-Based Questions for Examining Student Work

In this section, we elaborate on each question by discussing the link between the question and the different ways that expert mathematics educators from our study understood mathematics for teaching.

The Content Question: What is the Solution?

This question focuses on the mathematics content covered in the problem and is aligned with one's content knowledge. Although answering the *content question* does not require reviewing the student written work, an understanding of the mathematical concepts involved in a solution is foundational to understanding students' mathematical thinking. Such knowledge assists teachers in making sense of the student work, while establishing the level of understanding that is demonstrated by the student.

In our study, participants used content knowledge foundational to quadratic functions to generate solutions to the problems prior to interpreting student work. This is seen in Kurin's study of Figure 1 when they stated, "Knowing about the different kinds of shifts and changes to functions based upon where you put coefficients, I would say it is the middle one..." As evident here, an understanding of the solution to the given mathematics problem and multiple ways to reach it is critical to discerning the mathematical understandings present in student work.

The Connections Question: What Mathematical Concepts Informed the Student Work? What Will the Student's Work Inform?

The *connections question* also focuses on the mathematics and requires content knowledge. However, this form of knowledge situates the problem within a broader mathematical landscape by connecting prior, current, and future ideas. This question focuses attention to the concepts needed to devise a solution to the problem and those that will be built upon the concepts developed through completing the mathematics problem. For instance, knowing how to complete the square informs how to write a quadratic function in vertex form, enabling the identification of the vertex and coefficients that are relevant to the function's average rate of change; understanding the relationship between function coefficients and the average rate of change informs creating mathematical models of quantitative relationships and the exploration of derivatives.

During their interviews, participants discussed the mathematical concepts that might have informed a student's work and how those concepts could inform their learning of new mathematics. For example, linking concepts that could inform the student's work in Figure 1, "Jamie" remarked, "if they understand that the slope of a line – if it's greater than one, then it's steeper and if it's less than one, then it's less steep, they can easily transition that into their understanding of parabolas." By considering mathematical connections across the secondary mathematics curriculum and beyond, teachers can develop instructional plans that build from, and connect to, what students know and understand.

The Interpretations Question: What Mathematical Understandings is the Student Demonstrating?

The *interpretations question* guides teachers to examine student work for evidence of what mathematical understandings the student is likely to have. This question shifts focus from the mathematics to the student and allows teachers to make assertions about the student's mathematical knowledge based on evidence from their written work. For instance, a teacher might recognize the values of the functions at their vertices and closed brackets in the student's intervals in Figure 1 and based on this observation, claim that the student knows how to describe sets of real numbers, determine the vertex of a quadratic function, and perhaps how to complete the square. Further, noticing the relationship between the vertex of the quadratic function and the given intervals may provide additional insight into the student's thinking. Highlighting what a student understands and thinks provides teachers an array of cognitive resources that might be useful in subsequent instruction. In addition, a focus on what students know and can do mathematically on a task may also specify what ideas the student has yet to learn.

In our study, participants carefully studied the student work before discussing the possible mathematical understandings represented. They contemplated the details of the student work and used them to support claims about what they believed the student was thinking. Knowing how students think, such as Kurin's claim that "they are looking vertical instead of looking horizontal", is vital to incorporating student perspectives into instruction.

The Conjectures Question: What Additional Understandings is the Student Likely to Have? What Should They Learn Next?

The *conjectures questions* maintain a focus on the student and encourage teachers to consider how students arrived at their solution and hypothesize about other understandings the student may have that are not reflected in their work. These inferences can then assist teachers in identifying what students should learn next. The *conjectures questions* allow teachers to formulate a more complete picture of what the student knows, which in turn helps them to prepare for instruction by considering the various questions, strategies, or difficulties that students may encounter. For example, a teacher who believes the student selected function c because -5 is the smallest of the three quadratic coefficients may conjecture that the student should next develop an understanding of how multiplying a function by various constants affects the rate of change of its values.

In our interviews, participants build from their interpretations to conjecture what mathematical understandings the student had and what new idea would most likely advance student learning. They discussed experiences with former students with understandings they believed to be like those reflected in the student work they were examining. For example, as "Cameron" analyzed the response in Figure 1, they stated, "our textbook has certain questions where they are given quadratic functions and they are asked what the intervals for which the function is increasing and decreasing. I think that is what this student is doing when I see their written intervals."

The Instruction Question: What Could I Do to Build on the Student's Understanding?

The *instruction question* shifts attention to the teacher and focuses on what teachers might do to continue or enhance student learning. Though it is likely the question that teachers ask themselves most, postponing an instructional decision until after considering evidence of what a student knows is an aspect of strengths-based teaching (Lopez & Louis, 2009). Rather than focusing potential instructional moves on "fixing" what is incorrect about a student's thinking, this question encourages teachers to leverage a student's knowledge as a foundation for their subsequent teaching. For example, Kurin's decision to graph the three quadratic functions and compare them at the same value builds from her assertion that the student understands the range of each quadratic function and an inference that the student had envisioned the graphs of the functions and was focusing on resulting parabolas vertically.

During our interviews, participants addressed what they would do only after carefully determining what knowledge was demonstrated in the student work and contemplating how the student could have arrived at their response. For example, initially Cameron thought the student work represented increasing or decreasing intervals, but after close examination, changed their observation and stated,

> Wait, on second thought, that interval notation, they are looking for the range. I might give this student some simpler functions. So, I think this student might just need a simpler set of functions to compare, to get the idea of width across. Once they can see that, then I would introduce more complicated functions.

The Resources Question: What Resources Would Be Helpful in Extending the Student's Understanding?

The *resources question* directs attention to the tools a teacher might provide to support students in using what they know to build a new understanding. When considering this question, teachers draw upon their knowledge of instructional materials and resources that promote student engagement and understanding, such as Kurin's idea of utilizing DESMOS to assist the student in determining the parabola with the greatest width by adjusting the quadratic coefficient.

Participants in our study discussed a variety of tools that they would use to build from or extend student understanding based on their interpretations and conjectures. They discussed graphing calculators, online applets and graphing tools, as well as open curriculum sources that they believed would advance a particular student's learning of quadratic functions. This is seen in "Jeremy's" remarks as they stated,

> I would encourage graphing on a calculator because I don't want the graphing to be the exercise. I need the graph to be the tool to show them what their misconception is. I would have them get out the graphing calculator or go to the DESMOS app. I wouldn't want them to graph it by hand - that's not the point here. We aren't teaching graphing; we are teaching the differences. In DESMOS, it allows sliders – with the slider value as the leading coefficient, have them change the value and see what happens.

These six questions that embody the work of teaching encourage a thoughtful and productive engagement with student written work. Collectively, the questions provide a strengths-based guide to uplift and build upon the mathematical ideas of the students, while simultaneously providing opportunities for teachers to reflect upon and expand their own knowledge relevant to the content, student, and teaching. The content and connections questions provide teachers opportunities to expand their knowledge of content and content across the curriculum. The interpretations and conjectures questions allow teachers to grow their understanding of student thinking, relevant to specific content. Finally, the instruction and resources questions push teachers to think about content specific instruction and tools, hence increasing the knowledge of both.

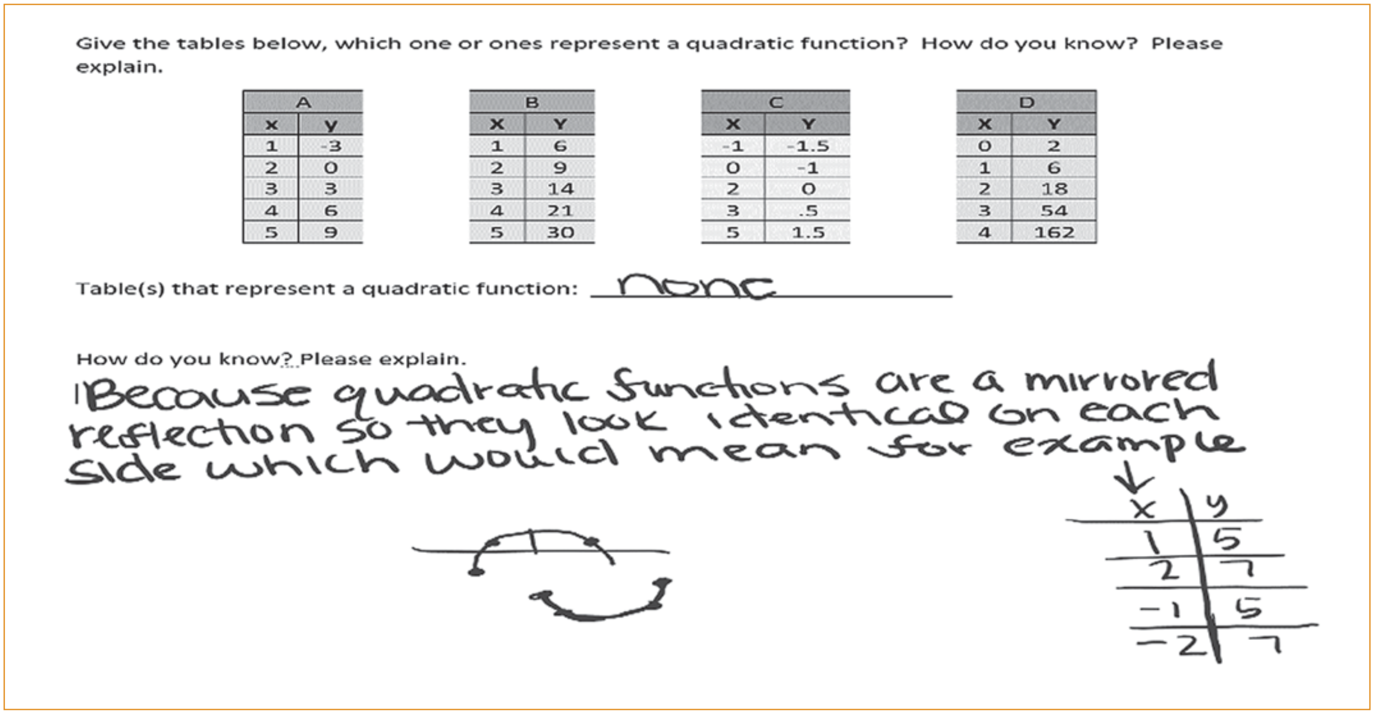
Utilizing the Six Strengths-Based Questions to Examine Student Work

