How might we ensure teachers enter the classroom well-prepared to teach STEM?

PRE-SERVICE TEACHERS OFTEN LACK EFFECTIVE COACHING.

Written by
MAY LEE, MICHIGAN STATE UNIVERSITY

01 CONTEXT AND TRENDS

Teaching science, technology, engineering, and mathematics (STEM) is difficult to do well, even for veteran teachers. Thus, clinical preparation is critical in developing preservice teachers' pedagogical content knowledge (Shulman, 1986), of which the mentor teacher's classroom is a central component of that experience (Wang & Odell, 2002). The quality of the clinical preparation is important because it affects the preservice teachers' opportunities to observe high-quality teaching in real time and practice their teaching in real classrooms.

02 DISCUSSION

> "Without access to effective mentors, preservice teachers typically lack opportunities to (1) observe high-quality teaching, and/or (2) practice their teaching in classrooms where they feel safe enough to experiment and "learn from mistakes."

The type of guidance mentors provide to preservice teachers is partly dependent on the roles mentors perceive for themselves (Forbes & Biggers, 2016; Koballa, Bradbury, Glynn, & Deaton, 2008; Smith, 2007; Wang & Fulton, 2012). Mentors may perceive themselves, for instance, as sources of moral support or as critical evaluators (Hall, Draper, Smith, & Bullough, Jr., 2008). Since mentors are typically involved in the assessment of their preservice teachers, preservice teachers often imitate and conform to their mentors' instructional approaches to receive positive evaluations, instead of experimenting to establish their own instructional approaches (Anderson, 2007; Barrows, 1979). Imitating their mentors' instructional approaches may be beneficial to preservice teachers, but that mainly occurs when their mentors already implement research-based teaching practices effectively.

However, being a good teacher does not automatically make one an effective mentor to preservice teachers (Schneider, 2008). Without access to effective mentors, preservice teachers typically lack opportunities to (1) observe high-quality teaching (Bradbury & Koballa, 2007; Gunckel & Wood, 2015; Wang & Odell, 2002), and/or (2) practice their teaching in classrooms where they feel safe enough to experiment and "learn from mistakes that are inevitable when engaging in complex practice" (Luehmann, 2016, p. 26). The consequences of having preservice teachers paired with less effective mentors can be contrasted with those paired with more effective mentors, for whom the benefits are likely to be richer. Preservice teachers paired with mentors who utilize research-based teaching practices, like inquiry-based teaching, are more likely to take up and experiment with using those practices (Koballa & Bradbury, 2012; Luft, Roehrig, & Patterson, 2003) than those not paired with more effective mentors.

"The shortage of effective mentors is primarily due to a lack of training available for how mentors can effectively model for and coach preservice teachers. Without training, many mentors emphasize what and how to teach—such as laboratory management—rather than why content should be taught in particular ways."

The shortage of effective mentors is primarily due to a lack of training available for how mentors can effectively model for and coach preservice teachers. Without training, many mentors emphasize what and how to teach—such as laboratory management (Bradbury & Koballa, 2007)—rather than why content should be taught in particular ways (Wang & Odell, 2002), which is key in developing preservice teachers' pedagogical content knowledge (Shulman, 1986). Some mentors have even advised their mentees to disregard instructional approaches addressed in their methods courses (due to a presumed lack of applicability to real classroom contexts), even though those approaches were research-based and shown to support student learning (Forbes & Biggers, 2016). These findings suggest that if mentors were provided with adequate support on how to effectively model and coach teaching, their preservice teachers would more likely have teaching experiences that could prepare them to be strong and effective teachers themselves.

03 BRIGHT SPOTS

While more research is needed on how to scaffold clinical preparation for preservice teachers to ensure they are provided with effective modeling and coaching, some teacher preparation programs have begun this effort by transforming the traditional relationship between mentors and preservice teachers. One such effort is the Beyond Bridging project (as cited in Gunckel & Wood, 2015). This project brought together preservice elementary teachers and their mentors to co-learn specific tasks that addressed practical classroom issues through the use of research-based teaching principles in science. Project findings indicate that these tasks increased the mentors' familiarity with research-based science teaching principles, providing them with novel insights and perspectives into science teaching. These tasks also supported preservice teachers' abilities to see how the methods they were learning in their coursework aligned with how they were teaching in their mentors' classrooms.

Another approach to transforming the traditional relationship between preservice teachers and mentors is educative mentoring (Feiman-Nemser, 1998), in which mentors help preservice teachers develop their abilities to learn from and in their teaching. In this approach, educative mentors help their mentees gain insight into "teaching as a complex process where there is rarely one 'right' answer" (Bradbury, 2010, p. 1052). Mentoring preservice STEM teachers through this approach with may help prepare the future STEM teacher workforce in enacting and maintaining more student-centered teaching practices (Koballa & Bradbury, 2012).

Although educative mentoring has not been the primary focus for a particular project, it has been taken up by many individual mentors across disciplines. For instance, Barnett and Friedrichsen (2015) described a veteran biology educative mentor's support in developing her mentee's pedagogical content knowledge by providing him resources that addressed a challenge he was facing in his teaching: identifying and implementing classroom activities that would meaningfully engage students with the content. This mentor gave her mentee access to and accountings of previous activities she implemented with her former students, in addition to having him review those students' responses to old exams. By having him reflect on how the students' responses to previous activities and old exams related to particular instructional approaches, she helped him see which activities were more likely to be supportive of student learning. Additionally, the mentor's explicit critical reflections on the effectiveness of her own instructional approaches provided a model to her mentee of how she wanted him to think about teaching science.

