A Model for Selecting Exemplary Mathematics and Science Teacher Leaders

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Abstract: Teachers' situated knowledge of the classroom and teaching suggests that they can play an important role in promoting and supporting change in teaching practice even if they are not formally designated as leaders. We selected 32 secondary mathematics and science teachers and supported them in enriching their instructional practice and in becoming instructionally-focused teacher leaders. We describe the qualities we sought in teachers who were to become effective teacher leaders, and we share the ways in which we assessed those characteristics. We explain our rationale, instruments, and interview questions used in the selection of the teacher leaders. After four years, our teachers have served and continue to serve in numerous formal and informal leadership roles. We offer three recommendations to administrators for nurturing teacher leaders.

Teacher leaders can be an important resource to bring to bear in our efforts to continually improve schools. Research on school development and change emphasizes the need for teachers to extend their sphere of influence into leadership activities. This is based on the belief that they, with their proximity to the classroom, can implement changes that improve teaching and learning (Crowther, Kaagan, Ferguson, & Hann, 2002; Harris & Muijs, 2005; Lieberman, Saxl, & Miles, 2000). Their situated knowledge of teaching and the classroom setting suggests that they can play an important role in promoting and supporting change in teaching practice whether or not they are formally designated or defined as leaders (Mangin & Stoelinga, 2008). Researchers have identified several reasons to develop teacher leaders in schools: demands currently made of principals are practically impossible to meet; principals may not have content-specific expertise; a teacher's tenure at a site is typically longer than a principal's average 3–4 year tenure; and the teaching profession provides few opportunities for advancement, so serving as a teacher leader provides an important opportunity for promotion (Danielson, 2007; McNeill, Lowenhaupt, & Katsh-Singer, 2018; York-Barr & Duke, 2004). The Teacher Leadership Exploratory Consortium affirmed, "This form of leadership can be distinguished from, but work in tandem with, formal administrative leadership roles to support good teaching and promote student learning" (2011, p. 3).

Teacher-leadership literature includes a description of a wide variety of work at multiple levels in educational systems—work that is focused on instructional and professional development. We adopt York-Barr and Duke's (2004) definition of teacher leadership as "the process by which teachers, individually or collectively, influence their colleagues, principals, and other members of the school community to improve teaching and learning practices with the aim of increased student learning and achievement" (pp. 287–288). Our particular interest is in instructionally-focused teacher leaders in mathematics and science.

Through a grant from the National Science Foundation, we supported 32 secondary mathematics and science teachers to improve their instructional practice and become teacher leaders. Our project goals were to (a) support strong mathematics and science teachers in enriching their practice through engagement with

content and students' thinking so that they could emerge into extraordinary teachers, and (b) to support these teachers in becoming teacher leaders who would then support teachers at their school site, teachers in the district and county, and student teachers.

We know that teaching effectively is complicated work, and furthermore, we knew that identifying those features of instructional practice that we wanted our teachers to exhibit––along with appropriate characteristics related to becoming a teacher leader–– would be a challenge. We were also aware of the changing landscape of mathematics and science teaching given the recent adoptions of the *Common Core State Standards for Mathematics* (National Governors Association & Council of Chief State School Officers, 2010) and the *Next Generation Science Standards* (Achieve, Inc., 2013). These new frontiers simultaneously provided opportunities and challenges. Our goal in this article was to describe the qualities one might seek in teachers who become effective teacher leaders and to share one way in which we assessed those characteristics.

Qualities of Teachers and Teacher Leaders

The Teacher Leader Model Standards guided our thinking about what qualities we wanted to develop in our teacher leaders (Teacher Leadership Exploratory Consortium, 2011). Those qualities stemmed from a subset of the Standard Domains: I) fostering a collaborative culture to support educator development and student learning, II) accessing and using research to improve practice and student learning, III) promoting professional learning for continuous improvement, and IV) facilitating improvements in instruction and student learning. We knew that in order to support teachers who could engage teachers in these experiences, the teacher leaders we selected would themselves have to be able to work collaboratively (Domain I), access and use research to improve practice (Domain II), engage personally in continuous improvement (Domain III), and be able to facilitate student learning (Domain IV). Therefore, we chose to focus on two particular characteristics when selecting teacher leaders: effective teaching practice (Domains II and IV) and learner disposition (Domains I and III). In particular, we knew that effective teachers and teacher leaders should have content-specific pedagogical expertise.