In this section, we illustrate how mathematics leaders might use the questions to assist teachers in adopting a strengths-based approach to teaching mathematics. Consider a mathematics leader facilitating a professional learning community (PLC) of high school algebra teachers. Using the questions, leaders can support teachers in focusing on what students know and how to build upon their knowing. As a part of their regular review of student work, a leader might ask a PLC to consider the student work in Figure 3 by first focusing on the mathematics, then the student, and finally focusing on how they might support further learning.

Focusing on Mathematics with the Content and Connections Questions

How teachers think about a problem directly impacts how they interpret the student's written response. For example, thinking of quadratic functions as parabolas in the Cartesian plane might suggest a graphing approach for the problem in Figure 3, whereas thinking of quadratics as functions with a linear rate of change might lead to an examination of differences between successive differences in values of the range over consistent intervals of the domain. Therefore, before examining the specifics of the student response, leaders can encourage teachers to reflect on their solution, methods, and the mathematical ideas that precede and follow from the concepts by posing the *content and connections questions.*

FIGURE 3. *Student Work Sample 2*


Give the tables below, which one or ones represent a quadratic function? How do you know? Please explain.

A	
x	y
1	-3
2	0
3	3
4	6
5	9

B	
X	Y
1	6
2	9
3	14
4	21
5	30

C	
X	Y
-1	-1.5
0	-1
2	0
3	.5
5	1.5

D	
X	Y
0	2
1	6
2	18
3	54
4	162

Table(s) that represent a quadratic function: none

How do you know? Please explain.

Because quadratic functions are a mirrored reflection so they look identical on each side which would mean for example

x	y
1	5
2	7
-1	5
-2	7

By asking teachers to develop and share a solution using the content question, leaders can highlight the different ways of approaching the problem. For example, teachers might discuss looking for patterns of covariation, a strategy of examining first and second differences for linear and constant rates of change, identifying key function features in tabular representations, or creating a graphical representation. In facilitating a discussion where teachers publicize and discuss different approaches to solving the problem, leaders can create learning opportunities for teachers to enhance and extend their MKT for teaching quadratics.

After surfacing knowledge of quadratic functions useful in solving the problem, leaders might use the *connections questions* to shift teachers' focus to articulate prerequisite knowledge to the mathematical concept(s) required by the problem. Detailing the concepts needed to identify quadratic functions from tabular representations provides a foundation for insights into the gaps or connections that might be present in the student's work and an opportunity for the PLC to consider the prior knowledge needed to successfully complete the task. For example, teachers might discuss the importance of recognizing patterns to understand rates of change or identifying intervals of increasing and decreasing values of a function. Similarly, the connections questions can assist teachers in linking the mathematical concepts that are their current instructional focus to those that will be enabled by them in the future. Through discussions of how analyzing multiple representations and analyzing rates of change are essential for understanding function families in future courses for example, leaders can create opportunities for the PLC to deepen these understandings of vertical alignment in the mathematics curriculum and how their instructional choices build from previous learning and enable learning in the future.

Focusing on Students with the Interpretations and Conjectures Questions

Teachers can learn from the students' work through professional dialogue with their colleagues. However, the process of learning from student work requires a level of intentionality that moves the review beyond just being right or wrong. For instance, reviewing the student response in Figure 3 could result in the work being evaluated as incorrect. However, purposefully seeking out the mathematical ideas embedded in student work would reveal that the student knows that symmetry is a characteristic of quadratic functions, but possibly thinks that quadratics are only symmetric about the y-axis. Leaders can help teachers deeply engage with the student thinking demonstrated through written work by utilizing the interpretations and conjectures questions.

By asking teachers to attend to the mathematical understandings represented in student work using the *interpretations question*, leaders can facilitate a discussion of the various interpretations that teachers posit, while encouraging them to provide evidence of student knowledge and identify strengths in the work. Whereas some insights into student thinking may be shared across community members, such as the student knowing the graphical representation of quadratic functions, it is those insights that are uncommon that provide PLC members opportunities to broaden their understanding of student thinking and experiences, hence expanding MKT.

As the PLC works to interpret the mathematical meanings conveyed in the student work, leaders can introduce the *conjectures questions* to guide the PLC to theorize about prior instruction and experiences that could have influenced the student's response. Making inferences about student thinking based on evidence that are beyond what is presented in the written work can refine teachers' interpretations and may lead them to recognize why the solution made sense to the student. For example, careful review of Figure 3 reveals that the student can represent symmetry to the y-axis in both tabular and graphical form. Also, the student demonstrated a graphical representation that is not symmetrical about the y-axis. Hence, teachers might conjecture the student has not had the opportunity to analyze tables for quadratic functions where elements of the domain are not proximal to the vertex located on the y-axis. After exploring the mathematics represented in the student's work and then contemplating how the student arrived at their solution, leaders can then shift the discussion to considering how teachers might expand student understanding and further their learning.

Focusing on Teaching with the Instruction and Resources Questions

In PLC discussions, teachers have opportunities to consider different instructional choices that are appropriate for students based on the knowledge they have demonstrated in their written work. However, as diverse as student knowledge is, so are the instructional choices of teachers. PLCs are environments where teachers can learn from their colleagues by sharing what they would do based on the student's demonstrated understandings. Having multiple instructional paths in mind can help teachers ensure that the learning needs of all students can be addressed.

Using the *instruction question*, leaders can assist teachers in expanding their pedagogical knowledge by encouraging PLC members to consider and share different instructional choices they might take based on the work. For example, teachers may decide to have the student graph all of the tables in Figure 3 while others may want to encourage the student to determine the rates of change in the tables and extend the tables to see which functions have a local minimum or maximum. Identifying and evaluating different instructional moves with colleagues can assist teachers in determining how to build what students already know to meet their instructional goals.

As a PLC discusses instructional paths likely to be productive for students based on their written work, leaders can encourage teachers to consider what resources are available to scaffold student learning and to weigh their relative affordances and constraints. For example, using a graphing calculator to plot function values for each table might focus the student whose work is displayed in Figure 3 to examine changes in each function's average rate of change. While the use of a graphing calculator in this way might support a discussion of how quadratic functions have a linear rate of change, it is more difficult to build from the student's understanding of a quadratic function's line of symmetry. Alternatively, using a math action tool such as DESMOS or GeoGebra to generate dynamically linked multiple representations of a quadratic function in vertex form with sliders for its parameters would build upon the student's knowledge of symmetry but might not support a discussion of average rates of change. By facilitating PLC discussions around different pedagogical choices and resources, leaders can support teachers in expanding their instructional repertoires and their understandings of how to build from what students already understand.

Discussion

Building new understandings from current conceptions is a foundational principle of learning (National Academies of Sciences, Engineering, and Medicine, 2018; National Research Council, 2000). Examining student work provides an opportunity for teachers to identify the mathematical concepts that a student understands and consider how they might use them to support new learning. By focusing on what students know and considering them as strengths, teachers can create instructional experiences that build upon and extend student understandings.

The questions for examining student work presented in this paper provide mathematics leaders a guide for supporting teachers to engage productively with records of student understanding. Based on the ways accomplished mathematics educators analyzed student work in our study, the questions encourage teachers to draw upon and use their mathematical knowledge for teaching and, in doing so, create opportunities to learn from students. By encouraging teachers to identify what students know and consider ways that they use those understandings in future instruction, the questions also create opportunities for teachers to deepen their own mathematical knowledge for teaching.

