



How Teachers Develop Social Capital: Illustrative Cases from the Knowles Science Teaching Foundation

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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. The KSTF Teaching Fellows Program, the Foundation's signature program, awards five-year Fellowships to promising early-career, secondary science and mathematics teachers, and supports them in their efforts to improve education in their own classrooms and beyond. The KSTF community includes more than 300 Fellows who taught science, math and related subjects to nearly 30,000 high school students during the 2015–2016 academic year. For more information, visit www.kstf.org.

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INTRODUCTION

The Knowles Science Teaching Foundation (KSTF) Teaching Fellows Program awards five-year Fellowships to early-career science and mathematics teachers, providing them with extensive financial and professional support. Fellows are supported in deepening their subject-matter knowledge and utilizing exemplary teaching practices. In the latter phases of the Fellowship, KSTF increases the focus on how Fellows can situate themselves as leaders in their school communities.

Fellows who complete the five-year Fellowship become Senior Fellows. The Senior Fellows Program supports a range of teacher leadership work that leverages and extends the Fellowship program to contribute to KSTF and the wider educational system. Senior Fellows have opportunities and support for further leadership development in areas of need/interest such as coaching, facilitating professional development or professional writing. KSTF offers monetary support for Senior Fellows to work collaboratively on educational improvement within their local contexts and beyond. KSTF also invites Senior Fellows to participate in national-level KSTF initiatives, such as Project ASCENT (a multi-school networked improvement community) and the Lever Engineering Group (a Senior Fellow-driven initiative to create and share resources for improving engineering instruction). The opportunities for leadership and ongoing connection to the KSTF network offer Senior Fellows multiple ways to increase their capacity to positively impact education beyond their own classrooms.

The overarching goal of KSTF is to create a national network of leading teachers who will take responsibility for their own ongoing development, collaborate with their colleagues to improve instruction for students beyond those in their own classrooms, and drive meaningful education reform in their schools/districts. As Fellows develop as leaders, KSTF envisions that they will mobilize the resources at their disposal to improve science and mathematics teaching in their schools, so that the investment in Fellows pays dividends beyond the Fellows themselves. KSTF prepares and encourages Fellows to engage with their colleagues in a variety of ways (e.g., observing each other's classroom and providing feedback, facilitating teacher inquiry/study groups, providing professional development workshops or seminars). KSTF's support for leadership activities is intended to develop the capacity of the KSTF network and others who are affected by those activities, multiplying the impact of KSTF's investment in the Fellows.

KSTF contracted with Horizon Research, Inc., (HRI) to conduct a qualitative multiple-case study of a sample of KSTF fifth-year Fellows and Senior Fellows to examine how Fellows developed social capital in their schools and/or districts. The main goals of this study are to understand what the Fellows do as leaders, and what effects the Fellows' activities have on their colleagues, schools, and/or districts.

THEORETICAL FRAMING

The study is framed by ideas about human and social capital, and the understanding that teacher and school improvement is a social endeavor, involving teachers' knowledge and skills, their ability to draw on others' expertise, and the nature of the education community in which they work. In essence, individual teachers have human capital related to teaching, which "encompasses a teacher's cumulative abilities, knowledge, and skills developed through formal education and on-the-job experience" (Leana & Pil, 2016, 4). In addition, individuals have access to social capital—resources and networks that they can tap into—to further develop their knowledge and skills. Collectively, the human capital of the individuals in a department and the social capital they have access to make up the expertise that is available to the group.

Recently, the education community's interest in examining the effects of social relationships among teachers has increased, and research provides evidence that social relationships within schools do affect a variety of outcomes. For example, collaborative and supportive school environments have

been associated with greater teacher learning and improvement (Kraft & Papay, 2016; Ronfeldt, 2016), as well as higher student achievement (Leana & Pil, 2016; Ronfeldt, 2016). Other studies have highlighted the importance of trust among faculty in schools, and its relationship with productivity (Bryk & Schneider, 2002).

Coburn and Russell (2008) distilled four essential features of social capital necessary for school improvement:

1. Access to expertise within the network—members have, or have access to, disciplinary and pedagogical content knowledge and resources for implementing effective practices;
2. The structure of the social network—the patterns and strength of “ties,” i.e., connections among teachers in the school, as well as their connections outside the school network;
3. Trust among members of the network—members have shared expectations for working with one another, and believe that others have good intentions; and
4. The content of teachers’ interactions—related to improvement goals and deep enough to lead to teachers learning new disciplinary or pedagogical knowledge.

In addition, Coburn and Russell, as well as others (e.g., Penuel et al., 2010), have identified how various factors may mediate this process by facilitating or inhibiting social network development, including common planning time, support for school-based professional development (PD), classroom location, and shared professional experiences. More recently, Ling and Dale (2013) argued that to mobilize social capital and create changes, individuals and communities require agency, or the “force behind social action” (Ling & Dale, 2013, p. 1), and they identified various barriers to change that can prevent agency. At the department level, potential barriers include lack of leadership to motivate the change process, and lack of physical or financial resources. At the individual level, a lack of concern about an issue; resistance to change; belief that one person cannot make a difference; or financial, psychological, or physical barriers can prevent personal agency. These factors, and indications of work to overcome them, provide insight into how the essential features of social capital may be changing within a school.

In contrast to many efforts to increase social capital in schools through reforms initiated by schools or districts (e.g., Coburn & Russell, 2008; Penuel et al., 2010), KSTF believes that social capital can be built by teachers working together in their schools. To this end, KSTF seeks to equip Fellows with the knowledge and skills needed to be catalysts of change in their schools. For example, KSTF works to bolster Fellows’ science- and mathematics-specific knowledge for teaching, understanding of strategies for engaging other teachers in shared inquiry, experience in opening their teaching practice to others, and facility with protocols to guide productive conversations about teaching and learning. These tools are intended to support Fellows’ work to increase the social capital in their school contexts by increasing the available expertise, encouraging collaboration among colleagues, building trust, and focusing teacher conversations on issues that affect student learning.

