FEW ELEMENTARY TEACHER PREPARATION PROGRAMS HAVE A STEM FOCUS.

Written by
JENNIFER KASZUBA, UNIVERSITY OF TEXAS AT AUSTIN

01 CONTEXT AND TRENDS

Teacher preparation programs are faced with a seemingly insurmountable task: Instill teacher candidates with the theory, strategies, and skills—in both pedagogy and subject-specific content—to craft lessons, engage students in instruction, assess students, and differentiate instruction for diverse learners. Add to this the time needed to observe classrooms in action and practice teaching, and the task is challenging at best.

Preparing high-quality teachers becomes particularly difficult at the elementary level, where teachers have so many responsibilities. They are expected to have content knowledge and teach students the foundations of multiple disciplines (reading, writing, literature, history, geography, mathematics, science, art, etc.), ground their instruction in educational theories about young children's sociocultural and socio-emotional development, and manage classrooms effectively (Kennedy, 2016).

These demands leave little room for elementary teachers to expose children to subjects that have traditionally been viewed as secondary (e.g., science) or supplementary (e.g., engineering and technology; Tsupros, Kohler, & Hallinen, 2009; Volmert, Baran, Kendall-Taylor, & O'Neil, 2013). This being the case, this critical question must be asked in today's more scientifically and technologically driven world: Are teacher preparation programs adequately preparing elementary teachers to provide the full range of science, technology, engineering, and mathematics (STEM) learning experiences students so direly need for academic and career success?

02 DISCUSSION

In 2014, almost half (47 percent) of the 907 undergraduate and graduate elementary teacher preparation programs reviewed by the National Council on Teacher Quality (NCTQ) "fail[ed] to ensure that teacher candidates are capable STEM instructors" (Greenberg, Walsh, & McKee, 2015). The report cites a lack of math coursework as one contributing factor, as well as the fact that many programs don't even include a science requirement. Even among the top-ranked prep programs in the country, both the STEM content coursework requirements and the STEM-specific pedagogy requirements are minimal. For example, while the prep programs at Texas A&M and Ohio State University, ranked No. 2 and 3 respectively by the NCTQ, offer coursework in multiple disciplines of science, such as biology and either geology or physical science, along with courses in mathematics, students are required to complete only two such courses (Ohio State University, 2016; Texas A&M University, 2016). Beyond content, only one methods course in mathematics and one in science is required in each of these universities' programs, and there is no indication students take courses that focus on how to integrate technology and engineering principles into classroom instruction.

> "Only 18 states require elementary teacher candidates to pass each core subject of an elementary content test to earn their licenses."

More broadly, only 18 states require elementary teacher candidates to pass each core subject of an elementary content test to earn their licenses (Greenberg et al., 2015). In the remainder of the states, elementary teacher candidates are required only to pass a general test of knowledge, where a high score in one subject area can compensate for a low score in another. By comparison, for middle and high-school teacher candidates, most states have content-specific licensing tests, especially in the area of mathematics (Greenberg et al., 2015).

Niess (2005) calls attention to a further issue in the preparation for elementary teachers related to STEM. Niess (2005) notes that teacher preparation programs virtually ignore technology education, leaving teacher candidates essentially on their own in terms of determining if, when, and how to integrate technology education into their elementary classrooms. Even when technology in the context of education is included as part of an elementary teacher preparation program, the content is frequently taught in an isolated manner, instead of being integrated into methodology courses. She states, "[P]reservice teacher students learn much about technology outside both the development of their knowledge of subject matter and the development of their knowledge of teaching and learning" (p. 510).

Although the lack of focus on technology in elementary teacher prep programs is no doubt important, Niess may not be capturing the full extent of the problem in pointing out this important gap. In her reporting, Niess (2005) defines technology as computer-based, electronic technology, a relatively narrow definition that is, regrettably, all too common in education. Technology defined as such only stalls an integrated approach to STEM teaching and learning by giving little attention to the full range of technology knowledge and skills available to enhance the STEM learning experiences that will greatly contribute to students' success in today's digitally connected world. Preparation programs also fail to prepare elementary candidates to teach engineering processes (DiFrancesca, Lee, & McIntyre, 2014), despite evidence that integration of engineering processes is motivational to students and results in increased mastery of science and mathematics content (McGrew, 2012). So little attention is given to preparation of teachers to teach engineering design processes that there is even no mention made of it in the results of the NCTQ study (Greenberg et al., 2015).

These critical gaps in elementary teachers' preparation leave teachers feeling less comfortable with being able to introduce and effectively integrate science into the curriculum, let alone the full range of STEM content and skills. As noted by a report focusing on the preparation of elementary school teachers in California, "[F]irst-year teachers consistently have reported themselves better prepared to teach reading and math than science" (California Council on Science and Technology, 2010).

