



## Building a Strong Backbone for STEM Education

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To give every student a solid foundation in subjects that are critical to Americans' personal and professional success, educators and policymakers have launched broad-scale efforts to strengthen math and science standards, create new courses, write new curricula, and design STEM-related software programs and resources for students. But in spite of all this action, we still struggle to ensure that students have access to experienced, effective STEM teachers.

A steady influx of new teachers cannot solve this problem. Rather, what is needed is more teachers with deep expertise in the STEM fields and a commitment to staying in the profession long enough to hone their craft and take on leadership roles that will strengthen the profession *without* leaving their classrooms and students.

Ensuring that STEM teachers will forgo more lucrative and professionally rewarding opportunities elsewhere and stay in the classroom as mentors and leaders in the profession is no easy lift. It requires making significant changes in policy and practice to help ensure that individuals with crucial STEM skills and knowledge see teaching as an attractive, rewarding, and viable career path.

For the past decade, the Knowles Science Teaching Foundation (KSTF) has been developing and testing approaches to identify the most promising new STEM teachers, provide them with a vision of teacher professionalism and leadership and prepare them to lead from the classroom from the onset of their careers. The Foundation also has been exploring what it takes to give STEM teachers access to the kind of intensive, peer-to-peer professional development that allows individuals in every field to feel connected and empowered, to continue to learn and be challenged, and to sustain their interest and job-satisfaction over a long career.

Such a network will not only improve STEM instruction, but also encourage more highly qualified educators to stay in teaching and bolster student interest in pursuing STEM careers.

## **THE BACKBONE TEACHER AND THE NETWORK EFFECT**

Building a national network of leading teachers<sup>1</sup> is exactly what is taking place in China, where, like the United States, there's now a national push to improve teaching practice as a key lever to bolstering student outcomes. At the school, district, and regional levels, China is identifying and supporting a core group of highly trained, highly effective "backbone teachers." Beginning early in their careers, these teachers are trained and supported to become leaders, model effective practices, and conduct wide-ranging inquiry into teaching and learning. They take on roles as instructional leaders and exemplars within their buildings, as leading teachers supporting their peers and novice teachers in their districts, and as thought leaders advancing the art and science of pedagogy in their subjects and disciplines.

To bring this approach to scale, China has now launched a National Teaching Training Program. This program, which aims to select and train one million teachers nationwide—and send 10,000 abroad for further education—focuses on preparing these backbone teachers to support their peers and mentor novice teachers.

### **A Potential Model for the United States**

Instead of mandating systems and structures, the United States can build and strengthen education from within, allowing teachers to collaborate, develop and share effective teaching

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<sup>1</sup>Although teacher leaders is a more commonly-used term, Nicole Gillespie, KSTF Executive Director, wrote a May 6, 2014 blog post on the Huffington Post, arguing that leading teacher is a more appropriate term.

practices, grounded in the realities of students and classrooms, that can be adapted to work in many settings. This approach comes from the bottom up and would grow organically, but it needs a support system to hold it together and foster the propagation of professional knowledge. That support system could be made up of an array of discipline-specific networks that attract, support, and retain excellent teachers in high-need subject areas such as STEM, and develop them as leading teachers from the onset of their careers. Not tied to any one curriculum or program, these teacher-led networks could allow ideas to spread organically across states, districts, and schools whose structural boundaries have resisted top-down efforts at replication. They can provide the kind of intensive, peer-to-peer professional development needed to truly transform teaching practice and student learning. And they can provide avenues for leadership and career-long professional growth for teachers, allowing us to attract and retain the best and brightest educators in high-demand fields such as STEM.

## **BUILDING A NATIONAL NETWORK: THE KSTF DESIGN**

Since 1999, the Knowles Science Teaching Foundation has been building and studying such a network in the STEM subjects. The work of KSTF was inspired by the engineering design, prototype, and development process of founder Harry Knowles, an engineer who invented the barcode scanner and who currently holds the most patents of any living individual in the United States.

