Critical Issues in STEM Education: Research on Effective STEM Teachers and Teaching

Adem Ekmekci, Ph.D.
RUSMP Director of Research

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What Matters the Most in Education???
What Matters the Most in Education???
What is the Most Important Key Player in Education???
THE MODERN SCHOOLTEACHER

Disheveled hair from getting up at 5:00 after getting to bed at 1:16

Money for classroom supplies (out of her own pocket)

Shoes for traffic duty, playground duty, cafeteria duty and that really fast brat

Prank from student (future cartoonist)

Lesson plans, papers to grade and grade books to update by tomorrow

Note from parent saying teachers get paid too much
“It doesn't matter how long you've been teaching or how much you care about children. This job is hard.”

- Justin Minkel
(2007 Arkansas Teacher of the Year)
Need for Teachers

• Severe teacher shortages in math and science across the country (Cross, 2017)

• Eight percent of public school teachers leave and another eight percent change schools (Learning Policy Institute, 2019)

• Reasons: dissatisfaction, lack of support, autonomy, lack of collaboration opportunities

• High-poverty, high-minority, urban public schools are the most hurting (Ingersoll, May, & Collins, 2019)
A Framework for Effective Teaching

**Inputs**
- Teacher Qualifications: Education, certification, credentials, and experience.
- Teacher Characteristics: Attitudes, attributes, beliefs, self-efficacy, race, and gender.

**Processes**
- Teacher Practices (Teaching Quality): Practices both in and out of the classroom (impacted by school and classroom context): planning, instructional delivery, classroom management, interactions with students.

**Teacher Quality**

**Outcomes**
- Teacher Effectiveness: Teacher evaluations, quality of instruction, leadership skills, and student learning.

**Student Success**

Adapted from Goe (2007); supported by Darling-Hammond (2000), Hill et al. (2012), National Council on Teacher Quality (2004), and Rice (2003, 2010)
Teacher Qualifications and Algebra I Achievement

Teacher performance on math certification exams and years of experience teaching math are the qualifications most strongly associated with middle school students’ Algebra I achievement.

Institute of Education Sciences (2019)
Note from the presentation: We discussed student outcomes other than test performance including education attainment and life and career expectations/outcomes (as included in the next slide with SCCT) and 21st Century Skills including communication, collaboration, creativity, and critical thinking.
Social Cognitive Career Theory (SCCT)
SCCT (cont’d)

• Individual (background, demographics etc.)
• Motivational and behavioral (self-efficacy, identity, utility, interest, course-taking, course effort, achievement)
• Contextual (school, teacher, family, etc.)

Lent, Brown, & Hackett (1994)
Effective Teaching: Key Ingredients

**Subject Matter Knowledge**
- Common content knowledge (CCK)
- Horizon content knowledge

**Pedagogical Content Knowledge**
- Specialized content knowledge (SCK)
- Knowledge of content and students (KCS)
- Knowledge of content and teaching (KCT)
- Knowledge of content and curriculum
Effective Teaching: Key Ingredients – MKT

Mathematical Knowledge for Teaching (MKT)—transcends the pure content knowledge and includes knowledge about students’ ideas, knowledge, and conceptual understanding of material.

Hill, Ball, & Schilling (2008)
Effective Teaching: Key Ingredients – MKT (cont’d)

Strong positive association with mathematical knowledge for teaching and student performance

Hill & Chin (2018); Hill, Rowan, & Ball (2005)
Effective Teaching: Key Ingredients – Motivational Beliefs

• Self-efficacy in the content area
• Self-efficacy for teaching
• Intrinsic value for teaching
• Epistemic beliefs
RUSMP Research Results - 1

• A bachelor’s degree in mathematics,
• Mathematical Knowledge for Teaching, and
• Epistemic Beliefs

had significant positive effects on students’ math achievement.