METHODOLOGY

This study was designed to explore the types of impacts on social capital that have occurred as a result of the work of KSTF Fellows, as well as factors that have mediated these effects, using case study methodology (Stake, 1995). HRI, in collaboration with KSTF, identified a set of potential case study participants. A selection of fifth-year Fellows and Fellows transitioning to the Senior Fellows Program were identified by KSTF, based on what was known about the types of leadership in which each was involved. Fourteen Fellows were invited to participate,¹ of whom 12 consented; selection of the final sample was based primarily on schools’ willingness to participate.

¹Two Fellows identified by KSTF were not invited because their school districts were not accepting applications to conduct research.

In addition, each Fellow was asked to nominate three colleagues, including at least one teacher and at least one administrator/supervisor, to participate in the study. In two cases, the Fellow nominated a fourth colleague, and one Fellow nominated only one colleague. However, 2 of the 24 nominated colleagues did not respond to requests to participate. A list of the Fellows and their participating colleagues is shown in Table 1.

Table 1: Participants²

School	Fellow	Colleagues
Growing Minds Charter School	Joseph Henken Senior Fellow	Mr. Thompson, Math Teacher
Middletown High School	Michelle Prewett Fifth-year Fellow	Mr. Stokes, Teacher Dr. Naegel, Principal
Scenic High School	Jessica Keyes Senior Fellow	Mrs. Morgan, Science Teacher Ms. Guest, Science Teacher Ms. Wittman, Assistant Principal
Forestview	Robert Haskett Fifth-year Fellow	Mrs. Simmons, Science Teacher Ms. Turino, Department Head Ms. Penton, Head of School
Green Mountain High School	Elizabeth Sulewski Fifth-year Fellow	Mrs. Mayberry, Physics Teacher Mrs. Spence, Science Department Chair Mr. Guillory, Principal Ms. Eckert, District Science Curriculum Supervisor
Woodrow Wilson High School	Amber Carmody Senior Fellow	Mrs. Germain, Chemistry Teacher Mr. Perce, HS County Science Specialist Mrs. Vogel, Assistant Principal
	Jennifer Fredrickson Senior Fellow	Mr. Eklund, Science Teacher Ms. Amber Carmody, Department Head Mrs. Vogel, Assistant Principal
Succeed Academies	Clarissa Westfall Senior Fellow	Mr. Sheldon, Biology Teacher Ms. Sepulveda, Science Content Specialist & Teacher Ms. Greenlee, Director of Strategic Initiatives

HRI conducted a semi-structured telephone interview with each participant, focused on the Fellow's leadership and teaching activities and the impacts of those activities on his/her colleagues and school/department as a whole. These interviews were personalized based on information about known leadership activities provided by KSTF. For each case, the Fellow interview was conducted first, and at the conclusion of the interview the Fellow was asked to nominate three colleagues who could share insights into how his/her leadership activities have affected others in the school or district. Colleague interviews focused on effects the Fellow had on the colleague, other teachers, the department, and the school as a whole. These interviews were also personalized using information from the Fellow interview as well as from KSTF.

²All names, including teacher, school, and district names, are pseudonyms.

Each interview was audiotaped and transcribed, and interview data pertaining to each Fellow were coded to identify themes in each case. Each individual case was reviewed by the Fellow to confirm accuracy. The four features of social capital described in the theoretical framework (access to expertise, network structure, trust, and content of interactions) were used to analyze the seven cases, with a goal of describing Fellows' impacts on the social capital available within their departments or schools.

Although the methods used in this study were rigorous, it is important to acknowledge aspects of the study that may affect the validity of claims made or the extent to which they are likely to generalize to the population of Fellows. The Fellows in this study were purposefully selected because they were engaged in activities with their colleagues that could impact social capital in their school contexts. Therefore, impacts they have had on their schools may not be representative of Fellows in general. All of the Fellows were still relatively new teachers who had been in their schools for at most five years, so it is not yet evident to what extent the impacts described will be lasting. In addition, the cases rely on self-reported and colleague-reported data, and social pressure may have discouraged participants from sharing unflattering information about the Fellows or others in their schools.

GROWING MINDS CHARTER SCHOOL CASE—IF IT'S NOT BROKEN, DON'T FIX IT: ONE FELLOW'S EFFORTS TO EXTEND A SUCCESSFUL SCHOOL CULTURE

There is nothing traditional about Growing Minds Charter School. The school takes a sustainability education approach, with an emphasis on interconnected global problems such as environmental crises, energy crises, poverty, and disease. The curriculum is structured to be cross-curricular and project based, acknowledging the complex dynamics of existing global problems. The school-wide culture of collaboration and continued improvement is intended to support students in developing knowledge, skills, and habits of mind to understand and respond to these problems. Further, teachers are committed to challenging students to think deeply, dream big, and take action.

It was this focus on sustainability education that drew Joseph Henken, a KSTF Fellow, to Growing Minds Charter School:

I just think the description of the school really spoke to me. The description of the science program not being isolated to chemistry and not isolated to physics or biology—but how the theme of the science program was to incorporate all of those subjects through topics and projects and how they relate to one another.

Joseph embraced the school culture, as he found it to be a natural extension of what he had experienced as a KSTF Fellow:

KSTF did such a good job of making the environment and atmosphere noncompetitive...KSTF was the first thing in science that I've ever had where I didn't feel that I had to put on a front so other people would think I was smarter than I actually was or that I knew more than I did. I could just genuinely be myself and ask questions that I had and not be afraid.

Now in his fifth year as the upper-grades science teacher at Growing Minds, Joseph consistently works to uphold and extend this collaborative school culture. He is committed to fostering curricular connections between mathematics and science, regularly bringing in speakers and other resources to prompt faculty thinking about how to make these connections in their courses. Joseph attributes his interest and emphasis on this cross-curricular approach to his experience in KSTF:

[KSTF] really gave me an appreciation for how understanding particular physics concepts or particular chemistry concepts really weren't just isolated to physics or chemistry. It involves mathematical reasoning, so it involves mathematical understanding. It involves sort of an understanding of the ability to draw upon the past experience and kind of know the ways in which that past experience helps you and hurts you in terms of understanding a concept in science really effectively....I think KSTF helped me realize that a lot of the concepts in math and science can really be understood through a variety of ways, and kind of helped me realize that it is important to make those connections.