Effective Teaching Practice

Given that the teachers we selected would become teacher leaders, we wanted to select teachers who already exhibited effective instructional practices (Knight, 2006). As Johnson (2016) pointed out, effective teaching practices are essential for activities such as modeling effective lessons and coaching peers in their classrooms. To identify these effective teaching practices, we used Boston's (2012) observable indicators of ambitious mathematics instruction, which include 1) using cognitively challenging tasks, 2) providing opportunities for students to engage in high -level thinking and reasoning and to explain their reasoning verbally and in written work, and 3) exhibiting high expectations for students' learning. We agreed that these indicators would be similar for both mathematics and science teachers. We thus sought to identify the degree to which teachers exhibited these features of practice in the materials our applicants submitted.

Teacher as Learner

We know that the most qualified and expert professionals in any field can always grow and learn, so we viewed those who recognize their capacity for continual growth as a hallmark of a successful professional, and in particular, of a successful teacher leader. Therefore, we took the position that those who become teacher leaders should exhibit an explicit view of themselves as learners. Harrison & Killion (2007) posited, "Among the most important roles teacher leaders assume is that of learner. Learners model continual improvement, demonstrate lifelong learning, and use what they learn to help all students achieve" (p. 76). In addition, there are several aspects of holding a learner disposition that can support one's capacity to build relationships with others. These aspects include an ability to admit mistakes and acknowledge room for growth, a respectful disposition for the profession and the autonomy of others, a willingness to show vulnerability, and a stance toward collaborating with other teachers to solve difficult issues of practice (Lasater, 2016). Silva, Gimbert, & Nolan (2000) found that teacher leaders who saw themselves as colearners more readily obtained buy-in from colleagues and promoted professional development in others by modeling professional learning. We thus took seriously the notion that as both teachers and teacher leaders, every teacher we selected should have a learner disposition.

Application Materials and Rationale for Inclusion

We asked teachers to submit materials that reflected both the orientation of the professional development and the orientations and expertise we sought in those who would be selected. Table 1 displays the application components, and they are described and explained in the following sections.

Table 1

Application Components

A. Unedited 10-minute video clip with responses to reflection questions:
   1. In what ways do you consider this clip to be typical of your teaching?
   2. Describe the mathematics/science your students were engaged with during the clip.
   3. Describe what stands out for you in this clip.
   4. What do you see as the strengths of the classroom experiences shown in this clip?
   5. We all know that there is no perfect lesson. If you could change one aspect of the classroom experiences shown in the clip, what would it be and why? (The one aspect can be related to you, your students, your questioning, their engagement, and so on).

B. Responses to two mathematics OR science student-thinking questions

C. Response to the prompt, *What are your immediate and long-term goals in mathematics or science teaching***?**

D. One letter of recommendation that addresses

   how the applicant might benefit from the fellowship.

   how the other fellows might benefit from this applicant's participation.

   any strong interpersonal or leadership qualities of the applicant.

   an assessment of the applicant's teaching.

E. One set of transcripts reflecting coursework at the undergraduate level and above.

Ten-Minute Video Clip with Responses to Reflection Questions

We asked applicants to submit an unedited, continuous 10-minute video clip of their classroom teaching. We also asked them to respond to the following five prompts:

1. In what ways do you consider this clip to be typical of your teaching?

2. Describe the mathematics/science your students were engaged with during the clip.

3. Describe what stands out for you in this clip.

4. What do you see as the strengths of the classroom experiences shown in this clip?

5. We all know that there is no perfect lesson. If you could change one aspect of the classroom experiences shown in the clip, what would it be and why? (The one aspect can be related to you, your students, your questioning, their engagement, and so on).

Rationale. The video clip provided a window into the teachers' instructional practice. The teachers could select any clip they wanted, so we assumed that we received an "upper bound" in relation to the teacher's perception of their most effective practice. The clip allowed us to view how the teachers engaged with students and the lesson content, how they supported students' learning, and whether and how they responded to students' content-specific ideas. The five reflection questions provided opportunities to gather additional information about the lesson content, the teacher's articulation of the lesson content, and in particular, the teacher's reflection and growth process.

Responses to Two Student-Thinking Questions

We asked applicants to respond to prompts about students' content-specific ideas[1] as another measure of their instructional practice. In the next two sections we share a subset of the items we used in our application materials.

Math example. A student declares that $y = x^2 + 2x - 3$ and $y = 2x^2 + 4x - 6$ are the same quadratic because "they have the same roots. The coefficients of the second are twice as much as coefficients of the first. We know we can multiply through an equation without changing the solution set, as in $x^2 + 2x - 3 = 0$ and $2x^2 + 4x - 6 = 0$."

a. Is the student correct? Why or why not?

b. How would you respond to this student?