Through a five-year fellowship program, KSTF has built a growing corps of highly skilled, highly trained “backbone” science and math teachers who have been supported to become experts in their subject areas and in pedagogy. These outstanding, highly connected teachers emerge as leaders in their schools and their districts, and contribute to a growing body of professional knowledge about what works in the classroom. Building on research and insight from best practices on how similar networks have impacted other fields (e.g., medicine, agriculture, and the military), KSTF has also begun studying how our Teaching Fellows and Senior Fellows can leverage the impact of high-quality backbone teachers at all levels—school, district, state, and national.

**The Teaching Fellows Program.** KSTF’s five-year Fellowship identifies promising novice teachers in STEM fields with a demonstrated commitment to K-12 education and the potential to serve as leaders and provides them with resources, mentoring and professional and leadership development.

KSTF invests heavily in providing Fellows with sustained learning opportunities to develop STEM content knowledge for teaching and pedagogy; create powerful learning opportunities for students; use data to inform and improve instruction and learning; design instruction that challenges and supports students at all levels of readiness; and build leadership capacity. Fellows meet regularly with each other, have access to scientists, mathematicians, veteran teachers, researchers and other education professionals and use online spaces to support each other, share elements of their practice, and provide critical feedback. They are purposefully given opportunities and support to engage in extended inquiry into various aspects of teaching practice, and to critically evaluate curriculum, research, technology, and other resources. Through these experiences they develop the skill and inclination to delve into problems of practice, collecting and analyzing data with other members of the community.

**Building backbone teachers.** After completing the five-year Fellowship, teachers become Senior Fellows—KSTF’s own cadre of backbone teachers. Most (over 80 percent) continue to teach mathematics or science in high schools, some pursue education careers outside the high school classroom, but all remain active as leaders in the network. Senior Fellows play key roles in (1) leadership, collaboration, and advocacy work in schools and districts; (2) pilot projects in areas such as curriculum design and teacher professional development; (3) teacher inquiry, study,

and support groups; and (4) leadership and support for new KSTF Teaching Fellows; and (5) KSTF program development and improvement.

By providing continuing support, although less structured and intensive than during the Teaching Fellows Program, KSTF continues to foster the development of these teachers as leaders. Equally important, providing meaningful opportunities for Senior Fellows to continue collaborating and refining practice makes it more likely they will remain in the teaching profession.

**Leveraging the network.** Senior Fellows bring colleagues from their schools and districts into KSTF's online spaces and other projects, expanding and strengthening the impact of the network. For example, KSTF provides financial support for a Senior Fellow to lead KSTF Fellows in the Washington, D.C., area in developing and studying the International Baccalaureate (IB) physics curriculum, a group which has expanded to include other teachers. KSTF also supports another Senior Fellow's training from the National Board of Professional Teaching Standards to support peers working towards National Board Certification—another network of highly effective teachers whose expertise is often tapped for building-level leadership roles.

**Transforming education.** Through our intentional efforts to build a national network that supports these teachers throughout their careers and allows them to collaborate and share effective practices and innovative new ideas and expand the scope of their collaboration to peers in their schools, districts, and beyond, we believe we have created the backbone of a system that can transform STEM instruction in this nation.

Building networks around subject-area expertise instead of solely by geographic boundaries can also help address a wide range of policy needs involving teacher capacity, including:

- Mirroring policy emphasis and research on not just improving pedagogy, but content-specific pedagogy
- Acknowledging the differences in curriculum and policy between and within states and districts by focusing on what works in instruction, allowing the shared knowledge of the network to be leveraged everywhere
- Addressing teacher retention by keeping teachers engaged through leadership and research opportunities and ongoing support from experts and peers
- Providing a realistic way of promoting the deep knowledge and expertise required for the Common Core and other more rigorous standards through peer collaboration and professional learning. With studies suggesting that professional development must be between 49 and 100 hours to have a meaningful impact on student learning, a collaborative, teacher-led approach is the only feasible way to build professional knowledge for lasting impact.

## THE IMPACT

**Breaking boundaries that limit professional growth.** KSTF's network approach has allowed our cadre to grow to more than 250 expert STEM teachers across 42 states. Through the network, Fellows collaborate with, learn from, and support peers in their own districts and across the country. This structure allows teachers to transcend the isolation of the classroom, eliminates geographic boundaries to the support and mentoring of novice teachers and provides leadership opportunities for more experienced ones.

