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The need for STEM teacher leadership

The idea of teacher leadership has been considered for almost 50 years (Andrew, 1974). The lack of a consistent definition as well as limited empirically based conceptual frameworks to help guide research in the area have made advancements in teacher leadership research challenging (Wenner & Campbell, 2017). Furthermore, only recently has the literature begun to include emphases in content-specific teacher leadership (e.g., Criswell et al., 2018, Lotter et al., 2020; Mohan et al., 2017; National Research Council, 2014; Sinha & Hanuscin, 2017; Yow et al., 2020), as research has recognized the importance of content-expertise to enacting curricular reforms and school improvement goals (Berg et al., 2014; Wenner & Campbell, 2017). Teachers acting in leadership roles within schools can create change through collaborative work that improves students' learning (Katzenmeyer & Moller, 2009; York-Barr & Duke, 2004). Teacher learning and teacher leadership are connected, especially collaborative inquiry among teachers, which can facilitate teachers in developing as leaders (Darling-Hammond et al., 2017; Szczesiul & Huizenga, 2015; Yow & Lotter, 2016). Recent research has found that schools in which teachers feel they have a voice in instructional and school-based decisions, especially those concerning student discipline and school improvement issues, have higher student academic achievement (Ingersoll, 2018; Shen et al., 2020). In addition to improved student learning, teacher leadership opportunities have also been shown to be important for increasing teacher's instructional efficacy, work satisfaction, and retention (Muijs & Harris, 2006; National Research Council, 2014; Torres, 2019).

Retaining effective science, technology, engineering, and mathematics (STEM) teacher leaders is important, especially during this time of high teacher turnover, to maintain the STEM instructional expertise needed to prepare students for future STEM professions and a STEM-infused world (Podolsky et al., 2019). National efforts to build STEM ecosystems (e.g., Battelle, n.d.; STEM Funders Network, (n.d.)) and recent efforts to build national standards around a constantly changing STEM knowledge base (Common Core State Standards Initiative, 2010; NGSS Lead States, 2013) require STEM teacher leaders that not only know the concepts and practices of STEM, but also how to communicate them to students and the public. STEM teachers may also be more likely to leave the profession to find more opportunities in the private sector so finding ways to encourage their staying

in the classroom as teacher leaders is crucial (Podolsky et al., 2019). In addition, the dearth of school leaders (e.g., principals and superintendents) with STEM backgrounds demands that STEM teacher leaders have an active voice in school policy and practice (Glass et al., 2000).

1 | TEACHER LEADERSHIP AND STEM TEACHER LEADERSHIP FRAMEWORKS

The difficulty in a consistent teacher leader definition may explain the number of varied teacher leadership frameworks presented over the years. We see many of the frameworks as helpful for offering different ways to view teacher leadership and implement teacher leadership development in education. At the same time, so many frameworks may also cause confusion and delay advancement in the field as scholars work to reach consensus on what teacher leadership is and why it matters. Wenner and Campbell (2017) define teacher leaders as "teachers who maintain K-12 classroom-based teaching responsibilities, while also taking on leadership responsibilities outside of the classroom" (p. 7). Below, we present a few teacher leader and STEM teacher leader frameworks to familiarize readers with current work in the field. Each framework is complex so readers are encouraged to explore each framework more independently.

1.1 | Teacher leader model standards

In 2011, the Teacher Leadership Consortium published the Teacher Leader Model Standards listing seven domains of teacher leadership: (I) Fostering a Collaborative Culture to Support Educator Development, (II) Accessing and Using Research to Improve Practice and Student Learning, (III) Promoting Professional Learning for Continuous Improvement, (IV) Facilitating Improvements in Instruction and Student Learning, (V) Promoting the Use of Assessments and Data for School and District Improvements, (VI) Improving Outreach and Collaboration with Families and Community, and (VII) Advocating for Student Learning and the Profession (Teacher Leadership Exploratory Consortium, 2011). In addition to this national

model, many states have adopted teacher leader models to help guide and develop teacher leaders (e.g., Kentucky Department of Education, 2015; Ohio Department of Education, 2017).

1.2 | Teacher leader development model

Smylie and Eckert (2018) offer "a conceptual–theoretical model for teacher leadership development" (p. 561) that places the school at the center of the development and focuses on both the development of the teacher leader and the practice of teacher leadership. Their model contains eight elements: (1) Principal Development, (2) Principal Support for Teacher Leadership Development, (3) Initial Teacher Capacity for Leadership, (4) Leadership Work Design, (5) Development Activities and Experiences, (6) Teacher Leader Capacity, (7) Teacher Leadership Practice, and (8) Teacher Leadership Outcomes. Smylie and Eckert (2018) also suggest relationships among these eight elements and how they may link together in order to represent a more complete picture of the intricacies of teacher leader development.