Science example[2]. This item includes partial student responses to a scientific phenomenon. Imagine you are the teacher of these students. Respond to these prompts:

a. Indicate which partial response is most correct and describe why it is correct.

b. Describe your next lesson and explain how it would support growth in students' understanding.

A teacher asks her students what happens when an apple falls on the ground, rots, and disappears.

Sam: I think small organisms use it for energy and building.

Jess: I think it is just something that happens over time. It just goes away.

Taylor: I think wind and water soften it and over time it just dissolves in pieces.

Terry: I think the atoms and molecules in the apples just break apart.

Rationale. Because we know that understanding students' reasoning and building on that reasoning are critical components of effective teaching (Jacobs, Lamb & Philipp, 2010), we asked teachers to share their understanding of students' reasoning and for their next steps in supporting or extending the students' understandings. We identified the degree to which teachers understood the mathematical/scientific ideas underlying the students' reasoning and the degree to which teachers built on these ideas to inform their next steps.

Essay Response

We asked applicants to respond to the following prompt: What are your immediate and long-term goals in mathematics or science teaching and learning, and how do you hope that this fellowship will further those goals?

Rationale. In posing this prompt, we sought to understand the teachers' goals and whether they aligned with the professional development goals. We also looked for evidence that teachers held a disposition as a learner. Although we asked applicants to discuss how the fellowship might support them in furthering goals for mathematics and science teaching and learning, some applicants instead provided a list of the experiences or expertise that they had demonstrated in other settings. We noted these responses as potential indications that the applicant did not necessarily believe that there was more to learn. Others, however, provided evidence of their reflective, inquisitive nature. For example, one of the applicants who was selected as a fellow wrote, "Had I not pursued this [fellowship opportunity], I would not have started to question what I do––and most importantly, how I can learn to do it better. I have rekindled a desire within me to improve my craft, and that energizes me to dream how different my future years in teaching can be." The essay thus provided a window into the disposition toward learning that we might expect from the teachers during professional development experiences.

References

Similar to other application materials used for hiring or selection purposes, we asked applicants to submit a letter of recommendation and to provide the names of two additional references. However, we were specific in the information we sought from the recommenders, which is listed below:

- In what capacity and for how long has the recommender known the applicant?
- How might the applicant benefit from this fellowship?
- How might the other fellows benefit from the applicant's participation?
- Describe any strong interpersonal or leadership qualities of the applicant.
- Provide the recommender's assessment of the applicant's teaching.

Rationale. In the request for a letter of recommendation, we included a description of this fellowship opportunity so that recommenders would have a sense of the opportunity the applicant was seeking and the kind of information we hoped to learn about the applicant. We provided prompts in order to obtain information on three teacher qualities we valued: their ability to collaborate effectively, their general teaching performance, and their possible benefit from the fellowship.

Selection Criteria for Application Materials

We reviewed applications by analyzing the degree to which the provided evidence displayed effective teaching practices and a learner disposition. When analyzing effective teacher practices, we considered teachers' attention to students' reasoning, the quality of their interactions demonstrated in the video clip, and the strength of content knowledge. We analyzed

four sources of evidence: (a) 10-minute video clips and reflection on the clip, which provided an opportunity to see the teacher "in action"; (b) responses to student thinking items, which provided an opportunity to show how teachers would respond to individual students' ideas; (c) references and recommendations from individuals who had seen the teacher in his/her classroom; and (d) teacher responses to interview questions that related to their teaching practice (see next section). Evidence for teachers' learner disposition came from (a) their reflections on their video clip, (b) their essay response, and (c) their responses to the interview questions.

After reviewing application materials, we selected approximately one third of the teachers for an interview. The interview process is discussed below.

Teacher Interviews

Interviews were used to determine final teacher selections. At least two project leaders used Skype to interview applicants who were selected from the application materials. They used six interview questions to further assess the quality of the teachers' learner disposition and their reflectiveness on their mathematics or science teaching. Because we knew that the teachers would work together collaboratively for several years, we also sought teachers who had strong interpersonal skills. We thus posed the following questions:

1. What is the single biggest reason you would like to participate in this project?

2. What is one aspect of your teaching that you have been working to improve? Share a specific example.

3. Is good teaching just good teaching, or is there something particular about effective mathematics (science) teaching that is specific to mathematics (science) and different from effective teaching in general?

4. We imagine that you have opportunities to work with other teachers at your school site. Can you describe what one of those relationships is like?