**Career-long learning.** Teachers who complete the five-year Teaching Fellows Program use KSTF's network as an avenue for continued collaboration, to work with nationally known researchers to develop new pedagogical practices grounded in the realities of the classroom, and to help train and support the next generation of novice STEM teachers.

**Researching—and sharing—what works in the classroom.** The network provides a way to surface effective practices and innovative ideas in math/science instruction grounded in the experience of expert teachers, as well as a national network to disseminate it. Our Fellows have had their work on pedagogy published in journals and developed innovative professional development programs used at both the local and national levels.

**Informing policy and practice.** Along with informal leadership/collaborative roles within their schools and districts, KSTF Fellows are beginning to play more substantive roles in system change. For example, KSTF Senior Fellows have formed an Engineering Task Force that will develop models to integrate engineering into all science classes to meet the aspirations and requirements of the Next Generation Science Standards.

**Scaling through collaboration.** KSTF has begun exploring ways to scale its network, in part by collaborating with other organizations that support high-quality teaching to broaden overall knowledge of quality math and science instruction.

**A sustainable network that can drive system change.** The ultimate impact has been an emerging network that transcends and connects traditional education networks/structures: schools, districts, states, and national. This cadre of “backbone” teachers is what can hold all these disparate structures together by strengthening the overall quality of STEM instruction.

## THE NETWORK EFFECT: HOW IT WORKS

KSTF has begun to systematically study the spillover effect of empowering STEM leading teachers. The three examples below illustrate the powerful impact networked STEM leading teachers can have on local and national educational systems:

**Heather Buskirk**, a KSTF Senior Fellow, hasn’t let the fact that she is the only physics teacher in her small upstate New York district keep her from sharing her practice broadly with her colleagues—first in workshops on project-based learning and differentiated instruction, and then by co-founding a STEM-focused school in a shuttered elementary school building that she hopes will serve as a magnet for professional learning in her district.

“KSTF not only created great practices in one teacher, but also supported a district to support more teachers,” says Patricia Kilburn, assistant superintendent of the Greater Johnstown School District.

Called The Learning Project, the half-day school focuses on project-based learning and integrates core subjects for seniors who are on track to graduate but haven’t set clear goals. “They’re tired of sitting in rows and following directions.” Students with past records of high absenteeism are now attending school on a daily basis and are eager participants in the learning process. They are even learning new technology skills, thanks to individual laptops donated by the state.

Buskirk credits the KSTF Fellowship for “reshaping my vision of what teaching is and helping me see it as a lofty, challenging, intellectually stimulating, and exciting career path.”

Physics teacher **Bradford Hill**, a KSTF Fellow from Southridge High School, in Beaverton, Ore., splits his time between teaching high school physics and leading professional development for his district’s science teachers. Hill has played key roles in revamping science curriculum at both the district and the state level. His work on the pattern approach to teaching high school physics has been published in academic journals and presented at national conferences. But he argues that the largest impact he’s had as a teacher and leader can be seen in his classroom—and those of his peers.

"The level of rigor has definitely increased," he says. "Students have gone to more thoughtful, rigorous analysis multiple times a week and are always wrestling with informational texts. I've given my own students such a better learning experience—so much more inquiry, so much more being engaged with difficult material with the right amount of support."

Opportunities to serve as a leading teacher through the KSTF Fellowship prepared Hill to provide professional development, including developing new science curricula for the district and a weeklong professional development course to prepare teachers who would be teaching physics for the first time.

District officials say that Hill's work has had a spillover effect on improving overall science curriculum and teaching. "We had teachers walk out saying it was the best professional development they had ever had," says Dr. Susan Holveck, the district's secondary science coordinator. "You could see the light bulbs going off in their heads."

**Kevin Henson**, chosen as part of the second cohort of KSTF Teaching Fellows, has remained at the same New Jersey high school since he started teaching a decade ago, driving change at the district level without leaving the classroom. "What I like is that I have the ability to provoke change," he says. "I can see the culture beginning to turn."