We illustrated how mathematics leaders might use the questions to analyze student work in a PLC setting, but we believe the questions could be useful in other contexts such as one-on-one coaching cycles or developing common assessments. Over time and in multiple contexts, the questions can support teachers in developing a routine that first considers the mathematical content of a task, followed by focusing on evidence of student knowledge, and then articulating and evaluating instructional next steps. By considering student knowledge as an asset for teaching, the questions can support teachers in developing and strengthening not only their mathematical knowledge for teaching but also a strengths-based perspective on teaching and learning. ✪

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Influencing Elementary Principals' Leadership Self-efficacy for Mathematics: A Professional Development Case Study

Kelly Gomez Johnson and Paula Jakopovic
University of Nebraska at Omaha

Abstract

Building principals are uniquely positioned to drive change, however, often find themselves learning alongside teachers. Principals are key in establishing a vision for high-quality instruction and influencing teacher practice. However, professional development (PD) for principals needs to prepare and support their beliefs, knowledge, and skills as instructional leaders in subject-specific areas like mathematics. This article describes a districtwide, mathematics-focused PD model to support principal development. This study examined how PD activities, designed around Bandura's sources of self-efficacy, influenced principal self-efficacy as mathematics instructional leaders. Findings of this qualitative case study include four themes of PD activities that enhanced principal self-efficacy. Implications of this study may serve school district leaders as they support principals' development as instructional leaders in subject-specific areas.

Introduction

The National Council of Supervisors of Mathematics (NCSM) states that "mathematics programs will only get better when leaders open themselves and other teachers to new ideas, risk imaginatively, and enthusiastically inspire those they lead with a desire to learn and grow together" (NCSM, 2008, p. 56). Over the past decade, the instructional emphasis of elementary mathematics teaching and learning has shifted away from teacher-centered, procedurally focused instruction to a more balanced approach of instruction inviting more student-centered, conceptual understanding (National Council of Teachers of Mathematics (NCTM, 2014). With this shift, many teachers and leaders have been charged to learn, unlearn, and re-learn many instructional practices and expectations. Strong principal leadership has been identified as a pivotal component of the school improvement process (Branch et al., 2012; Grissom & Loeb, 2011; Hallinger & Heck, 1996; Leithwood & Louis, 2012; Zheng et al., 2017). Effective leaders are positioned to facilitate teachers' professional growth (Backor & Gordon, 2015; Burkhauser, 2017), positively impact student achievement gains (Leithwood et al., 2010; Marzano et al., 2005; Wallace Foundation, 2011), and support and sustain a culture conducive to learning (Louis et al., 2010). Yet, principals have a plethora of responsibilities on their shoulders and require training and support themselves to meet the growing demands of their position and the changing landscape of content area pedagogical philosophies.

When faced with change initiatives, principals are called to go beyond school management. They are expected to be knowledgeable enough to lead instructional change and to earn the trust of their staff (Fennell, 2007). Like pedagogical content knowledge for teachers (Shulman, 1986), professional development (PD) centered around the leadership content knowledge (LCK) of principals is a growing area of investigation as the educational community grapples with addressing change and improving student learning outcomes (Quebec Fuentes & Jimerson, 2020; Stein & Nelson, 2003). Without foundational knowledge of pedagogical content that is important to effective and equitable teaching practices, principals may neglect to notice minor or major areas of focus in leading their teachers and school. Further, principals may be uncomfortable or ill-equipped to engage in meaningful dialogue or to address their own misconceptions around teaching and learning due to gaps in their LCK (e.g., Brazer & Bauer, 2013; Louis et al., 2010; May & Supovitz, 2011). Facilitating instructionally focused conversations requires skills in coaching (e.g., Desimone & Pak, 2017; Knight, 2009), as well as familiarity with instructional strategies that are discipline specific (e.g., Marzano & Waters, 2009; Marzano et al., 2011).

Although teachers have traditionally been the focus of PD, there is increasing momentum for on-going, job-embedded training for principals around LCK and their overall instructional leadership practice (Honig, 2012). Through the lens of Bandura's theory of self-efficacy, this study examines a yearlong, district-led PD series designed to increase the self-efficacy of elementary principals as instructional mathematics leaders. Self-efficacy, the belief in one's ability to lead elementary mathematics reform in this case, is a dynamic construct that can be influenced by four main sources: 1) enactive mastery, 2) vicarious experiences, 3) verbal persuasion, and 4) attention to psychological or emotional state. The purpose of this study is to add to the body of knowledge around instructional leadership in mathematics and to examine how self-efficacy as a theoretical construct can frame professional development that influences principals' beliefs and ultimately, leadership actions. We also aim to add to literature about how principals access mathematical LCK through PD and in what ways they are positioned to lead instructional change in the future.

Theoretical Perspectives and Literature Review

Reform-Based Mathematics Instruction

In the past, defining "effective teaching" in mathematics has often been a challenge due to a lack of universal agreement on what constitutes best practice, but in 2014, the National Council of Teachers of Mathematics (NCTM) released a framework called *Principles to Actions: Ensuring Mathematics Success for All* (PtA). This framework outlines quality mathematics teaching and learning practices and guiding principles for school programs. PtA identifies eight high-leverage, research-grounded instructional practices (NCTM, 2014). "High-leverage" refers to "those practices at the heart of the work of teaching that are most likely to affect student learning" (Ball & Forzani, 2010, p. 45). The practices include:

1. Establish mathematical goals to focus learning
2. Implement tasks that promote reasoning and problem solving
3. Use and connect mathematical representations
4. Facilitate meaningful mathematical discourse
5. Pose purposeful questions
6. Build procedural fluency from conceptual understanding
7. Support productive struggle in learning mathematics
8. Elicit and use evidence of student thinking

The primary purpose of the PtA practices is to create a common language to aid in the successful implementation of research-based mathematics teaching practices, policies, and programs in a time of rigorous standards-based curricula adoptions (NCTM, 2014). PtA practices serve as a framework for quality instruction, regardless of the adopted curricula, demographics of schools, or other unique organizational structures. For all educational stakeholders, including school principals, PtA practices provide an opportunity to increase the systemic implementation of high-quality mathematics instructions in PrK-12 mathematics programs.

The Role of Instructional Leadership

Creating and supporting an environment of quality teaching and learning is the bedrock of effective school leadership for improved student learning (e.g., Gurr & Drysdale, 2010; Hallinger & Heck, 2011; Leithwood & Day, 2010). Principals are called to lead in many roles (e.g., budget, discipline, facilities, personnel), but over the past two decades principals are increasingly being asked to implement and support instructional reforms in a variety of contexts (e.g., subject-areas, multi-tiered systems of support) (Horng et al., 2010; Spillane et al., 2011). The requirements of building-level principals have shifted away from pure managerial tasks (Firestone & Wilson, 1985) and toward acting as leaders of curriculum and instruction (Spillane & Hunt, 2010). Like the role of principals, the definition of instructional leadership varies in the literature. For the purpose of this study, instructional leadership is broadly defined as practices exhibited by principals to improve teaching and learning in the classroom or school building (Hallinger & Heck, 1996).

In U.S. public schools, large-scale instructional improvement efforts have reinforced the accountability of teachers and instructional leaders to implement standards-based reform systemwide (Mehta, 2013; Schimmer et al., 2018; Spillane et al., 2011). Principals have been found to have significant influence on the overall working conditions and instructional practices of their staff (Backor & Gordon, 2015; Burkhauser, 2017), therefore, as policies and practices continue to change principals are in a prime position to support and ensure the enactment of reform. However, these actions require specialized knowledge and skills on the part of building leaders.

With the performance of principals under scrutiny like never before to improve student learning and achievement, the Council of Chief State Schools Officers (CCSSO) and the National Policy Board for Education Administration (NPBEA) established the National Educational Leadership Preparation (NELP) Program Recognition Standards for building level leaders (NELP, 2018). The NELP standards specify what novice leaders should know and be able to do following preparation as building and district level leaders. The standards were created to add clarity and benchmarks for educational leaders. With consistency among standards, the Council for the Accreditation of Educator Preparation (CAEP, 2017), stated that the NELP standards "ensures a coherent continuum of expectations" (p. 10). The NELP standards include:

- Mission, vision, and improvement
- Ethics and professional norms
- Equity, inclusiveness, and cultural responsiveness
- Learning and instruction
- Community and external leadership
- Operations and management
- Building professional capacity
- Internship (NPBEA, 2018)

Much like PtA clarified best practices for teaching mathematics (NCTM, 2014), the NELP standards further clarified best practices for instructional leaders to support the continued growth of their community, teachers, and students.