To this end, he spearheaded the development of online science and mathematics resource kits, allowing teachers to easily share resources and lessons plans with one another. He also developed the entire 11th and 12th grade science curriculum, which he envisions as a model for other science teachers due to its focus on real-world connections:

It's a really good example of how you can take a standard chemistry or physics curriculum and broaden it to incorporate the real world. It's relevant and engaging to student topics and still teaches the chemistry and physics that students need to have a basis and a background in that. So I think that the curriculum is really well put together and I think it would serve as a really creative and engaging base for someone if some other teacher were to take over. It will be something really cool to start with. It's pretty unique and I've never really seen an example of another curriculum that's like it.

Mr. Thompson, the upper-grades mathematics teacher at Growing Minds, credited Joseph with helping to develop a common vision of what a sustainability focus looks like in science and mathematics education:

Mathematics is really tough, so he's done a lot of work getting us to develop that [vision], including encouraging other teachers to take risks. I feel like I've had some training in it, but other teachers haven't so they don't know what it's about or what it's even supposed to look like. So Joseph's been really good in establishing that, in helping us get a vision of what sustainability-focused math education would even start to look like.

As a result of Joseph's efforts to operationalize sustainability in the context of science and mathematics, Mr. Thompson has made changes to his mathematics teaching, increasingly focusing on modeling and discussions of environmental concerns and social justice.

Another way Joseph has extended the school culture of collaboration at Growing Minds is by serving as an instructional coach. In this role, Joseph opened his classroom and welcomed others to observe his teaching and come to him with questions. Joseph took a particular interest in helping others design and facilitate opportunities for effective group work, an approach that he explored as a KSTF Fellow:

One of the things that I worked hard to develop my skills at, and KSTF really helped with, is how to design group work and how to have students work effectively in groups. For a lot of the teachers that I was working with, that's one area where I was really able to help in getting teachers to think about it. They could take a lesson and tweak it in a particular way where it's really designed to challenge students to work together in groups...I can think of this one science teacher in particular that I worked with. I think when we started to see a shift in the approach towards teaching group work, it shifted a lot of the responsibility and the emphasis off of the teacher and onto the students in terms of active engagement.

Mr. Thompson praised Joseph's ability to constructively offer targeted feedback, and described a particular way Joseph's coaching has impacted his teaching:

He gave me the suggestion of having the whole class start [a task], but after five minutes, tell them after five minutes, you're going to pause the class. So that even if students are stuck, they should generate questions about what they're stuck on. And that went remarkably well in terms of the expectations of what they're supposed to do, that students can understand if they got stuck that doesn't mean that they're just done. It provides a chance for them to help one another and so much discussion, classroom discussion, as a result.

Mr. Thompson also described how Joseph shaped the way he plans for instruction. As a result of his collaboration with Joseph, Mr. Thompson indicated that he carefully thinks about ways to differentiate his instruction and make lessons engaging to students:

That careful preparatory work ahead of time just set [the lesson] up to be so much more successful than it would've been otherwise—that careful foresight for planning and that shaping for the class environment. So that level of thinking, I will keep aspiring to that long after Joseph and I have stopped teaching together.

KSTF Support and Influence

KSTF's influence and support are apparent in Joseph's approach to collaboration. He explained that his KSTF experiences illustrated the power of observing other teachers as they plan and teach for improving one's own practice. Reflecting on his practice has helped him identify features of his own classroom that might be of interest to others, and therefore valuable to share. He attributed his willingness to share what happens in his classroom to a pride in his work that is fueled by his work with KSTF:

Even if a lesson doesn't go as I had expected or planned, I feel proud of what I'm doing on a day-to-day basis and therefore I feel really willing to work with other teachers. So KSTF has kind of given me the tools to really understand where I want my teaching to be and how to get it there.

KSTF has also provided Joseph with resources to foster collaboration, such as protocols to support coaching conversations, and experience in talking about student learning. He has used these resources to pursue conversations with other teachers in which he engages in shared inquiry, rather than trying to impose a solution on another teacher. For example, he described working with a former colleague who was a talented lecturer, but who found it difficult to keep students in one particular class engaged. Joseph began not by suggesting changes to the teacher's practice, but by asking how the other teacher knew when students were developing an understanding of a topic. Their work eventually led the teacher to conclude that more active learning strategies might be appropriate for that class and possibly for other classes that did appear attentive during lectures. As Joseph explained:

That led to more discussions about, "If you're lecturing to a class that is really attentive, how do you know that they are understanding the concept that you are teaching?" That led to this idea...that you actually don't know students are getting it. They may have a particular appearance or the class may look or feel a certain way, but that doesn't necessarily mean they're getting it or that they are creating new knowledge or making the connections that you're hoping for....[They needed] a more vivid approach, like adding some more strategies... to help them understand. I think this other teacher realized, too, [those strategies] could be really good also for the classes that seemed to be attentive during that lecture time. So by working on the approach that was more focused on getting students to be active and make sense of a particular phenomenon, we were able to not only work on that practice, which was difficult, but also see some more effective ways.

Sustainable Impacts

When asked about lasting impacts of Joseph's work, Mr. Thompson thought some of the materials Joseph has developed would continue to be used, even if he were to leave. Mr. Thompson gave an example from his own curriculum, describing a mathematics project that his predecessor had developed with Joseph, and that Mr. Thompson adopted when he began teaching at Growing Minds.