Henson plays a key role in Lenape Regional High School's teacher induction program, a required three-year course for all new teachers focused on research-based pedagogy, and in the development of the district's teacher evaluation model. "We wanted to make sure we weren't doing something just for the sake of doing it, but to get teachers thinking about how it can impact students," he says. "My role as a leader is to have that conversation, whether formal or informal." As a result of the alternate model the district developed, he says, "teachers are finding value in the [system] as opposed to seeing a mandate."

The KSTF Fellowship's emphasis on teacher leadership played a key role as Henson shaped his career—and ultimately stayed in the classroom. "The Fellowship helped establish for me what it means to be a leader," he says. "If I didn't have the Fellowship, I would have felt like I couldn't have a voice without 10 or 15 years of experience. It also doesn't mean you have to take a position with a title or leave teaching."

KSTF has also helped Henson focus on ensuring that teachers take advantage of what students bring to the classroom. He is part of a group of Fellows who collaborate on equity issues addressing student identity in the classroom. "That's at the heart of the Fellowship, and as a teacher my role is to try and be the voice of the students and make sure their interests are at the forefront of decisions," he says.

## IMPLICATIONS FOR THE FIELD

KSTF believes its experience developing an emerging network of backbone teachers in STEM fields has broader implications for professional development, teacher leadership, and instructional improvement. Among our findings to date:

- Bringing leading teacher networks to scale requires high-touch and high-tech approaches for delivering support, enabling the generation and sharing of professional knowledge, and strengthening collegial relationships.
- Teachers who take responsibility for their own professional learning and support their peers through collaborative networks can transform teaching and learning within their buildings, districts, and beyond.

- Trying to replicate specific programs across varied contexts will not be as effective as supporting individual teachers to connect across schools, districts, and states, to transform student learning, teacher practice, delivery of effective programs, education policy and the teaching profession more broadly.
- Even in high-need subject areas, we need to identify and cultivate future master teachers with more than just content expertise; rather, we need to identify those who also demonstrate an ability and willingness to continually improve their teaching and potential to be leaders in the profession.
- Effective development of content and pedagogical expertise and teaching practice takes time and effort. KSTF's five-year fellowship model and its collaborative network are examples of the kinds of intensive supports needed to have an impact on student learning.
- Teachers must be given the opportunities and training to share experiences with peers and contribute to the direction of their schools and districts.
- Systemic improvement must be grounded in the realities of teaching. KSTF's national network, including partnerships with leading researchers and practitioners, ensure that teacher-generated professional knowledge and effective practices in STEM education are shared at all levels of policy and practice.

## **BUILDING A NATIONAL BACKBONE: THE NEXT STEPS**

For decades, policymakers and educators have attempted to solve the question of how best to scale promising practices across different individual school cultures, structures, and populations; local, state, and district policies; varying curricular requirements; and all the other variable contexts that define the American educational system. Broad-based efforts such as the Common Core State Standards and the Next Generation Science Standards hold great promise, but are unlikely to live up to their potential without significant efforts to improve teacher capacity and provide support during implementation.

Given the significant investment in time and effort needed for professional development to have an impact on student learning, networks comprised of teachers committed to improving their practice and supporting each other as educators may be the best way to ensure effective implementation of such initiatives as the Common Core and NGSS. Unlike China, the United States can't build a top-down network of high-quality teachers by government fiat. What we can do is support efforts to support promising teachers and develop their leadership and pedagogical skills, as well as connect them through networks that grow organically by subject area or need. We can also seek ways to link these networks together into "networks of networks" that address specific local or curricular needs, but also allow research and best practices to scale across networks and traditional educational boundaries.

For such networks to flourish, they need the support of policymakers, philanthropy, and other stakeholders at all levels to ensure they have the resources needed to grow from the bottom up. Backbone teachers must be identified and nurtured before they can become leaders capable of building strong networks, and that challenging work requires an equally strong backbone of support.

## ABOUT KSTF

The Knowles Science Teaching Foundation (KSTF) was established by Janet H. and C. Harry Knowles in 1999 to increase the number of high quality high school science and mathematics teachers and ultimately, improve math and science education in the United States. KSTF operates three programs that build national capacity for improving STEM teaching, leading, and learning: Teaching Fellows, Senior Fellows, and Research & Evaluation. To date, KSTF has supported more than 250 Fellows in 42 states.

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