Principals as Mathematics Leaders

There is often an assumption that principals are prepared with the knowledge and skills to lead both broad instructional reforms and content specific innovations in their buildings. Principals are responsible for several subject areas and grade levels and certainly cannot be expected to know everything (e.g., Steele et al., 2015). However, in their role as instructional evaluators, it is important for principals to have research-based, content-area credibility in knowing the foundational practices of teaching and learning (Munter, 2014). Leadership Content Knowledge (LCK) (Stein & Nelson, 2003) is the knowledge of academic subjects that principals use as instructional leaders in their school. LCK builds on Shulman's (1986) concept of pedagogical content knowledge (PCK), which explains the need for teacher knowledge to go beyond basic content knowledge and into knowing how to teach the subject matter and what makes the learning of specific topics (e.g., mathematics) easy or difficult, etc. When examining principals as leaders, LCK assumes that principals have their own specialized knowledge and expertise in teaching and learning. In content areas where they have limited knowledge, skills, or previous experiences, they develop those areas through in-depth explorations of important but bounded slices of the subject the way it is learned by students and taught (Stein & Nelson, 2003). Oftentimes principals gain deeper LCK from classroom observations of teaching and engaging in conversations with teachers about PCK (Brazer & Bauer, 2013).

Principals with LCK and knowledge of how students learn those subjects have a significant advantage as instructional leaders (Nelson & Sassi, 2003). LCK provides an important context for principals' work, especially in times of change (Burch, 2007; Spillane, et al., 2001) where active, rather than passive, leadership is needed in the face of philosophical shifts in culture and practices (NCTM, 2020; Nelson, 1999). In one particular study examining principal practices and mathematics, Nelson and Sassi (2005) found that principals made significant indirect impact utilizing their LCK in areas such as supporting teachers' use of high-quality mathematics tasks and posing purposeful questions to foster students' connection-making. These two practices are included in the PtA framework and highlight how principals can leverage their LCK to lead mathematics instruction with these practices in mind. Principals must be able to frame and facilitate communication about subject-area instructional goals to promote quality teaching and learning practices equitable from classroom to classroom (e.g., Gaziele, 2007). Doing so can ensure principal support and inclusive PD across building stakeholders (e.g., teachers, instructional coaches) provides cohesion and clarity on the direction of subject-specific instruction in areas such as mathematics (Cohen et al., 2013).

Principal Professional Development

Principals are called to provide PD for their teachers as instructional leaders. This role requires them to have the knowledge, skills, and strength of character to ensure PD is translated into ongoing practice (Stein & Nelson, 2003). In recent decades, school districts have devoted increased resources and time to principal PD to support improvement in student achievement from a variety of directions (Burch, 2007; Fink & Resnick, 2001; Herrmann et al., 2019). Effective PD is comprehensive, substantive, and intensive training to improve teachers' and principals' effectiveness in raising student achievement (Wei et al., 2009). Principals bring various teaching experiences, preparation, beliefs, and educational experiences to their complex roles. Ultimately, principal PD aims to increase the capabilities of leaders to create and support conditions in schools where quality teaching and learning are possible (e.g., Hallinger & Heck, 2011; Hauserman & Stick, 2014; Leithwood & Day, 2010). This requires finding out what principals already know and what beliefs they hold instead of providing a large amount of "one size fits all" PD and expecting immediate results (DeMonte, 2013). When districts provide principals with job-embedded PD, there is a significant relationship between their time spent on instructional leadership tasks and their ability to engage their teachers outside of the classroom to improve instruction (Augustine et al., 2009; Darling-Hammond, 2017).

One purpose of principal PD is to support their vision for quality academic success as instructional leaders. A principal's vision for teaching and learning is a key factor in predicting standard-based expectations but is relatively difficult in mathematics in comparison to other subject areas (Katterfeld, 2013). Equipping principals with frameworks, like PtA, and observation tools through which to view classroom instruction, communicate with teachers, and articulate a vision for mathematics education is one way to enact instructional leadership practices within a school. Framing a conversation around practice using common language and tools can provide principals, along with teachers and coaches, with opportunities to identify next steps toward meeting instructional goals to improve overall teaching and learning in their building (Boston, 2013; Boston & Steele, 2014). In alignment with ongoing PD practices, common structures and supports can allow principals to provide more specific and targeted feedback to help teachers enact high-leverage instructional practices (Spillane et al., 2004). With specific content and pedagogical feedback accessible and aligned with instructional initiatives, principals have the tools to promote and provide accountability for high standards in mathematics teaching and learning (Cobb & Jackson, 2011).

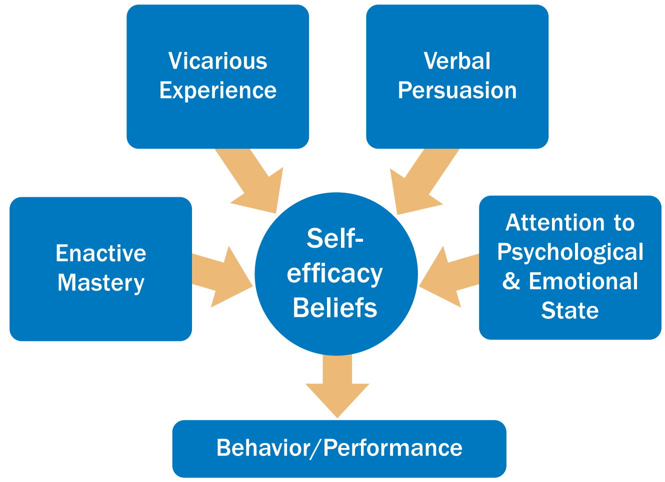
Theoretical Framework

Developing leaders involves helping them see who they are, what they value, and how their actions affect both other individuals and their organization's environment. Bandura's Social Cognitive Theory defines efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Self-efficacy is an important factor to consider in the development of foundational leadership strategies for principals. Self-efficacy can influence the actions of principals in establishing a school's vision, adapting and implementing instructional change, and persisting despite obstacles (Bandura, 1986). When principals are considered knowledgeable and collaborate with teachers they are better able to interrogate the existing culture of instructional practices perceived to be inequitable or ineffective, with a compelling vision for improving instruction (Nelson & Sassi, 2003). Without collaboration and up-to-date research justification, administrators who are considered to be math experts may be disregarded if teachers believe they are purely acting on their own beliefs (Lochmiller, 2015).

A leader's judgment of self-efficacy, LSE, can greatly influence how they initiate, commit, and persist through change (Bandura, 1977, 1986, 1997; Tschannen-Moran & Gareis, 2004; Tschannen-Moran & Woolfolk-Hoy, 2007). Individuals are more likely to initiate and engage in tasks where they feel competent. Conversely, they are more likely to resist tasks where they feel inept. Often this results in individuals avoiding challenging environments or unknown endeavors (Stajkovic & Luthans, 1998). For principals, this could be evident in their support of the status quo to avoid instructional or managerial conflict or situations where they feel ill-equipped to justify change. Self-efficacy beliefs impact an individual's reactions and thought patterns (Pajares, 1996). LSE beliefs provide insight into the amount of effort or commitment a person will exert in an activity and their persistence through challenging times. In schools, change can often create resistance from stakeholders like parents, teachers, and/or students. In these times, leaders with high self-efficacy are more likely to exhibit leadership behaviors demonstrating commitment and persistence to a task while enacting instructional change (Bandura, 1997; Smith & Guarino, 2005). Self-efficacy beliefs are task specific. Principals expected to lead initiatives using their LCK in areas like mathematics need opportunities to grow in their beliefs to lead in these areas. Leaders are shown to exert more effort and persist in their instructional leadership actions when they have strong self-efficacy beliefs in a specific evidence-based educational initiative (Federici & Skaalvik, 2011, 2012).

Recognizing that principals' self-efficacy can directly affect their beliefs and actions around instructional change leads us to frame the current study around Bandura's four sources of efficacy (1977). Bandura's theory posits that these four sources, 1) enactive mastery, 2) vicarious experience, 3) verbal persuasion, and 4) psychological or emotional state, can lead to the development of self-efficacy, which influences subsequent behavior and performance. Examining the four sources of self-efficacy individually, and in combination, provides a picture of how beliefs regarding one's abilities can be constructed or changed (Figure 1).

FIGURE 1.
Bandura's Sources of Self-efficacy (1997)



Note. Bandura (1997).

Enactive mastery experience, or performance outcomes, is defined as the "experience overcoming obstacles through perseverant effort" (Bandura, 1997, p. 80). Both positive and negative experiences can impact an individual's self-efficacy, however if tasks are viewed as futile or insignificant, the impact on self-efficacy is often minimal. The perception that one's performance is a success can increase self-efficacy, while the perception of failure can lessen self-efficacy in a task (Bandura, 1986). An individual's conscious evaluation of their performance based on various factors can influence their future beliefs in similar tasks.

Vicarious experience, or watching others, is defined as "learning mediated through modeled attainments" (Bandura, 1997, p. 86). By watching others attempt to complete a task, individuals can develop their own high or low beliefs in their ability to be successful. For example, if an individual observes another's failure, this can lower their self-efficacy in that "if they can't do it, then I surely will fail as well" (Bandura, 1977). This social comparison is a powerful factor influencing vicarious experience attributes such as age, gender, ethnicity, education, positionality, and socioeconomic level, which can have a strong sway over those observing a modeled task. Without the risk of failure, vicarious learning allows individuals to process and hypothesize what they might find success doing in the future based on the results of others.