In addition, Joseph's work as an instructional coach has had a lasting impact on colleagues with whom he worked closely. Mr. Thompson, for example, described Joseph's concrete suggestions as helping him bridge a gap he perceived between education theory and practice, saying:

In terms of a major shift in my teaching, I think he helped me fill in some things. When I was in graduate school—there's a lot of great theory out there. When you get to the actual reality of teaching classes, getting that theory to help with reality is really challenging, and seeing ways for that to happen can be tricky.

Although Joseph has been an integral part of his school community and has affected some of his colleague's teaching practices, it is difficult to point to widespread school changes that have occurred as a result of his leadership. However, there is no need to fix something that is not broken. Joseph has found a way to work in an already successful system, drawing on his strengths to uphold and extend the school culture and support his colleagues in providing effective instruction.

MIDDLETOWN HIGH SCHOOL CASE—THE WHOLE IS GREATER THAN THE SUM OF ITS PARTS: HOW A KSTF FELLOW LEVERAGES THE KNOWLEDGE OF COLLEAGUES

Middletown High School has approximately 1,500 students and is situated in an affluent suburb of a major metropolitan city. A multitude of AP and honors-level classes are offered to students, and opportunities are available for dual-enrollment classes at the local universities. The school has the highest graduation rate in its county at almost 97 percent, and 93 percent of the most recent graduating class matriculated to college, being awarded over four million dollars in scholarships.

Opening its doors for the first time in 2012, the school only recently established the character and principles that define its culture. Faculty were recruited from a wide area, and brought a variety of norms, attitudes, and behaviors. As Dr. Nagel, the principal who founded the school, noted, "We had teachers that had come from all different places and they held onto their comforts and their habits from their previous schools. It took us about three years to figure out 'What does a teacher at Middletown High School do?'"

Key to the school culture, and the norms that were negotiated by the teaching staff, is a belief reflected in the school's mission statement that student success is achieved through a collaborative community effort. Support for this belief is evident as there is dedicated time during the school day for teachers to work in professional learning communities (PLCs) as the students engage in non-academic programming. There is also about one day per month that teachers have to plan and work together.

Michelle Prewett, a KSTF fellow, leads the PLC for honors biology teachers. Michelle began her science teaching career at Middletown High School during its inaugural year and has remained at the school ever since. Prior to teaching, she worked for five years as a microbiologist and left that position to enter a master's program, during which she joined KSTF, in order to become a high school science teacher. According to Michelle, she wanted to share her passion for science

after observing how little science her nephew was experiencing in school. As she explained her transition into teaching:

I thought, "How can we get our younger generations to be passionate and care about science... have as much passion for it as I do and want to go into all of these careers if they're doing so little in their classes?"

Michelle's philosophy for her PLC is to build a strong collaborative team, drawing on the strengths of its members. In her view, everyone has different experiences and insights that they draw from that can be useful to the team. As she noted:

I don't want to be in the director role because I'm only a fourth-year teacher and some teachers on my team have been teaching 15–20 years. And I don't in any way think that I know more than they do. I think we all have something to learn from each other.

This philosophy of collaboration is embodied in the way Michelle organizes the PLC. Often members of the team are asked to facilitate particular sessions depending on the topic and the background and skills of the PLC members. As Michelle describes:

From week to week a different person may lead the team if we're looking at student data or if we're working on writing a shared test or an assessment that we're all going to use or whatever we might be doing that week. I might ask one of the other teachers that is stronger in that area and say, "This is an area that's much more your expertise. Would you mind stepping up this week and taking the lead?" So everyone has more ownership in the team and it doesn't feel like I'm the director. I'm not just telling everyone what to do.

Mr. Stokes, a member of the PLC, believes that Michelle's knowledge of the people on the PLC, and her ability to bring together their varied expertise, is a key aspect of her leadership ability. As he stated:

She knows our strengths and our weaknesses as teachers, so she tries to build off of that as far as moving forward...So [she tries] to build us up so that we're kind of all reaching for the same level of knowledge.

Michelle has been involved in a district-level initiative, working with teachers from other schools to update curriculum guidelines and define expectations for biology students at different levels. She drew on her experiences in KSTF with curriculum topic study and exploring pedagogical content knowledge to inform this work. She indicated that she works hard to bring the results of this work, as well as what she learns from other conferences she attends, back to her PLC. Michelle believes that these discussions and the team approach can be effective for new teachers or teachers who are struggling in a particular area. As she explained:

Sometimes we get a teacher that's brand new to teaching and maybe is not very strong in the content, but because our team is strong we can help that teacher, we can guide that teacher, we can assist the teacher in learning new techniques. Because as a team, we've already established this trust and we have this effective way of working well together.

According to Michelle, the biggest impact of this collaborative work with her team has stemmed from the discussions looking at student data and examining their practice. Ultimately, this experience has led to the group being more thoughtful about their instruction:

Those have been some very rich conversations that I feel like the teachers have really gained from...I've seen the biggest improvement in myself and in the teachers that I collaborate with, just being more mindful of what we're doing and how our teaching strategies, our grading practices, and what we do is impacting the field.

KSTF Influence and Support

Michelle attributes her ability to build a community of learners to her work in KSTF—in particular, what she learned about the role of, and need for, developing norms to guide the work. She described herself as someone who is not particularly outgoing, and was initially uncomfortable with the activities at KSTF sessions to build norms, establish roles, and manage personalities. However, she quickly changed her mind about these strategies as she saw the benefits of them unfold:

But then, because of my work with KSTF, I saw such a collaborative, such a strong collaborative community getting built. Where we all had so much trust in each other that I knew all of those things that they had us doing had a purpose.

KSTF also exposed Michelle to the Next Generation Science Standards. As a result, she believes that she was better prepared than others when she was asked to work on a district committee to assess curriculum and materials for alignment to national expectations. More generally, Michelle believes that KSTF exposed her to different ways that she could be a leader without leaving her classroom.

