

Measuring the Quantity and Quality of the K-12 STEM Teacher Pipeline

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In this paper, Suzanne Wilson, a nationally renowned expert on teacher preparation and professional development, reviews recent efforts to measure aspects of teaching and teachers' work that are difficult to quantify but that are more closely related to student learning outcomes than the most commonly used proxies for teacher quality. Wilson then describes the range of learning opportunities available to STEM teachers and the data available on the frequency and distribution of those teacher learning opportunities.

STEM teachers are essential to any effort to improve U.S. STEM education, both for students who eventually will work in STEM-related fields and for the general public. Efforts to enhance the quality of STEM teachers have focused on attracting more academically capable people to the field, improving the quality of teacher education programs, supporting teachers' continued learning once they have joined the profession, or rewarding and retaining the most effective teachers. In its report *Monitoring Progress Toward Successful K-12 STEM Education, the National Research Council* (2013) proposed the development and use of two indicators of STEM teacher quality:

- Teachers' science and mathematics content knowledge for teaching
- Teachers' participation in STEM-specific professional development activities.

Currently available data on science and mathematics teacher quality have improved considerably over the last 25 years, and researchers are no longer dependent on proxies like teachers' college grade point average or number of math or science courses taken. This is heartening because measures like these have shown weak—if any—relationship to student learning and engagement.

Content Knowledge for Teaching

Research has shown that the knowledge needed for teaching goes well beyond that of disciplinary subject matter per se, and few if any districts or states would claim to have valid, consistent data on teacher content knowledge for teaching. The NRC *Monitoring Progress* report recommended an indicator of *content knowledge for teaching*, which includes not only the understanding of a discipline that one might develop as an undergraduate major or minor, but also specialized disciplinary understanding specific to teaching (such as the specific mathematics taught at the grade level one teaches) and pedagogical content knowledge, which includes the subject-specific understanding of how to teach the relevant subject matter content and how students learn that

content. Several research projects are under way to improve our ability to assess teachers' content knowledge for teaching by developing measures that could be used on a large scale for tracking teacher content knowledge for teaching.

STEM-Specific Teacher Learning Opportunities

The NRC *Monitoring Progress* report also argued for an indicator that tracks teachers' participation in STEM-related professional learning opportunities. Professional development itself is being reconceptualized to include formal and informal opportunities to learn, in and out of school. Teachers have regularly noted that serving as mentors for new teachers, as peer observers, or on textbook selection committees has been an important source of professional growth. Many widely administered teacher surveys track the amount of time that teachers spend in professional development, but survey questions typically refer to all kinds of professional development rather than calling out STEM subjects in particular. Moreover, survey items on professional development often are understood to address formal professional development sessions and fail to ask about less structured learning opportunities, such as mentoring and collaboration with colleagues. A comprehensive measure of the quantity of STEM professional learning opportunities teachers have would include the latter kinds of activities.

Current Efforts to Track and Promote Teacher Quality

Current efforts to track STEM teacher quality collect information on teachers' years of experience, credentials and licenses, out-of-field teaching, and test scores. The table below shows the differences across states in the areas in which they mandate tests of teacher quality. As the table indicates, teachers' instructional practice (pedagogy) is the component of their competence that is least likely to be tested.

Recently, several states have invested in more comprehensive data systems that can assess teacher quality, including professional learning and teacher evaluations. The North Carolina Education Research Data Center was established in 2000 to store and manage data on the state's public schools, students, and teachers. The ability to work across these data sets has

enabled researchers to investigate many questions concerning teacher quality. For example, using data from a biannual working conditions survey, researchers found that the level of support in a school environment matters for teaching and learning: North Carolina schools with the most supportive professional environments also had more qualified teachers.

U.S. Teacher Testing Requirements

	Basic Skills	Content Knowledge	Pedagogy
Required	AL, AK, AR, CA, CY, DC, DE, FL, GA, HI, ID, IL, IN, IA, LA, KY, MA, MD, ME, MI, MN, MS, MO, NE, NH, NV, NM, NY, ND, OH, OK, OR, PA, SC, TN, VT, VA, WA, WV, WI	AL, AK, AR, AZ, CA, CO, CT, DC, FL, GA, HI, ID, IL, IA (elementary teachers only), KS, KY, LA, ME, MA, MI, MN, MS, MO, NH, NC, NJ, NV, NM, NY, NC, ND, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WV, WI, WY	AZ, AR, DC, FL, ID, IL, IA (elementary teachers only), LA, KS, KY, ME, MN, MS, MO, NH, NC, NV, NM, NY, OH, OK, PA, RI, SC, SD, TN, TX, UT, WV
Maybe/it depends/sometimes	NC, TX	DE, MD	VA
Not required	AZ, CO, KS, NJ, RI, SD, UT, WY	MT, IN, NE	AL, AK, CA, CT, CO, DC, DE, GA, HI, IN, MA, MD, MI, MT, NE, NJ, ND, OR, VT, WA, WI, WY

Implications for Policy and Practice

Schools and districts should provide STEM teachers with opportunities to engage in professional learning throughout their careers. STEM fields are constantly evolving, and teachers need ongoing opportunities to learn about relevant developments. Additionally, teachers need opportunities to learn about new teaching and curriculum standards, instructional methods, and research that enhance their capacity to meet the needs of all children.

States need databases that permit them to link teachers' characteristics and learning opportunities with student and school outcomes to investigate questions concerning teacher quality.

Currently, states typically maintain separate databases for teacher and student information and have limited ability to relate teacher qualifications and teacher support programs to student outcomes.

Districts and states should consider using surveys that measure teacher content knowledge for teaching and teachers' opportunities to learn and that gather important contextual information about teachers' backgrounds and experiences, teaching assignments, working conditions, and beliefs about students and subject matter. While these survey measures are not appropriate for making judgments about individual teachers, they are useful for estimating patterns for larger groups of teachers and thus for identifying areas where teacher preparation and ongoing support should be strengthened. At present, available assessments of content knowledge for teaching do not cover all relevant content areas for K-12 mathematics and science teachers. A national indicator system would need to even out those differences in coverage and conceptualization.



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