04 CONCLUSION

To increase the likelihood that all learners have access to strong STEM experiences in the classroom, teachers need to be prepared to teach STEM subjects effectively. Because the attitudes, beliefs, and efforts mentors have about STEM teaching directly impact the attitudes, beliefs, and ideas preservice teachers may have about teaching, mentors need to be open in order to be attentive to the pedagogical content knowledge needs of their mentees and explicit in the guidance they provide to them. By transforming the traditional relationships between mentors and their mentees, as described above, preservice teachers are more likely to experience the type of modeling and coaching that is needed for them to be reflective of their own practice, to experiment with more innovative approaches and best practices based on current research, and to teach STEM subjects effectively.

ABOUT THE GRAND CHALLENGES WHITE PAPERS

In 2017, 100Kin10 released an unprecedented representation of the big, systemic challenges to preparing and supporting STEM teachers following over two years of extensive research alongside more than 1,500 STEM teachers and hundreds of other education experts. As a part of this work, 100Kin10 commissioned a series of short white papers from well-versed thinkers and practice-oriented researchers to synthesize the most relevant research around the specific challenge areas. Together, they compose a thoughtful and well-rounded examination of the systemic challenges currently facing STEM teaching.

REFERENCES

Anderson, D. (2007). The role of cooperating teachers' power in student teaching. *Education, 128*, 307–323.

Barnett, E., & Friedrichsen, P. J. (2015). Educative mentoring: How a mentor supported a preservice biology teacher's pedagogical content knowledge development. *Journal of Science Teacher Education, 26*(7), 647–668. Retrieved from https://doi.org/10.1007/s10972-015-9442-3

Barrows, L. K. (1979). *Power relationships in the student teaching triad.* Presented at the American Educational Research Association, San Francisco, CA. Retrieved from http://eric.ed.gov/?id=ED173335

Bradbury, L. U. (2010). Educative mentoring: Promoting reform-based science teaching through mentoring relationships. *Science Education, 94*(6), 1049–1071. Retrieved from https://doi.org/10.1002/sce.20393

Bradbury, L. U., & Koballa, T. R. (2007). Mentor advice giving in an alternative certification program for secondary science teaching: Opportunities and roadblocks in developing a knowledge base for teaching. *Journal of Science Teacher Education, 18*(6), 817–840. Retrieved from https://doi.org/10.1007/s10972-007-9076-1

Feiman-Nemser, S. (1998). Teachers as teacher educators. *European Journal of Teacher Education, 21*(1), 63–74. Retrieved from https://doi.org/10.1080/0261976980210107

Forbes, C. T., & Biggers, M. (2016). Curricular role identity: What kind of science teacher will I be? Teachers' curricular role identity for elementary science. In L. Avraamidou (Ed.), *Studying Science Teacher Identity* (Vol. 20, pp. 129–152). Boston, MA: Sense Publishers. Retrieved from https://doi.org/10.1007/978-94-6300-528-9_1

Gunckel, K. L., & Wood, M. B. (2015). The principle–practical discourse edge: Elementary preservice and mentor teachers working together on colearning tasks. *Science Education, 100*(1), 96–121. Retrieved https://doi.org/10.1002/sce.21187

Hall, K. M., Draper, R. J., Smith, L. K., & Bullough, Jr., R. V. (2008). More than a place to teach: Exploring the perceptions of the roles and responsibilities of mentor teachers. *Mentoring & Tutoring: Partnership in Learning, 16*(3), 328–345. Retrieved from https://doi.org/10.1080/13611260802231708

Koballa, T. R., & Bradbury, L. U. (2012). Mentoring in support of reform-based science teaching. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.), *Second International Handbook of Science Education* (Vol. 1, pp. 361 - 371). Netherlands: Springer. Retrieved from https://doi.org/10.1007/978-1-4020-9041-7_25

Koballa, T. R., Bradbury, L. U., Glynn, S. M., & Deaton, C. M. (2008). Conceptions of science teacher mentoring and mentoring practice in an alternative certification program. *Journal of Science Teacher Education, 19*(4), 391–411. Retrieved from https://doi.org/10.1007/s10972-008-9101-z

Luehmann, A. (2016). Practice-linked identity development in science teacher education: GET REAL! Science as a figured world. In L. Avraamidou (Ed.), *Studying Science Teacher Identity* (Vol. 20, pp. 15–47). Boston, MA: Sense Publishers. https://doi.org/10.1007/978-94-6300-528-9_1

Luft, J. A., Roehrig, G. H., & Patterson, N. C. (2003). Contrasting landscapes: A comparison of the impact of different induction programs on beginning secondary science teachers' practices, beliefs, and experiences. *Journal of Research in Science Teaching, 40*(1), 77–97. https://doi.org/10.1002/tea.10061

Schneider, R. (2008). Mentoring new mentors: Learning to mentor preservice science teachers. *Journal of Science Teacher Education, 19*(2), 113–116. https://doi.org/10.1007/s10972-007-9088-x

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Smith, E. R. (2007). Negotiating power and pedagogy in student teaching: Expanding and shifting roles in expert–novice discourse. *Mentoring & Tutoring: Partnership in Learning, 15*(1), 87–106. https://doi.org/10.1080/13611260601037405

Wang, J., & Fulton, L. A. (2012). Mentor-novice relationships and learning to teach in teacher induction: A critical review of research. *REMIE Multidisciplinary Journal of Educational Research, 2*(1), 56–104. https://doi.org/10.4471/remie.2012.03

Wang, J., & Odell, S. J. (2002). Mentored learning to teach according to standards-based reform: A critical review. *Review of Educational Research, 72*(3), 481–546. https://doi.org/10.3102/00346543072003481