Sustainable Impacts

When asked what impacts of Michelle’s work would be sustained if she left, both Mr. Stokes and Dr. Nagel indicated the norms and process that she has established for discussions would continue. In sum, Dr. Nagel stated that the lasting impact of Michelle’s work will be the belief that she built among teachers that collaboration is a good thing. As he noted:

It will be hard to replace her. She’s done a good job. Even within our science department, we have little modules or pods. We have five biology teachers and she kind of keeps them together. Different personalities came from different places, and she kind of keeps them together rowing in the same direction. I think if she weren’t here, I would notice a gap, especially with the biology teachers.

SCENIC HIGH SCHOOL CASE— CREATING A CULTURE OF COLLABORATION

Scenic High School is a top-ranked high school surrounded by universities, technology firms, and research centers. About half of the school’s approximately 1,900 students are White, with most of the remainder almost evenly split between students of Asian and Hispanic ethnicity. Expectations for students are high, and most students go on to attend a four-year college after graduation. The school offers many honors and Advanced Placement (AP) courses, and has an open access policy that allows any student to enroll in any advanced course. In addition, a parent-organized foundation has generously supported the district schools, providing funds for reduced class sizes, internet connectivity in classrooms, and state-of-the-art science equipment for the district’s two high schools (allocating \$125,000 out of over \$1.5 million donated to the two schools for this equipment in the last year alone).

It is not uncommon in settings like this one for schools to resist change—with parents, administrators, and teachers believing that methods that have worked in the past will continue to work in the future. Thus, it is not surprising that, although science teachers teaching the same course at Scenic are organized in “collaborative course teams,” the extent of collaboration beyond the expected use of common summative assessments and grading schemes varies widely. It was into this environment that Jessica Keyes joined the science department four years ago after teaching for one year in a small charter school.

As a third-year Fellow at the time, Jessica was used to, and found value in, reflecting on her teaching with other KSTF Fellows and wanted to create a similar culture of collaboration with her colleagues at Scenic. Cognizant that she was a new teacher in a high-performing school, Jessica carefully worked on fostering relationships with her colleagues as opportunities arose.

One such opportunity was through her work on a course team for a new AP Environmental Science course at Scenic. Mrs. Guest, a colleague of Jessica's, explained that she and Jessica develop common lectures, labs, homework, grading policies, and assessments to help ensure that all students who took the course would have similar, high-quality experiences. They also check in with one another frequently, strategize about follow-up when students in either of their classes need extra help with an idea, and grade assessments together. As Mrs. Guest said:

Jessica and I collaborate more than I would say your average teacher at our school. What that looks like for us is that we plan everything together...After we do a lab, we'll get together and be like, "Hey, my kids had a hard time on this. How about yours?" and we'll talk about—if it's the same thing they had a hard time on, then we talk about what we can do the next day to clear that up and make it easier for them. If it's different things they had a hard time on, then we'll share with each other, "Well, this is what worked for me..." and the other will go back to their kids with that.

Mrs. Guest also indicated how her relationship with Jessica has continued to grow more collaborative over time and that she now feels comfortable being completely open with her:

It's super helpful to have someone that you can discuss ideas with and learn from and share with and go, "I have this idea, what do you think?" And it's a very trusting and open relationship. So if there's something that one of us doesn't think is going to work, there's no problem discussing, "Hey, I'm not sure and this is why." And it's just really great and I've never had this kind of collaborating experience before.

She also thinks that their collaboration has served as a model for other teachers in the school, and has started to change the culture of the department. In contrast to her past experiences, Mrs. Guest thinks that the science teachers at Scenic are beginning to feel comfortable opening up their classrooms to others and recognizing that they may be able to learn from each other to improve their practice:

I think that other teachers see the success that we have in collaboration, and then are more willing to discuss other topics as well. I have, in the past, been in schools where there's a negative atmosphere between teachers, and I feel like here at this school, when they see that positive relationship, then it becomes more open. If they see us not judging each other, then the little bit of the barrier, perhaps they think I'm not going to judge them either, and so they're more open to sharing with me.

Another way Jessica has tried to foster a collaborative culture in the science department has been by serving as an informal mentor to newly hired science teachers. Mrs. Guest was able to discuss Jessica's influence from the perspective of a newly hired teacher. She found that several teachers in the department were willing to share their course materials with her, but that Jessica went beyond simply giving her materials and was willing to discuss ideas for using them. Mrs. Guest went on to describe how, when she was first hired, she spent many of her planning periods observing Jessica teach:

At the beginning of the first unit I was always in her room every day during my prep period, watching her teach. And she was very open to that and talking to her about the unit and the curriculum.

Jessica's willingness to teach a variety of courses, not just those that attract the best students, has allowed her to continue building these types of relationships with new teachers. Now, the department head assigns Jessica to the same courses as new teachers so that she can support them. As one of her colleagues described:

We have two new colleagues in our department this year. And she really is instrumental in bringing the new people in and helping them figure out what to do and making them feel like actually a part of the department as opposed to just an outsider watching the department. She is the main person in our department who takes on that role. It's not a designated role that she has; it's one that she has informally taken up.

Despite these efforts to foster a collaborative culture within the science department, Jessica was growing frustrated that there were not opportunities for the department to work together on issues of practice. Department meetings served solely as a conduit of information from the administration to teachers, and left limited time to talk about best practices. Jessica was also cognizant that her KSTF Fellowship was drawing to an end. Hoping to create a similar type of support group, she decided to initiate a small "inquiry group" with three other teachers in her department as part of her fifth-year KSTF inquiry. The group intends to meet twice a month after school to discuss ways to improve the teaching and learning for all students in the school. As Mrs. Morgan, a relatively experienced teacher in the department, described:

We're focusing on the achievement gap. We've collected data on students who are not successful in our classes and we have an enrollment gap for some of our more rigorous courses. We're focusing on how we can increase enrollment and how we can support those students' success.

Mrs. Guest added that, although the group is starting with just a subset of the department, she hopes it will expand to include the rest of the department in the future.

I don't want to be in an exclusive group. But...I realized it's not an exclusive group, it's a pilot group. We're testing it out this year with the four of us to see how it goes, and then we're hoping to open it to the department next year after we've worked out the kinks...So far it's been going great and I can see it being opened up to the whole department in the future and changing the shape of how we work together.