5. Many of us have experienced instances of mentoring that were not effective. What do you think are some of the common pitfalls of mentoring relationships among professionals?

6. Briefly, how do you see your career trajectory unfolding in the next five or more years?

Interview Selection Criteria

Teacher interview responses were used to determine the degree to which the applicant met six criteria:

a. a set of learning goals that align with the focus of the professional development;

b. a commitment to learning and growing as a teacher (that is, the teacher recognized that there was always room to grow);

c. a commitment not only to teaching generally, but to teaching mathematics or science specifically;

d. a willingness and interest in collaborating with a community of learners;

e. a stance of reflectiveness about teaching and learning; and

f. a commitment to emerging into a teacher leader.

Whereas the application materials focused primarily on the applicants' mathematics or science teaching practice, the interviews focused on their teaching practice along with their collaborative practice, learner disposition, and leadership potential. Given both the project's long-term nature (five years) and goals, we felt that these were all critical characteristics that were important for teachers to learn and grow alongside their peers.

Brief Report of Fellows' Participation: Four Years After Selection

Four years ago, we selected our teachers to become teacher leaders. Each year we supported the teachers with 10 days of professional development, which was comprised of one intensive week during the summer and five follow-up days throughout the academic year. Since the beginning of the project, the teachers have emerged into reflective and productive teacher leaders. For example, they now promote collaborative cultures, serve in leadership roles, provide professional development to others, and support teachers statewide and nationally by presenting at conferences. Our teacher leaders led more than 90 professional development opportunities for teachers, and this year 19 of these teachers provided 35 professional development experiences for other teachers. Twenty-six of our teacher leaders have served in leadership positions that include department chair, science/math resource teacher, support provider for beginning teachers, MESA (Mathematics, Engineering and Science Achievement) advisor, curriculum writing team member, district math curriculum specialist, TK-12 district science

resource teacher, district standards implementation director, and research partner to help increase the number of Latinas in STEM fields. Similarly, over the past two years, *every* teacher that we selected has served as a guide teacher for a university's student teachers, while each year about one third of the teachers presented at state and national conferences.

Discussion

We sought to select and support instructionally-focused teacher leaders. Teachers working together have the potential to lead instructional improvement regardless of formal leadership authority (Mangin & Stoelinga, 2008). Developing teacher leadership can have the clear benefit of greater teacher collaboration and an associated improvement in teachers' self-efficacy and self-esteem. Increased self-efficacy can bolster a teacher's willingness to take risks and try new instructional practices that may positively impact teacher effectiveness (Harris & Muijs, 2005; Lieberman et al., 2000). We see effective teachers as leaders who foster a collaborative culture to support peer development and facilitate improvements in instruction and student learning.

As noted earlier, our teacher leaders have served and continue to serve as formal department heads and subject leads. As *lead teachers*, some retain a teaching commitment but lead school-level or district-level instructional teams. In addition, our teachers have undertaken *informal leadership* (Leithwood, Jantzi, & Steinbeck, 1999), in which they share their expertise in the improvement of classroom instructional practices through engagement with their colleagues and by bringing new research-based ideas to their schools.

Administrators have a central role in nurturing teacher leadership (Crowther et al., 2002; Harris & Muijs, 2005). It is important that they identify those teachers with strong content knowledge, attention to student thinking, exemplary practice, a learner disposition, and those for whom professional relationships foster innovation. But while these qualities may be necessary, they may but not sufficient. We offer three additional recommendations:

1. Select teacher leaders well (we encourage you to use the framework and application materials we shared, and revise as appropriate). Administrator goals for teacher leaders may vary, so we encourage them to think of this work as a jumping off point––a frame for thinking about the information to gather from teachers and the criteria they can apply in selecting them. Our biggest finding is that teacher learner disposition was more important for the growth of teacher leaders' teaching and leading practices than traditional hiring criteria.

2. Create a climate to support collaboration and inquiry around teaching practice and student learning. Administrators can promote school organizational conditions that enhance leadership learning. Gigante and Firestone's (2008) study suggests that teachers who appear to support other teachers' development have access to particular interrelated social and material resources. These include collaboration time, a climate of trust, and acknowledgement and support from administrators. Furthermore, interpersonal relationships between principals and teachers can positively influence development. In particular, results of a small scale study by Szeto and Cheng (2017) suggest, "If principals routinely shared their visions and built trust through interactions with teachers, it would facilitate teacher leader development in the schools" (p. 365).