Verbal persuasion, in the form of interpersonal support, is provided by peers, supervisors, and the community. Individuals can be led to believe they can achieve success (or failure) on a given task by the words of others (Tschannen-Moran & Hoy, 2007). When feedback in the form of encouragement or coaching is given, individuals feel they are more capable of achieving success than originally thought possible; hence, increased self-efficacy (Paglis & Green, 2002). While verbal persuasion is the most highly utilized of the four sources, especially in schools, it is statistically the least effective source with gains of efficacy beliefs being "weak and short-lived" (Bandura, 1994, p. 82). This may be due to the source (e.g., perceived equivalent peer, supervisor) of the verbal persuasion and past experiences of success or failure in the task.

The last source of self-efficacy is attention to *psychological or emotional state*. As individuals experience emotional arousal such as agitation, anxiety, and/or excitement, their interpretation of these psychological states can influence their efficacy beliefs (Bandura, 1977). This in turn can impact the actions of the individuals based on their perception of efficacy. In educational settings, learning is enhanced when the mood of the individuals (e.g., students, teachers, principals) correlates with their psychological state. This is evident for both increasing and decreasing efficacy beliefs. When an individual experiences excitement, this can be energizing and motivating (Bandura, 1997). Negative moods are usually linked back to previous failures or unpleasant experiences. This understanding of the psychological and emotional role as a source of self-efficacy can be useful in coordinating learning experiences where individuals feel more at ease and could attain higher self-efficacy beliefs.

Recognizing the facets of PD programming (e.g., LCK) that influence and potentially empower principals as mathematics instructional leaders can help districts and PD coordinators more effectively plan and implement change. This study seeks to better understand how a PD model in one school district leveraged self-efficacy as a framework to examine the development of principals as mathematics instructional leaders.

Context

This study took place in one Midwestern, suburban school district serving approximately 24,000 students each year and 25 total elementary schools K-5. At the time of this study, the district had just adopted a new, "reform curriculum" for elementary mathematics that was vastly different from the previous materials they had used for the past eight years. The new curriculum moved away from traditional teacher-led content delivery and homogeneous grouping methods by ability level. Instead, the new curriculum, framed around updated mathematics education research (e.g., PtA framework), emphasized representing mathematics in a variety of ways, increasing student discourse, and providing a more balanced approach to develop conceptual understanding and procedural fluency (NCTM, 2014).

Data over the last decade showed that district mathematics student achievement had flatlined and upper elementary through high school student achievement increasingly showed a negative trend as students matriculated through the grades. District leaders (e.g., Director of Elementary Education, K-5 Elementary Mathematics Curriculum Facilitator) looked to building-level elementary principals to move forward the instructional vision of mathematics education in the district, one school and teacher at a time. However, district leaders recognized that the principals would need support through focused and intentional PD. Through a university partnership, the district leaders engaged with a university researcher, the lead researcher and first author of this paper, to collaborate on the design and later research and evaluation of the PD model. District leaders provided access to the planning, communication, and implementation of all PD activities during the curriculum implementation year to inform this study. Prior to the new elementary curriculum implementation, the lead researcher and district leaders partnered to structure the year-long PD for administrators in instructional leadership for mathematics. These district leaders were responsible for facilitating and implementing all district-led mathematics PD for principals and served as "gatekeepers" (Bogdan & Biklen, 1992) to the lead researcher for all district PD opportunities and information for the study. For example, district leaders and the lead researcher cooperatively reviewed the observational field notes to provide an additional layer of member checking (Candela, 2019) and gathered additional district documentation and/or resources (e.g., emails to administrators regarding curriculum adoption, mathematics improvement plan).

To frame the year-long PD, the lead researcher and district leaders reviewed evidence-based research on instructional leadership, PD, and self-efficacy literature. The team initially designed four areas to be integrated into each aspect of principal PD model, including: a) mathematics process standards; b) curriculum materials and structures (Hill, 2007); c) effective teaching and learning practices in mathematics (NCTM, 2014; Steele et al., 2015; Shulman, 1986; Stein & Nelson, 2003); and d) scaffolded experiences to practice LCK learning (Borasi & Fonzi, 2002). These LCK experiences for principals included co-planning or co-teaching new curriculum lessons with teachers, watching and discussing videos of elementary math instruction created throughout the district in different grade-levels and school types (e.g., Title I, non-Title I), and participating in Instructional Rounds at a variety of district schools (City et al., 2009).

This article is situated within a larger study that measured and compared principals' general LSE and their mathematical LSE before and after the year-long PD focused on developing their mathematical LCK and skills (Gomez Johnson & Williams, in press). In that quantitative study, framed around leadership self-efficacy work by Smith and Guarino (2005), principals reported a statistically significant increase in their mathematics LSE beliefs in the following areas:

1) Their belief in their ability to influence teachers to utilize effective mathematics teaching and learning practices,

2) Their belief in their ability to apply district professional development to instructional leadership practices, and

3) Their belief in their ability to justify change in mathematics teaching and learning during curriculum reform.

With data to support that the district-provided PD significantly impacted principals' LSE in mathematics, researchers wanted to further investigate the PD opportunities and experiences that may have led to those quantitative results. Both district partners and the lead researcher were interested in how self-efficacy sources may have been present, in isolation or in combination, within PD experiences documented throughout the year. Therefore, this study seeks to examine the question: When PD activities are designed with Bandura's four sources of self-efficacy in mind, in what ways can the aspects of this PD design influence principals' self-efficacy as mathematics instructional leaders?

Methodology

Research Design

The research design for this study is an intrinsic qualitative case study, as case studies are well situated for closely examining such "How" and "Why" questions, focusing on an issue "in depth and within its real-world context" (Yin, 2018, p.14). Researchers engage in intrinsic case studies "...not because by studying it we learn about other cases or about some general problem, but because we need to learn about that particular case" (Stake, 1995, p. 3). The case in this study is bounded by a year-long PD program provided to a single Midwestern, suburban school district, aimed at developing elementary principals within the district as mathematics instructional leaders. Data collection occurred at required monthly PD meetings for principals and additional voluntary activities offered by the district during the first year of implementation of a reform-based curriculum.

Table 1: Data Collection Sources and Frequency

Data Sources	When	Source
PD Documents	ongoing	District Leaders
Observations/field notes of PD sessions	monthly	Participants
Principal reflection prompts	monthly	Participants
Open-ended survey responses	ongoing	Participants

Participants

The participants for this research study included 38 elementary school building principals and principal interns (assistant principals) from the same Midwestern, suburban school district. At the time of the study, the district was the third largest in the state with a student membership of over 23,700 students; 11,000 of those students filled K-5 classrooms in 25 different elementary school buildings. All principals were required to attend monthly district elementary leadership meetings that prioritized mathematics PD for at least one hour per meeting during the academic year. Additional optional PD opportunities throughout the year included lunch and learn conversations, invitations for one-on-one consultation with district math leaders, and structured classroom observation sessions (i.e., Instructional Rounds) held at three elementary locations.

Data Instrumentation & Analysis

We collected multiple data sources, including PD documentation (e.g., handouts, slide deck presentations), observational field notes from monthly principal meetings, and open-ended, reflective responses from principals following PD (Table 1). Throughout different PD activities, participants responded to consistent reflective prompts. These reflective prompts were aligned to the four key areas of district PD (e.g., standards, curriculum, PCK, LCK). The purpose of the consistent prompts was to increase principal discourse and collaboration during and following monthly PD tasks (e.g., co-planning, co-teaching, observing math lessons) and to make evidence of participant thinking and practice visible during PD sessions. The prompts included:

1. What skills/standards were taught?
2. What was the role of the teacher throughout the lesson?
3. How were students engaged with their learning?
4. What (curriculum) structures did you observe?
5. Which of the Mathematical Processes/Practices were evident?

FIGURE 2. *Qualitative Rubric to Assess Self-efficacy*

Self-Efficacy Sources	Primary PD Goal Planning Intentionally	Secondary PD Goal Coincidentally/ Evolved	Not Apparent/ Observed
Performance Outcomes (Enactive Mastery Experience)			X
Watching Others (Vicarious Experience)	X		
Verbal Persuasion, Encouragement, and Feedback		X	
Attention to Psychological and Emotional State			X

Note. Exemplar of qualitative rubric utilized to chart evidence of self-efficacy sources related to PD goals and activities.

We utilized naturalistic inquiry to investigate the PD opportunities from the perspective of the participants. Critical components of naturalistic inquiry call for researchers to carry out all observations and interactions with participants in their own environment to fully understand behavior, along with robust notetaking and gathering of direct quotes to ensure the credibility and authenticity of participant experiences (Lincoln & Guba, 1986, Thomas & Magilvy, 2011). The lead researcher documented field notes focused on the actions and interactions of principals during their PD experiences (i.e., monthly district-led principal meetings). In real time, the lead researcher documented principals' direct quote responses to reflective prompts around the PD structures and identified overarching themes from both small and whole group conversations around the prompts. This naturalistic research took place at two locations: the school district's support services center and district elementary school buildings where principals acquired and applied their PD.