1.3 | I-IMPACT teacher leader conceptual framework

Updating the metaphors for teacher leadership proposed by Dempsey (1992), Criswell et al. (2018) created the I-IMPACT Teacher Leader Conceptual Framework. This model describes four ways that the actions of teacher leaders can manifest themselves: Effective Practitioner, Learning Partner, Productive Scholar, and Policy Voice. In order for these manifestations to be realized, Criswell et al. (2018) argue that there are four capacities that must be developed in individuals: (1) Professional Identity, the view of oneself and the view of others that one functions as a teacher leader; (2) Professional Vision, the ability to see and articulate key aspects of the system in which the teacher leadership takes place; (3) Adaptive Expertise, the capability to flexibly apply understandings of educational practice to different contexts; and (4) System Sensitivity, the understanding of the system's structure, its leverage points, and its responses to attempts to promote change.

1.4 | STEM master teachers framework (STEMMaTe)

Hite and Milbourne (2018) propose a model that offers five rings of teacher leadership development culminating in teacher leadership experiences at the national level. These rings represent the levels of master teachers (which they also call teacher leaders) participation in different STEM communities of practice: Scholastic Effectiveness, Institutional Knowledge and Memory, Adaptability/Flexibility, Emergent Leadership, and Strategic Leadership.

2 | GROWING WORK IN THE FIELD

As seen from the abundance of teacher leadership models, teacher leadership roles and opportunities are diverse and can range from local to national advocacy and also include both formal (science or mathematics department chair) and informal (daily mentoring of peers) roles. Supportive and trusting administration, providing time during the work day for collaborative teacher leadership work, professional development experiences, and many other factors can influence teacher leadership opportunities and impact (Muijs & Harris, 2006). In addition, not all teacher leadership opportunities have an equivalent impact on teacher leader identities or school improvement goals, pointing to the need for more research in this area, especially the impact of content-specific leadership roles. We are a part of a National Science Foundation (NSF) collaborative grant, *Teacher Leadership: Investigating the Persistence and Trajectories of Noyce Master Teaching Fellows* (NSF DUE-1758462, DUE-1853560, DUE-1758342, DUE-1758452, DUE-1758438), that is investigating the impact of eight STEM teacher leadership programs on teacher leaders' identity development and their career trajectories-whether teacher leaders stay at their current schools, move schools, shift to other school positions (e.g., administrator or mathematics/science coach) or leave education. Our research group hopes to add knowledge about STEM teacher leadership experiences that are vital for developing and supporting teacher leaders, especially those that help teachers to remain in the teaching profession. Our research shows not only the importance of these professional development experiences (Criswell et al., 2018; Yow & Lotter, 2016), but also the need for collaborative school and university partnerships to make lasting changes.

3 | RESOURCES

Below we list several resources to learn more about and support teacher leadership and STEM teacher leadership

3.1 | Center for Teaching Quality

"Center for Teaching Quality draws from the unique insights of teachers, administrators, and system leaders to rethink and reimagine schools" (Center for Teaching Quality, n.d.).

3.2 | Center for Teacher Leadership

Center for teacher leadership's "mission is to promote and support teacher leadership in order to improve teaching and learning" (Center for Teacher Leadership, n.d.).

3.3 | Teach to lead

Teach to Lead envisions "a world in which teachers are valued as the foremost experts in instruction, and as such, are leaders of informing, developing, and implementing education policy and practice to steer systematic improvements to benefit student learning" (Teach to Lead, n.d.).

3.4 | STEM teacher leader network

The STEM Teacher Leader Network is a free online community that offers timely and specific support for STEM teacher leaders (STEM Teacher Leader Network, 2021).

3.5 | Robert Noyce teacher scholarship grants

NSF offers Robert Noyce Teacher Scholarship Grants with one track of this funding line specifically designed to develop STEM teacher leaders (American Association for the Advancement of Science and National Science Foundation, n.d.). Our work mentioned above is funded by this grant.

4 | CONCLUSION

We have only offered a few examples of the research and resources available within the field of STEM teacher leadership. Our goal was to help readers learn more about STEM teacher leadership as well as help readers better understand the need for STEM teacher leadership in our schools and in our research. Perhaps this need is no greater than it has been over the last year of a global pandemic which has placed a growing level of stress on all teachers, especially STEM teacher leaders who have been called upon—often times regardless of training—to be online technology experts as schools have been forced to rapidly shift their learning platforms from face-to-face instruction to virtual and hybrid settings. The pandemic has forced us all to rethink education and STEM teacher leaders can be poised to help reshape the field (Berry, 2020). More research and development of STEM teacher leaders, such as helping them gain the skills, confidence, and voice needed to advocate for themselves, other teachers and their students, can only strengthen the outcome of student learning for each and every student.

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