3. Recognize that everyone brings their own expertise. We sought teachers with a disposition for learning, which encompassed an orientation to learn from their peers. But it is also important that all members of the community, even those with more positional authority such as administrators and university faculty, "make genuine and visible efforts to position all group members including themselves as peers to the extent possible" (Whitney, 2013, p. 88).

Leadership enables individuals to work together for better learning for students (Donaldson, 2007). Administrators can put resources behind the efforts of teacher leaders by extending the capacity of teachers to work collaboratively (Gigante & Firestone, 2008; Harris & Muijs, 2005). They should understand that their own goals and initiatives can best be addressed by treating teacher leaders as partners. We can strengthen schools' performances by acknowledging the vital role of teacher leaders.

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Notes

[1]We provided four items for the science teachers and asked them to select and respond to two in order to account for the different content areas in science.

[2]Adapted from Keeley, Eberle, & Dorsey (2008).

References

Achieve, Inc. (2013). *Next Generation Science Standards.* Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS.

Boston, M. (2012). Assessing instructional quality in mathematics. *Elementary School Journal*, *113*(1), 76–104.

Crowther, F., Kaagan, S., Ferguson, M., & Hann, L. (2002). *Developing teacher leaders: How teacher leadership enhances school success.* Thousand Oaks, CA: Corwin Press.

Danielson, C. (2007). The many faces of leadership. *Educational Leadership, 65*(1), 14–19.

Donaldson, Jr., G. A. (2007). What do teachers bring to leadership? *Educational Leadership, 65*(1), 26–29.

Gigante, N. A., & Firestone, W. A. (2008) Administrative support and teacher leadership in schools implementing reform. *Journal of Educational Administration, 46*(3), 302–331.

Harris, A. & Muijs, D. (2005). *Improving schools through teacher leadership.* New York: Open University Press.

Harrison, C. & Killion, J. (2007). Ten roles for teacher leaders. *Educational Leadership, 65*(1), 74–77.

Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education, 41*(2), 169–202.

Johnson, K. G. (2016). Instructional coaching implementation: Considerations for K-12 administrators. *Journal of School Administration Research and Development, 1*(2), 37–40.

Keeley, P., Eberle, F. and Dorsey, C. (2008). *Uncovering student ideas in science––Another 25 formative assessment probes* (Vol. 3). Arlington, VA: NSTA Press.

Knight, J. (2006). Instructional coaching: Eight factors for realizing better classroom teaching through support, feedback and intensive, individualized professional learning. *The School Administrator*, *63* (4), 36–40.

Lasater, K. (2016). School leader relationships: The need for explicit training on rapport, trust, and communication. *Journal of School Administration Research and Development, 1*(2), 19–26.

Leithwood, K., Jantzi, D., & Steinbeck, R. (1999). *Changing leadership for changing times.* Buckingham: Open University Press.

Lieberman, A., Saxl, E. R., & Miles, M. B. (2000). Teacher leadership: ideology and practice. In M. Fullan (Ed.), *The Jossey-Bass reader on educational leadership.* San Francisco, CA: Jossey-Bass.

Mangin, M. M., & Stoelinga, S. R. (2008). *Teacher leadership: What it is and why it matters.* In M. M. Mangin & S. R. Stoelinga (Eds.), Effective teacher leadership: Using research to inform and reform (pp. 1–9). New York: Teachers College Press.

McNeill, K. L., Lowenhaupt, R. J., & Katsh-Singer, R. (2018). Instructional leadership in the era of the NGSS: Principals' understandings of science practices. *Science Education, 102,* 452–473.

National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common Core State Standards for Mathematics.* National Governors Association Center for Best Practices, Council of Chief State School Officers: Washington, DC.

Silva, D. Y., Gimbert, B., & Nolan, J. (2000). Sliding the doors: Locking and unlocking possibilities for teacher leadership. *Teachers College Record, 102*(4), 779–804.

Szeto, E., & Cheng, A. Y-N. (2017). Principal–teacher interactions and teacher leadership development: Beginning teachers' perspectives. *International Journal of Leadership in Education, 21*(3), 363–379.

Teacher Leadership Exploratory Consortium. (2011). *Teacher leader model standards.* Carrboro, NC: Author. Retrieved from http://www.teacherleaderstandards.org/downloads/TLS_Brochure.pdf

Whitney, A. E. (2013). When university faculty nurture teacher leadership: 'horizontal' practices and values in a professor's work with teachers, *International Journal of Leadership in Education, 16*(1), 71–93.

York-Barr, J., & Duke, K. (2004). What do we know about teacher leadership? Findings from two decades of scholarship. *Review of Educational Research, 74(3)*, 255–316.