Following individual PD sessions, the lead researcher completed reflective journaling (Lincoln & Guba, 1982; 2013; Thorpe, 2010) to identify patterns and trends of each PD activity and develop a qualitative rubric chart. The rubric chart documented individual self-efficacy source observations, or lack thereof, and designated the sources as primary (planned activities/goals for PD) or secondary (coincidental, emerged during PD) (see Figure 2).

The lead researcher utilized an ongoing, recursive process of examining, interpreting, and reinterpreting the multiple data sources (Richards, 2009). In the initial phase of coding data sources, we utilized *a priori* coding (Miles et al., 2020), a deductive approach to coding analysis, using Bandura's four sources of self-efficacy as a framework (Bandura, 1977). In this stage, we identified elements of the PD themes that specifically aligned with mastery enactment, vicarious experiences, instances of verbal persuasion, and psychological and emotional states (see Table 2 on next page).

In a second round of coding, we used open coding to look for themes in the PD experiences of participants around mathematics instructional leadership and their own professional learning. This dual layered analysis provided a textural description of the aspects of PD that emerged among the participants and how those sources layered and linked with their self-efficacy development as instructional leaders (Saldaña, 2013). In the following section, we present the interpretation of this analysis.

Findings

Bandura's self-efficacy construct served as the framework for this study. During an elementary mathematics curriculum implementation year, 38 principals received district-led PD aimed at subject-specific instructional leadership for mathematics. The lead researcher studied PD activities and opportunities and how they aligned

Table 2: Round 1 Open Coding

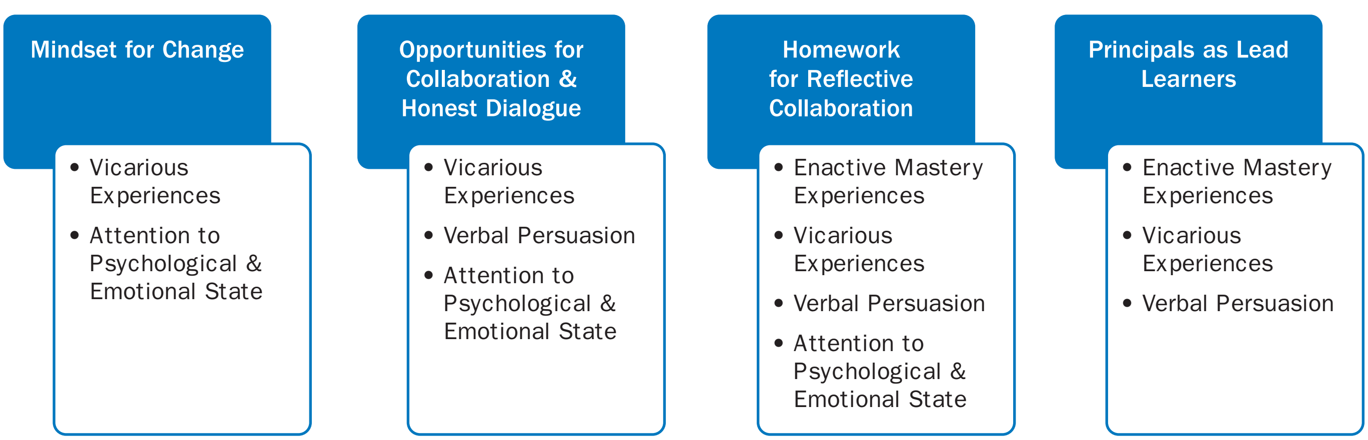
Self-Efficacy Source	Description	Examples of Coded Data
Enactive Mastery	Experience overcoming obstacles through perseverant effort	Opportunities for principals to participate in "scaffolded field experiences" to apply their professional learning back in their buildings.
Vicarious Experience	Learning mediated through modeled attainments	Opportunities for principals to collaborate with their peers to share strategies and experiences with mathematics instructional leadership practices.
Verbal Persuasion	Interpersonal support by peers, supervisors, or the community	Opportunities to discuss with district leaders and principal peers in a professional learning space on how to impact improvement through instructional leadership.
Psychological or Emotional State	Emotional arousal given a particular setting or experience	Opportunities to share success, frustration, etc. in a safe environment related to leading instruction.

with principals' instructional leadership self-efficacy. Four recurring themes emerged throughout the year-long PD activities for principals. These themes illuminate how district-led PD supported principal participants as mathematics instructional leaders in their buildings. Each of the themes emerged based on their coded alignment to two or more of the four sources of leadership self-efficacy. The themes were: (a) mindset for change; (b) opportunity for collaborative, honest dialogue; (c) homework for reflective observation; and (d) leaders as learners. A visual mapping of the four self-efficacy sources in relation to the four significant PD outcomes identified by the research are found in Figure 3 below.

Mindset for Change

Early in the PD process, even prior to adopting or implementing the new mathematics curriculum, district leaders stated they were "planting the seed" of change in a variety of ways. Throughout the PD and within the data, district leaders recalled the foundational work leading up to the implementation year (e.g., PtA book study; speaker Dr. Matt Larson, then current NCTM president). Principals acknowledged that their new PD experiences were not just

FIGURE 3.
Key themes framed around Bandura's sources of self-efficacy



about gaining knowledge about mathematics but unpacking their overall mindset about teaching and learning in their building. As one participant shared,

> I have had to really think about my beliefs of math instruction and how that aligned with the new curriculum. I feel that the "why" on my beliefs have grown and that I have a better understanding of the math instruction learning.

Another participant identified a shift in perspective when moving into a leadership role, explaining,

> Moving from a teaching position to an administrative position heavily influenced that change. My lens is different comparing what I did in my classroom to the systematic change that needs to happen to guide a whole building.

These participants shared how they negotiated and reflected on their own experiences and beliefs about teaching mathematics and how they perceived the need to think differently now that they were building leaders. After many principals shared their experiences co-planning or co-teaching a mathematics lesson with their peers at a monthly PD session, others identified learning from their peers' experiences (i.e., vicarious experiences) and impacting their thinking about their leadership role although they had not yet enacted those exercises yet. As one leader explained, "It's been a bit like the blind leading the blind in a sense. Though I had experience with curriculum, transferring that experience to leading others through the change is a bit difficult." Providing opportunities for principals to learn from one another's experiences and see similarities between their own prior experiences and now new perspectives on mathematics created a healthy environment of social comparison (Bandura, 1977), with principals all building upon their prior knowledge in new ways.

In addition to the impact vicarious experiences can have on mindset, Bandura (1994) explains that attending to individuals' psychological and emotional state impacts their moods and hence, their judgment of self-efficacy. District leaders designed professional development activities that invited principals to question historically accepted practices in the previous curriculum that now lacked strong evidence to continue (e.g., homogeneous grouping by ability). Principals were asked to bring their prior professional experiences to the table to grapple with how they would support or defend old and new practices, examine and ensure alignment between current mathematical teaching practices and evidence- based practices within their building. Analysis of the data illustrated that, for some, the new curriculum matched their beliefs and philosophy about teaching mathematics. One leader shared, "I certainly understand the [new math curriculum] philosophy better. I see the changes in approaches that teachers are taking. I have a better grasp of the importance of routines and how they impact student learning." In some instances, providing opportunities for principals to engage with the new curriculum and in dialogue with peers and district leaders helped to increase their comfort level with the curricular changes. For others, it did not.

When principals did not experience a positive sense of emotional arousal while engaged in the PD process, it negatively influenced their mindset around the impetus for change. For example, one principal shared, "The greatest challenge has been pushing [the teachers] through the change from small group focus to large group focus. It was hard because I wasn't sure, and still am not sure, if I agree fully with the philosophy." Providing PD that brought these emotions and beliefs to the forefront of conversations helped district leaders to guide and plan for future sessions that further attended to principals' uncertainty by promoting and justifying the new curriculum and aligned practices. As Bandura (1977) found, without acknowledgement or attention to perceived negative or unpleasant feelings, principals will likely not confront the challenge, in this case relating to instructional leadership in mathematics, and will not persist during the change effort.

Observing principals grappling with the challenges of leading in a new space supports Stein and Nelson's (2003) call for more attention to LCK. The goal for PD was to ensure all principals had access to opportunities to examine their mathematical mindset for change, as well as to promote more consistent and coherent implementation from building to building. Our findings indicate that the extent to which leaders were offered vicarious experiences engaging with the curriculum and their attitudes or emotional responses to the PD influenced their overall view, or mindset, about the curricular change.