Although the inquiry group is starting small, Jessica has leveraged her KSTF Fellowship to introduce best practices to her department more broadly. Using a strategy that she termed, "blame the Fellowship," Jessica told her department head that KSTF required that she give a presentation to her colleagues about her teaching and asked for time at a department meeting to do so. Through this presentation, Jessica was able to share an instructional strategy called POGIL³ that she learned about through KSTF. Similarly, Jessica introduced her department to five practices for orchestrating scientific discussions.⁴

Since Jessica's PD sessions, POGILs have become a regular part of instruction at Scenic. In fact, Mrs. Guest started using POGILs because other teachers were using them, without realizing that Jessica had introduced them to the department. In addition, chemistry teachers have sought out

³POGIL, or Process Oriented Guided Inquiry Learning, is a form of guided inquiry that incorporates exploration, concept invention, and application (see <https://pogil.org/> for additional information). An activity that follows the POGIL format is often referred to as a POGIL.

⁴See, for example, Cartier J., Smith M., Stein M. K., & Ross, D. (2013). 5 practices for orchestrating productive task-based discussions in science. Reston, VA: National Council of Teachers of Mathematics.

and adapted POGILs from a variety of sources, in addition to using resources that Jessica provided. Because relatively few POGILs are available for physics, one of the school's physics teachers even took the initiative to develop some of his own. Other teachers and the assistant principal agreed that POGILs were in the department to stay.

KSTF Support and Influence

KSTF's influence is apparent in Jessica's ideas about teacher collaboration and inquiry, which she described as based on her work with her KSTF cohort. She also described a variety of ways in which being a KSTF Fellow affected her teaching and leadership activities. In terms of KSTF's impacts on her views about teacher leadership, Jessica said that observing local leadership as part of the KSTF Year 4 activities helped her see ways she would like to see the department function differently as well as the current chair's strengths as a leader. The school inquiry group was part of Jessica's fifth-year KSTF inquiry project, and she received support from talking with KSTF staff and other Fellows. She was also applying for a leadership grant to help buy books and other supplies for the inquiry group.

In terms of teaching, Jessica first encountered the instructional strategies that she shared with colleagues (i.e., POGILs and the five practices) through KSTF, and she received a summer PD grant to attend a workshop on POGILs with other Fellows. Her presentations to her department were influenced both by attending and critiquing other Fellows' presentations and by her own presentations at KSTF meetings. She described her KSTF experiences as increasing her confidence about sharing her ideas:

They've also given me a lot of confidence. Being a new teacher and being young, I'm saying, "What authority do I have to tell other teachers what to do when I've barely planned my class?" And having gone to conferences and having read some great books in education and talked to people, I can walk in and say, "Well, I was discussing this with a bio teacher in MA," and that gives me the authority that this isn't just coming from my head, I have some confidence in this theory or this method.

Mrs. Wittman, an assistant principal at the school also recognized the contributions of KSTF to the school:

I think all the opportunities that she gets because of being part of [KSTF], she shares them, and she doesn't just keep them to herself and close her door. She's just really good about sharing things.

Sustainable Impacts

When asked about lasting impacts of Jessica's work at the school, Mrs. Wittman highlighted the teaching practices Jessica introduced to her colleagues in the department. For example,

People would continue to use POGILs because people really like them and think they're good for kids.

In addition, Jessica's colleague Mrs. Morgan, who because of her long tenure at the school is involved in hiring of new science teachers, credits Jessica with making her realize the importance of hiring the right people.

When you hire someone like Jessica, all that we've been able to learn from her, and the role she has played in the department, and the growth that we have seen in her in the four or five years she has been there has been amazing. And I also would, as I'm looking at resumes, if I see that someone is a Knowles Fellow that definitely pushes them up higher on my list too. Because the individuals Knowles chooses are reflective on their practice and continue to want to grow.

Mrs. Morgan also thinks the collaborative culture Jessica has been fostering, particularly with the inquiry group, would likely continue if Jessica were to leave Scenic:

The model of bringing people together that have similar teaching philosophies and have a problem they want to solve, and reading and talking. If that happens, then I hope the habit of mind and practice would be established.

Still, her colleagues agree that Jessica's leaving would be a loss for the school, as she has been a dynamic teacher and a catalyst for department-wide improvement. As Mrs. Guest said when describing Jessica's support for new teachers:

I think that if Jessica were to leave the department, then that particular role would be vacant, and that would not be a positive thing for new teachers. I don't anticipate anyone else picking that up in terms of the veteran teachers who are there.

FORESTVIEW CASE—A SCHOOL'S JOURNEY FORWARD: HOW A KSTF FELLOW HELPED BUILD MOMENTUM

Forestview is an academically rigorous private school located in a major city with approximately 600 students in grades 9–12. The school has been undergoing a transformation over the past decade. It has intentionally been diversifying its historically White upper-class student body so that currently, only about half of the student body is classified as White, with the remainder identifying as Asian American, multiracial, African American, Hispanic, or other race/ethnicity. In addition, the school now provides financial aid to 30 percent of its students. The school prides itself on the fact that 100 percent of Forestview graduates attend four-year postsecondary institutions.

Along with the broader changes at the school, four years ago the science department began a review of its teaching practices. The results of this review revealed that the department's practices were more traditional than the faculty intended, and department members committed to changing their instruction. Consequently, when Rob Haskett, at the time a third-year KSTF Teaching Fellow, was hired to join their physics team, the school was poised for a change. Although Rob did not start this movement when he joined the faculty three years ago, and has not been the only contributor, his efforts to foster a collaborative environment among his colleagues, focused on reflective practice, have help build and maintain momentum toward creating a department-wide, student-centered learning environment.

Since the review, the department has engaged in examining the curriculum in an effort to instill a more inquiry-based approach in their science teaching. Rob's ideas about student-centered, project-based learning contributed to this effort and have been welcomed by faculty members looking for new ideas. As Mrs. Simmons, who has taught physics at Forestview for over a decade, put it, "I'd worked with the same people for quite a few years and we were trying to innovate and change, but having someone come in with a different perspective and a different background has really helped."