Ekmekci, Corkin, & Fan (in press)
RUSMP Research Results – 1 (cont’d)

Impact on Math Portion of Stanford-10 Score

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<th>Score</th>
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<tr>
<td>Math Major</td>
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<td>MKT</td>
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<tr>
<td>Epistemic Beliefs</td>
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Effective Teaching: Key Ingredients – TPACK

Technological Pedagogical Content Knowledge (TPACK)—effective utilization of technology for teaching particular topics; knowledge of students’ understanding, thinking, and learning with technology in a particular subject; and knowledge of curriculum materials that integrate technology with learning in the subject area

Mishra & Koehler (2006)
Effective Teaching: Key Ingredients – TPACK (cont’d)
Effective Teaching: Key Ingredients – TPACK (cont’d)

Its significance is widely-agreed upon; however, TPACK’s relation to student outcomes and instructional quality has yet to be studied.
Motivational beliefs, professional background, and MKT are strongly and positively associated with teachers’ TPACK.

Ekmekci et al. (2019)
RUSMP Research Results – 2 (cont’d)

Percent Increase on TPACK Score

<table>
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<th>Category</th>
<th>Increase</th>
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<tr>
<td>Math Major</td>
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<tr>
<td>MKT</td>
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<td>Self-efficacy</td>
<td>7</td>
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<td>Intrinsic Value</td>
<td>10.3</td>
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<tr>
<td>Constructivist Math Teaching</td>
<td>8</td>
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<tr>
<td>Pedagogical preparedness</td>
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</table>
Teachers Asking Students to Use Technology for Collaboration

Institute of Education Sciences (2019)
Teachers Asking Students to Use Technology for Communication

Institute of Education Sciences (2019)
Teachers’ Use of Technology to Prompt Student Creativity

Institute of Education Sciences (2019)
Teachers’ Use of Technology to Prompt Student Critical Thinking

Institute of Education Sciences (2019)
So that's your new year's resolution, Mr. Fitz?

Err on the side of thinking.

Yes! I feel like school should be a place of thinking, yet nearly everything we're told to do actively discourages us from thinking!

"Us" the teachers, or "us" the students?

Err on both.

Did I write this right?

Let me consult the state testing rubric.
Science teachers’ constructivist teaching practices (inquiry-based and connections to real life and history of science), self-efficacy, degree in science had significant impact on students’ science motivation and achievement outcomes.

Ekmekci & Corkin (2019)
Math teachers’ constructivist teaching practices (focusing on conceptual understanding), self-efficacy, traditional certification, and degree in math had significant impact on students’ math motivation and achievement outcomes.

Corkin & Ekmekci (2019)
Both math and science teachers’ constructivist teaching practices and self-efficacy in teaching the content had a positive impact on high school students’ career expectations in STEM at age 30.

Ekmekci & Corkin (*in preparation*)
Sometimes, it only takes a single teacher to turn a child's life around.

Some children will come to school today because of that teacher.

Be that teacher, every day.
Professional Development
RUSMP Research Results – 4

Percentage Change after RUSMP Summer Campus Program

- Teaching self-efficacy: 10%
- TPACK: 8.25%
- MKT: 12.5%
- Pedagogical preparedness: 34.5%
- Epistemic beliefs: 3.7%
- Math self-concept: 5%
RUSMP Research Results – 5 Barriers

• Cultural
  • Student motivation and knowledge background
  • Student mindset for learning
  • Lack of collaboration among teachers
  • Attitude of other teachers

• Political
  • Lack of autonomy support from administrators
  • Lack of instructional resources
  • Testing culture

Corkin, Ekmekci, & Coleman (2018)
RUSMP Research Results – 6 Principal Autonomy Support

Percent increase by higher principal autonomy support

- Self-efficacy for teaching: 6
- Intrinsic value for teaching: 7
RUSMP Research Results – 6
Principal Autonomy Support (cont’d)
“Real teachers hear the heartbeats of crisis; always have time to listen; know they teach students, not subjects; and they are absolutely non-expendable.”

(Source unknown)
Other points discussed at the end of presentation in Q&A portion:

- Culturally relevant instruction and family/parent visits by teachers to motivate and engage diverse group of students, especially from minoritized and underserved populations

- Integration of computer science in algebra/geometry courses

- Desmos.com and its plethora of activities that can be used in school math instruction as an example of effective use of technology

- We need school and district administrators’ support for teacher autonomy and promoting effective professional development of teachers

- TEACHERS need to continue growing and developing professionally and take action to impact colleagues (leadership—not just a position but actions, for example, presenting at a conference serving in task forces at school/district)