Opportunity for Collaborative, Honest Dialogue

Along with a mindset for change, we identified that principals' ability to collaborate in honest, reflective dialogue with colleagues about mathematics reform was a significant PD opportunity that further supported self-efficacy beliefs. This theme developed from analysis of data coded for vicarious experiences, emotional arousal, and verbal persuasion occurring during peer discussions. Often the sole instructional leader in an elementary building, monthly PD provided a structured and reflective opportunity for principals to converse and learn vicariously through others' experiences. Social comparison can be powerful in changing the beliefs of individuals and their ability to complete a task, such as leadership in this case (Bandura, 1977). When principals observed someone with similar experiences, educational backgrounds, and roles, there was often a feeling "if he/she can do it, then maybe I can too".

After the initial monthly PD observations, district leaders and the first author reflected on how to hear more from principals about their authentic experiences and challenges. In initial PD sessions, many instructional, classroom-based issues were brought up in small group conversations, however, were not addressed with the whole group when prompted. For example, in small groups, principals discussed challenges with time to allow for student exploration, particularly in intermediate grades four and five. Additionally, many principals discussed how primary teachers thought the curriculum was repetitive and were skipping lessons. However, principals were reluctant to share these instructional concerns with the larger group and most of the whole group conversations revolved around the management of curriculum change (e.g., scheduling, getting more materials). Data showed that providing space for principals to talk in small group conversations and during mathematical activities assigned monthly helped them address concerns they were facing in perhaps a safer space (psychologically). While district leaders hoped more conversations would be brought to the forefront with the whole group, the ultimate goal was to surface instructional leadership victories, questions, and concerns beyond superficial, yet important, managerial tasks. Principals offered feedback and encouragement to each other via verbal persuasion so that they might feel more confident in their ability to go back with a plan in place to support teachers (Paglis & Green, 2002).

One collaborative learning experience principals engaged in to promote a more honest and meaningful conversation was watching videos of elementary mathematics instruction with the new curriculum involving a first grade, Title I classroom in their district. After watching a video of a young child leading her class confidently through the daily math routine, administrators conversed with their tables about their impressions. Principals commented on similarities and differences from that video to what they were seeing in their buildings, impressions of the learning environment, and other observations. Overall, their small group comments and resulting whole group discussion revolved around three observations:

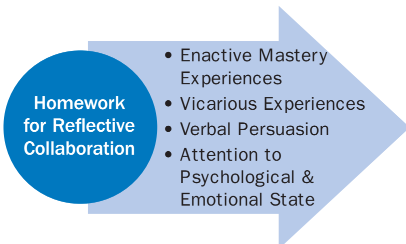
1. Principals believed most of their teachers were not comfortable enough to facilitate this type of learning yet.
2. Principals appreciated that the video was from a district, Title I school and proved that this instruction was relevant and possible.
3. Principals requested to use the video back in their schools to model what a curricular component looked like in action for teacher training.

The PD activity provided access to principals to observe the new curriculum-as-intended at an early point in the academic year.

As participants reflected on the collaborative experience afterwards, several shared the value they saw in the dialogic process. One principal noted, "The opportunities to observe teacher videos was extremely helpful to my learning. It was also important to have conversations among administration about places of struggle and success." Another reflected, "I appreciate observing lessons and working with other administrators to discuss what we saw. We also had opportunities to ask questions." These quotes help to illustrate how engaging in the vicarious experience of watching a teacher enact the new curriculum, paired with opportunities to share both psychological reactions and encouragement of each other through verbal persuasion, supported principals' beliefs as they headed back to their own settings.

Without honest dialogue, district leaders lacked the information necessary to plan for their own meaningful PD at the building level. The purposefully balanced design of PD opportunities in small and large group discussion structures ensured that feedback was as accurate and honest as possible to not only inform the curriculum change, but ongoing principal PD.

Homework for Reflective Collaboration



Early on in the PD series, district leaders emphasized curriculum implementation fidelity was a high priority. In other words, they did not want schools implementing the curriculum at various rates and levels of quality. They hoped with principal PD and strong instructional leadership, their building teachers would go all in with transitioning to the new curriculum and district mathematics philosophy.

In the beginning, many principals were at a loss for how to help their teachers instructionally. When prompted to state their greatest challenge during the curriculum reform process, their lack of experience was listed as an obstacle. As one principal stated:

> At times, it has felt like the blind leading the blind. My most important job has been to continue to educate myself about the curriculum and the new mathematical processes involved.

Other principals had similar statements related to the unfamiliar nature of their work, "I have not actually taught this curriculum for a period of time like I had with prior curriculum" and "It is new to me as it is new to the teachers." With limited prior knowledge on new reform-based curriculum paired with time away from daily classroom teaching, this environment placed principals in a vulnerable position to lead and promote change. Providing opportunities, like grade-level instructional leadership homework for principals to experience and practice enacting instructional leadership practices, became a focus of PD to develop principals' positive beliefs as mathematics leaders. Without engaging in mastery and vicarious experiences, principals might continue to feel ill equipped to lead and resist or avoid change (e.g., emotional arousal). In this case, research has shown that these negative beliefs could negatively impact principals' future actions to fully implement the intended change (Bandura, 1977).

Each month, principals received observational homework assignments at specific grade levels to complete in their buildings between PD sessions. These vicarious experiences included prompts designed to focus principals' observations on student and teacher actions, new curriculum structures, and evidence-based practices in mathematics teaching and learning (e.g., NCTM, 2014). Along with assigned observational homework, principals were encouraged to co-plan, co-teach, or even fully teach a mathematics lesson from the new curriculum.

Homework served a variety of PD purposes. Assigning a specific grade level provided principals with similar mathematics topics and challenges to discuss within the curriculum when they debriefed at subsequent PD sessions. Spanning 25 school buildings, the homework activities offered a starting point to launch conversations where principals voiced their observations and concerns and shared their teachers' instructional victories and challenges. As principals progressed from observations to co-planning and even teaching, their experiences provided additional opportunities for honest dialogue and feedback (another emergent theme). In turn, sharing experiences with others and providing and receiving feedback engaging in verbal persuasion further developed the principals' instructional leadership capacity to address similar obstacles within their own buildings.

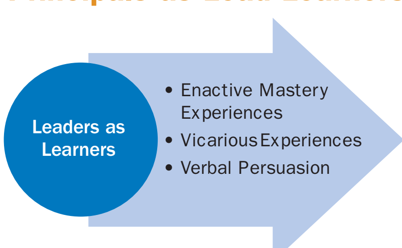
For example, one administrator offered to share her experience using a specific observational protocol she received from an optional curriculum training. The protocol, which she received from a trainer from the adopted curriculum, was directly aligned to the new curriculum and provided specific student and teacher actions to focus her observation. She shared that, with the curriculum being new, the pressure of evaluation was a struggle. By using the protocol, she shared that the evaluation process became a learning experience for her as the observer and her teacher being observed and provided feedback. She stated that "the tool (protocol) really helped me learn more about the curriculum" and that she "liked how explicit the tool was." Even without seeing the entire mathematics lesson, she felt she had valuable insights to discuss with her teacher. To her, seeing those evidence-based practices firsthand and helping her teacher see them as well was a moment of empowerment as an instructional leader. In her words, "if we reinforce those things, we will see that repetition." This principal's statements support previous research that principals with LCK have a significant advantage to be instructional leaders as they actively, rather than passively, support change and lead with purpose (Brazer & Bauer, 2013; NCTM, 2020; Nelson, 1999). The opportunity to engage in a mastery experience supported by the structures of the PD homework and resources offered this leader the opportunity to grow in her confidence in her beliefs as an instructional leader (e.g., self-efficacy).

Similarly, other principals identified positive shifts in their self-efficacy attainment because of engaging in both the homework opportunities and the subsequent debriefs with colleagues. As one participant shared:

> I love how [district leaders] always gave us an assignment to go back to the building and partake in. This was a great learning experience for me. Then coming back and sharing about that experience and hearing about other buildings was powerful.

Similarly, another principal reflected on the impact of the reflective assignments, sharing, "Doing focused observations and being allowed to debrief with peers was very powerful." Shared principal experiences such as structured homework and other instructional leadership tasks created district-wide consistency as the new vision of elementary mathematics instruction circulated from elementary building to building. One principal stated that teachers were already recognizing in the first year of implementation that "this is system-wide and if I don't play my part, then it is an issue." Such sentiments help to highlight the power of collaboration in fostering a sense of common purpose among district leaders, which, when scaffolded with activities to support their own growth, can support such system-wide change (Cohen et al., 2013).

Principals as Lead Learners



As previously mentioned, having a principal share her experience using a mathematics-specific observational tool as an avenue for professional learning sparked immediate action by district leaders. The team convened a group of elementary teacher leaders, curriculum facilitators, and principals to modify their previous informal walkthrough observation protocol to include a section specific to mathematics teaching and learning observational indicators. The new observation protocol was called the *Effective Mathematics Practices* (EMP) tool and was informed by NCTM's Principles to Action practices (NCTM, 2014). After strong principal support for the EMP tool creation based on key principal sponsors at previous PD sessions (vicarious learning, verbal persuasion), observational and survey data quickly revealed that translating the vision and intended use of the EMP tool would require numerous opportunities for practice. One issue was that the EMP tool was created to be a multi-use resource for principals, instructional coaches, and teachers to help drive the vision of mathematics district wide. District leaders intended for the EMP tool to serve three primary purposes for principals: 1) increase principals' LCK (e.g., understanding of what quality mathematics teaching and learning should look like) to recalibrate their principals' observational lens to what mathematical instructional practices mattered most, 2) connect evidence-based practice to new curriculum structures they wanted/needed to see, and 3) support principals in leading mathematical conversations about practice with teachers, parents, and students.