Rob's influence on the school is evident in the work of the three teachers who comprise the physics team. The team has moved toward starting each unit by engaging students directly with the phenomenon they are about to study, in order to help students connect the concepts with real-world, physical experiences. As Rob described it, "we always enter into any unit now with some experiment that is the actual thing that we're studying and not some...imagination, but something moving or something pushing something else; students feel those things and they see the motion." This strategy is part of a larger shift that the science department chair, Ms. Turino, has observed

in the physics team and the science department as a whole, toward making science content more accessible through connections to real-world experiences. She described the changes in the physics courses as follows:

It [physics instruction prior to Rob's hire] was much more mathematical—and I'm not sure that it was just math, but it felt much more formula based and theoretical. I think what they [the physics teachers] have really done is shift how they approach that material, so it's much more practical, it's much more real world, it's much more hands on. And then the students are discovering the mathematics behind it because they're wrestling with real-world stuff, like they're touching stuff—they're rolling carts and they're working with friction and they do these bowling ball races with brooms—and then deriving some of the math behind that, as opposed to, "Here, let me present you with a formula and some variables and teach you how to calculate this and then we'll start to measure things." This is just a different way of approaching it. That philosophy of how to teach this kind of material—there's been a significant shift, and [Rob] has really played an important role in that change.

This strategic shift has come about through the collaborative development of lessons and units for physics courses. For example, when the physics team was talking about how they could use project-based learning (PBL) for their unit on forces, Rob introduced an idea he had heard about for using actual Mars Lander data to teach about acceleration and force. Rob and Mrs. Simmons collaborated to develop a PBL based on these data that is now used by all three teachers in two different physics courses.

Rob has also reached outside of the science department to foster collaboration, working with other teachers in the school on student-centered, project-based teaching. As part of an engineering course he developed, students design and build skateboards that are then auctioned off by the school's parent association. Before building their skateboards, students create physical models, and with the assistance of the computer science teacher, virtual models. Rob also enlisted the help of the art teacher to help students build and decorate their actual skateboards. When describing Rob's collaborations, the principal, Ms. Penton, noted that he took the initiative to establish connections with teachers outside the science department.

Rob's fostering of a collaborative atmosphere has gone beyond helping to develop and revise curriculum. In Rob's first year at Forestview, he introduced the science department to the idea of a "three-minute observation club" for providing a structure for teachers' collective reflection on their teaching practices. The idea for the club came from KSTF; a number of Fellows have established groups of teachers who take turns hosting brief observations in their classrooms. The members of the club observe the host teacher for three minutes during their own planning time, using a prompt or question to focus their observation. After all the members have observed and briefly reflected on their observation and the prompt, they meet to discuss their observations as a group.

At Forestview, the "club" is the entire science department and the observations are hosted by a content team rather than a single teacher. For example, if the physics team hosts a month's observations, then each science teacher in the department chooses one of the three physics teachers to observe for three minutes. The department chose to have teams host to encourage attention to broader issues of teaching and learning rather than an individual teacher's actions, and Rob reported that the decision has shifted the focus of the conversation "pretty effectively away from the host teacher and towards teaching and talking about teaching and being reflective about your own practice."

Although it is voluntary, most of the science teachers participate in each monthly observation and discussion cycle. Ms. Turino, the department chair, described the science department's club as "another way that [Rob] has shifted how we're talking about teaching." She described the club as

a success in terms of its value for initiating discussions about teaching among the faculty. As she explained:

It's always just a starting place for a much larger, more interesting conversation that's about pedagogy, and what we're doing as teachers and what we want to do and what are pitfalls. It's some of the best professional development, frankly, that I think we do all year, in that it has people talking in a very concrete way about what we're doing in our classrooms and sharing ideas.

She went on to say, “[Rob] was the leadership behind the whole thing. He came in with the idea and presented it, and then pushed to create a schedule that was going to work.”

Rob now shares leadership of the club with another teacher, who has taken over sending calendar invitations and selecting prompts for the department to consider for the next round of observations, making the ongoing success of the club less dependent on him. Rob sees the club as a real “success story” because other teachers in the school are committed to it:

I like it because it's self-sustaining now—if I were to leave it would continue going, and they have access to all the prompts that I ever had and the information that I had, and people enjoy it, and they're not just being nice to me by coming.

Rob has also worked with his colleagues to change the school culture to be more student-centered in general. For example, Rob has engaged the other physics teachers in discussions about factors that affect student motivation, such as grading and homework policies. To this end, he and Mrs. Simmons revised the grading policy in one of their common courses from a normative approach (using a grading curve) to a four-point criterion-reference scale that Rob described as more developmentally appropriate. He explained:

We were able to see how we might grade with that [four-point scale] without curving everything, because it turned out the curve in our physics class would be like—the average of the test would be 70 percent and we would curve it up, but that still had the impact of kids feeling stupid. The impact, two days later, is they still don't feel good about the next thing we're learning.

Rob and Mrs. Simmons have also implemented a Google Plus™ community for their classrooms that enables students to share ideas and questions with one another. It is intended to create a more level playing field for students in the course, giving them greater ownership of their own learning. Mrs. Simmons described it as a way to provide everyone in the class access to other students' questions and answers about the course content, even for students who live in different neighborhoods or have not been part of the same school community in the past.

More broadly, both Ms. Turino, the science chair, and Ms. Penton, the principal, credited Rob with engaging other faculty members in conversations about equity. For example, Ms. Turino observed that Rob helped other teachers become aware of unconscious norms that could negatively affect students. As she put it:

He's a catalyst for those ongoing conversations and awareness of how issues play out in the real lives of our students. I think he keeps teachers talking about, “What are some of the invisible practices that we don't see that have impacts on kids, and how do we counter those or stop doing them?”