03
BRIGHT SPOTS

Changing the structure and focus of elementary teacher preparation programs is certainly a challenge, but there are potential strategies and solutions that can better prepare teachers to provide a strong science and more integrated STEM education. One approach is for universities to pair the teaching of STEM content with pedagogical practices more closely aligned to the goal of integrated STEM. This allows teacher candidates to engage in STEM learning activities that are similar to what they would themselves use with their own students. More importantly, an integrated approach to preparing elementary teachers to teach the foundations of STEM learning would also create efficiencies in the system by potentially limiting the number of distinct, stove-piped courses dedicated to each of the STEM disciplines.

One example of integrating teacher preparation program content with pedagogy is California Polytechnic State University, San Luis Obispo, where elementary teacher candidates take part in a program in which physical science topics are taught through guided inquiry. The purpose of the program is to address teacher candidate and elementary student misconceptions. As part of these courses, the preservice teachers also critique videos of elementary students discussing the topics the teacher candidates have just covered. This critique can involve discussion of both the content and the steps a teacher might take to correct student misconceptions. Engaging teacher candidates in coursework that integrates content with pedagogical methods provides the opportunity for teacher candidates to practice strategies for both assessing elementary students' ideas and knowledge about science and math content and discussing possible adaptations to lesson activities that would address the observed misconceptions.

Another example is Urban Teachers, a program that recruits high-achieving students (GPA 3.0 or higher is preferred) who hold a bachelor's degree to become teachers in urban areas. Based predominately in Baltimore and Washington, D.C., with a recent expansion to the Dallas/Fort Worth area, their model is based on research that has found that teacher candidate GPA is a predictor of student performance in math (Kukla-Acevedo, 2009). Their program includes a year of residency, two years of clinical coursework which result in a master's degree, and ongoing support once the candidate begins teaching. Elementary teacher candidates in the program take three courses in how elementary students think about mathematics and a course on teaching STEM in the elementary grades. A majority of teachers in the Urban Teachers program report that their math courses prepared them to teach effectively, and over 93 percent of these teachers feel this program gave them the knowledge/skills needed to be an effective teacher.

04
CONCLUSION

To better prepare elementary teachers to provide their students with a strong foundation in STEM, universities and other teacher preparation programs need to establish courses where teacher candidates themselves are engaged in coursework that integrates STEM content with STEM-specific pedagogical methods. By doing so, teacher candidates personally experience what STEM education looks like in practice, as well as the benefits that are afforded to the integrated learning process. This approach also better utilizes the time given to science and mathematics in preparation programs of study, rather than just adding to teacher candidates' course loads by increasing the number of discipline-specific classes. Finally, teacher preparation programs must work to increase the overall number of courses dedicated to STEM subjects, and states must assess elementary teacher candidates in ways that require substantial mathematics and science content knowledge.

> "Universities and other teacher preparation programs need to establish courses where teacher candidates themselves are engaged in coursework that integrates STEM content with STEM-specific pedagogical methods."

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

DiFrancesca, D., Lee, C., & McIntyre, E. (2014). Where is the "E" in STEM for young children? *Issues in Teacher Education, 23*(1), 49–64.

Greenberg, J., Walsh, K., & McKee, A. (2015). *2014 Teacher prep review: A review of the nation's teacher preparation programs.* Washington, DC: National Council on Teacher Quality. Retrieved from: http://www.nctq.org/teacherPrep/review2014.do

Kennedy, M. (2016). Parsing the practice of teaching. *Journal of Teacher Education, 67*(1), 6–17.

Kukla-Acevedo, S. (2009). Do teacher characteristics matter? New results on the effects of teacher preparation on student achievement. *Economics of Education Review, 28*(1), 49–57.

McGrew, C. (2012). Engineering at the elementary level. *Technology & Engineering Teacher, 71*(6), 19–22.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21,* 509–523.

Ohio State University. (2016). *Majors and Programs.* Retrieved from http://ehe.osu.edu/academics/programs/

Texas A&M University. (2016). *EC-6 Generalist.* Retrieved from http://tlac.tamu.edu/node/69

Tsupros, N., Kohler, R., & Hallinen, J. (2009). *STEM education in Southwestern Pennsylvania: Report of a project to identify the missing components.* Pittsburgh, PA: Leonard Gelfand Center for Servie Learning and Outreach at Carnegie Mellon University and the Intermediate Unit 1 Center for STEM Education. Retrieved from https://www.cmu.edu/gelfand/documents/stem-survey-report-cmu-iu1.pdf

Volmert, A., Baran, M., Kendall-Taylor, N., & O'Neil, M. (2013). "*You have to have the basics down really well": Mapping the gaps between expert and public understanding of STEM learning.* Washington, DC: FrameWorks Institute. Retrieved from http://www.frameworksinstitute.org/assets/files/PDF_STEM/STEMMTG10-18-13_proofedandformatted.pdf