However, after four months of using the EMP tool during monthly homework observations, principals continued to voice misconceptions regarding the intended use and purpose of the EMP tool. For example, in small group conversations about their use of the EMP tool, many principal responses documented by the lead researcher were non-mathematics related. For example, they stated they "saw the same thing I see usually", that "it (the EMP tool) was a lot of reading… (implied for teachers to use)" and "...it felt overwhelming (using the tool) because it was flipping through a lot." The researcher noted a number of principals' views of how to use the tool were not based on the purposes or expectations they were given by district leaders. Comments such as "Teachers could use this" and "I can't hand this whole document to a teacher" projected a perception that this document was more for teacher use and not to help them lead instructionally. Comments about the EMP tool being overwhelming revealed that principals were not focusing their observations on targeted practices, but instead trying to observe everything. District leaders recognized that PD design needed to change so that principals uniformly saw the EMP tool as a professional learning tool for them and not merely as something to be given to someone else or for someone else's learning.

District leaders steadily persuaded, encouraged, and provided instructional leadership feedback to principals through mastery experiences using the EMP tool, including various mathematical instructional rounds (City et al., 2009). Through this process, a small group of principals observed mathematics instruction and then reflected on the observations they documented using the EMP tool as a framework. District leaders prompted principals to spend their time discussing, "What would be next steps for you (the principal)?". As part of one Instructional Rounds session, principals composed and agreed upon a list of next steps as instructional leaders back in their buildings. In one session, this included the development of specific reflective prompts that encourage discussion with the teacher during post-observation conversations and revisited prior mathematics PD as a way to support the curriculum transition focused on quality teaching practices first. Engaging in instructional rounds as a mastery experience helped principals more purposefully use the EMP tool to support instructional change by promoting targeted, math-specific conversations with teachers. In response to their experiences participating in instructional rounds, principals shared:

> I feel like I learned so much. I was surprised. Math conversations are looking more natural. It's more natural and comfortable (for teachers) to carry on a conversation.
>
> It really helped you see where teachers are still uncomfortable, but they are trying…they are asking safe questions.

In subsequent PD sessions, principals shared further ideas and examples of how they translated or had already implemented what they learned from the instructional round experience (vicarious experiences) with their peers. For example, one principal explained that using the observational (EMP tool) helped her see how she could break her building's professional development calendar into different foci each month based on the sections of the tool (e.g., mathematical practices). Through her small group's conversations, she also decided to add reflection questions from the EMP tool to her weekly newsletter to teachers to help bring the practices and reflective thinking to the forefront. Through these brainstorming sessions, principals received feedback from their peers on ways they could continue to enact instructional leadership practices at their buildings focused on mathematics.

PD sessions also enabled principals to address some of their worries by putting their ideas into practice (attending to emotional and psychological state). Principals discussed the challenge of time and pacing, especially time in meaningful conversations with teachers. As one principal stated, "The heart of the experience is in the conversation, not just the observation. [It] makes me think about having peer observations in pairs versus solo so that they [teachers] can reflect about the experience." Sharing their candid concerns helped principals bring to light issues that they might face and persevere through in the future. Previous research supports that when educators (e.g., teachers, principals) feel supported with feedback (verbal persuasion) to try new practices, they are more likely to confront obstacles to implementation with a plan and persist through times of change (Bandura, 1977; Smith & Guarino, 2005; Tschannen-Moran & Gareis, 2004).

These comments show that over time, collaboration, and repeated opportunities to practice learning to lead mathematically (e.g., using the EMP tool), led to shifts in principals' thinking as instructional leaders of mathematics. Rather than general, non-mathematics specific leadership actions, principals translated their mathematics PD experiences to mathematics-focused leadership activities. Ongoing, job embedded PD was essential in offering principals multiple opportunities to enact mastery experiences through practice with instructional leadership resources to drive change. Principals gained knowledge and skills in applying ideas at both the PD sessions and back in their buildings. Previous research supports this structure, showing that these principals invested their time in instructional leadership practices because they were relevant and aligned to their direct job responsibilities and environment (Augustine et al., 2009). Further, access to verbal persuasion, both from district leaders and principal peers, solidified principals as lead learners where they could establish a cohesive vision of teaching and learning mathematics district-wide (Katterfeld, 2013).

Discussion and Implications

This study examined district-led PD activities for principals, designed around Bandura's four sources of self-efficacy, to understand in what ways PD could influence principals' self-efficacy as mathematics instructional leaders. Findings show that PD designed around self-efficacy sources provided an environment where principals could interrogate their own beliefs and mindset around mathematics teaching practices, interact authentically with other colleagues to address challenges and opportunities, and take risks as instructional learners and leaders. Principals act as the bridge between district and building-level initiatives and as such are in a unique position to impact and drive change (Stein & Nelson, 2003). This district-led PD provided principals with knowledge (e.g., LCK, PCK), support, and opportunities to practice their mathematical instructional leadership skills in a safe learning environment. Previous research has found that when principals' knowledge and skills are enhanced, they are more equipped to establish a shared vision for high-quality instruction, more empowered to take an active role in reform, and more likely to influence evidence-based practices within their buildings (Nelson, 1999; Nelson & Sassi, 2003). Therefore, this study highlights a unique opportunity, and call for future research, on increasing the focus on principals as instructional leaders based on their influence on teachers' professional growth (Backor & Gordon, 2015; Burkhauser, 2017) and instructional practice (e.g., Supovitz et al. 2010).

The combination of self-efficacy sources in PD should not be overlooked as a potentially impactful feature of reform as these sources can enrich the overall beliefs of individuals (Labone, 2004). This study leveraged the construct of self-efficacy as a framing to design and investigate PD due to its proven connections to individuals' (e.g., teachers, leaders) cognitive, motivational, and behavioral characteristics (Bandura, 1977, 1986, 1997; Federici & Skaalvik, 2011, 2012; Tschannen-Moran & Woolfolk-Hoy, 2007). The four sources of self-efficacy attainment can provide a clear and powerful roadmap to design PD activities and experiences that connect internal beliefs and emotions to external actions and motivations.

Twenty-first century principals are expected to be transformative leaders and champions of change as they support programs and PD in their buildings (Fullan, 2002; Leithwood & Day, 2010; NPBEA, 2018). To lead and not just manage change, principals must be equipped with the knowledge, skills, and dispositions to meet such challenges. Findings from this study add to literature on both principal PD and, more broadly, that of other administrators charged with instructional leadership. This is due to its focus on developing administrators' confidence and competence in subject-specific curricular areas like mathematics. Specifically, the implications of this study indicate:

- PD for administrators needs to be focused on developing a mindset for change. Leaders need an understanding of the rationale and research that backs the curricular and instructional change being asked of their teachers.
- PD for administrators needs to focus on both subject- and leadership-specific content and actions to support their development as instructional leaders.
- PD for administrators should offer collaborative "safe spaces" for instructional leaders to ask questions, share ideas, and voice concerns as they plan for and enact curricular and instructional change in their buildings.
- PD should offer "mastery experiences" for administrators to implement instructional leadership roles (e.g., observations, leading PD) with feedback to support their development as content-focused leaders.

As a case study, this work is not intended to be generalizable to other settings, therefore we recommend continued research in this area. Additional studies can continue to examine administrators' beliefs about their ability to enact instructional change, especially in areas of high need like mathematics. Further investigations of the role administrators' beliefs can play on their instructional leadership commitment and persistence can add to the body of existing research (Smith & Guarino, 2005; Tschannen-Moran & Gareis, 2004).

Conclusion

The changing landscape of mathematics education and other curriculum reform environments require building principals to be fully engaged and equipped to lead sustainable change (Elmore, 2004). Principals are expected to be instructional leaders who model reflective learning so that they can influence the instructional capacity of their staff for the benefit of student success (NPBEA, 2018). Having access to authentic instructional leadership experiences, conversations, and opportunities to see themselves as lead learners provides ownership of not just general, but subject-specific reform. Rather than look to external sources to influence best practices of mathematics in their building, with increased access to PD, principals are positioned to take on mathematics instruction as a building-level issue (Nelson & Sassi, 2003). This research continues the conversation on PD structures and activities that can empower principals through their beliefs as champions of change and school improvement. When PD is carefully designed for leaders around mathematics self-efficacy, it can impact principals' beliefs as to how they can influence, apply and justify change—a powerful triad as they navigate the complexities of their role in education. ✪

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