Ms. Turino attributed many of Rob's efforts to change classroom instruction to his passion for social justice, particularly equity concerns about reducing stereotype threat and providing a level playing field. This characterization was echoed by Ms. Penton:

He furthers the conversation around all sorts of things: about kids, about equity, about hands-on learning, about what's the right degree of rigor for kids, and what kind of rigorous school do we want to be? Do we want to be a school that's just "test, test, test, test," or do we want a thoughtful school where critical thinking and that kind of thing is present?

KSTF Support and Influence

KSTF's support and influence are evident in much of Rob's work at Forestview. For example, the idea and general structure for the three-minute observation club was from KSTF, and Rob secured a small KSTF leadership grant to provide refreshments as a way to encourage his colleagues to participate. He also used resources other Fellows had posted on a KSTF discussion board in the three-minute observation club, particularly the prompts that direct teachers' attention during the observation. Rob has also shared KSTF instructional resources with his colleagues, for example, the Patterns unit that was developed by another KSTF Fellow.

A less tangible influence of Rob's KSTF experience, beyond specific lesson or reflection ideas and KSTF grants, is his willingness to bring his ideas forward. Rob described his KSTF experiences as giving him courage to propose ideas for classroom activities and projects, indicating that conversations with KSTF colleagues were an opportunity to practice communication skills in a supportive setting, which gave him confidence to engage in potentially difficult conversations in his school context. As Rob put it, "KSTF has emboldened me to take risks or to speak up when I think that something should happen and to trust my training and trust my understanding of the situation."

Mrs. Simmons described KSTF as having "really impacted" Rob's teaching in ways that have also influenced her. In addition to benefitting from what Rob has learned through his participation in the KSTF Teaching Fellows program and shared with her, Mrs. Simmons felt she had access to a broader network of teachers through Rob. She explained:

I've had questions before and he's ended up posting them to his group, even if they weren't directly related to the classes that we taught together. So I feel fortunate that I've been able to work with him and have him go through this program, while I'm working with him. I feel like I've benefited from the resources he's had and the support that he's had; I've gained learning in my own teaching.

Sustainable Impacts

The Forestview faculty members were asked what impacts of Rob's work in the school would be sustained if he were to leave. The teachers indicated that the three-minute observation club would likely continue if Rob were to leave the school. In addition to teachers' generally positive attitude toward the club, some of the club's administrative tasks have been assumed by another teacher, providing a natural and knowledgeable successor for the club's leadership. In addition, the various projects that Rob has developed with his fellow physics teachers have become standard parts of the physics curriculum, and a new physics teacher would be expected to use them.

The science department chair, Ms. Turino, felt that the changes in philosophy she observed in the science department, toward teaching science from a project-based perspective and making science more accessible to students, had become the norm for teaching science at Forestview. She stated that "it would be very difficult to go back to the more traditional way of teaching." Ms. Penton, the principal, also thought the changes Rob has helped foster would continue, saying that "he's changed the curriculum for the department, and I have no doubt that that would persist" even if he were to leave the school. Furthermore, Ms. Penton felt sure that if Rob were to leave, they would "hire someone who shares those values that he has inculcated amongst that teaching team."

GREEN MOUNTAIN HIGH SCHOOL CASE— PROMOTING TEACHERS LEARNING TOGETHER

Green Mountain High School is one of about a dozen high schools in the large, suburban Johnson County School District. Almost 50 percent of the school's approximately 1,200 students are African American; about 25 percent are White, and 13 percent are Hispanic. The school offers a variety of Advanced Placement and Gifted and Talented courses, and two-thirds of its graduates go on to a four-year college following graduation, with most of the remainder attending two-year colleges.

Administrators at Green Mountain High School, and the Johnson County School District more broadly, believe that teachers can serve as valuable resources for their colleagues for improving teaching and learning. To promote the sharing of expertise, they have set up several ways for teachers to collaborate. For example, the county's science teachers have two days each year set aside for district-wide PD during which they participate in sessions led by other teachers; teachers also lead school-based sessions. In addition, Green Mountain is encouraging departments to become PLCs in which teachers examine instructional practices together and collaborate on lesson plans. These opportunities make available the knowledge of teachers who choose to remain classroom teachers and want to share their expertise; as Mr. Guillory, the principal at Green Mountain, put it:

You have to be able to use the talent of other teachers in the building, because teachers are doing some good things and I think we are our best resource. We learn better from each other.

To facilitate teachers' participation in providing school-based PD, each school in Johnson County has a teacher who works with school administrators to coordinate teacher development activities at the school, which includes new teacher support, PD for the entire staff, and helping teachers understand the teacher evaluation process. In the past, Green Mountain High School found that it was challenging for one person to coordinate all of these activities, so this year, they decided to distribute the duties among a team of coordinators. Fourth-year science teacher and fifth-year KSTF Fellow Elizabeth Sulewski was selected for the general teacher development coordinator position. Both the principal and her department chair thought she was a good choice because, in addition to having strong pedagogical and disciplinary content knowledge, she is well respected by her colleagues. Mrs. Spence, the department chair, explained that her colleagues' respect was inspired, in part, by Elizabeth's reputation as a rigorous but well liked teacher:

I think people respect her because students like her. It's very well known that she is a difficult teacher, but she's a fair teacher. I think her colleagues respect her and are willing to go to a PD session that she's leading because they know that they're going to come away from it with something meaningful, and that hasn't always been the case in our school.

Elizabeth has leveraged this role in a number of ways to foster teachers learning from each other. One change in the school-based PD that Elizabeth has overseen is to offer more options so that teachers can select PD that they see as relevant. Green Mountain's principal, Mr. Guillory, explained that there had been a strong emphasis on the Common Core in the previous couple of years, and that they needed to find ways to meet teachers' desire for other options now that teachers were familiar with the Common Core. Elizabeth described a range of different types of opportunities she had planned, such as sessions about integrating technology into instruction, meeting with a small group of colleagues to examine a particular instructional practice or framework, and two ongoing book clubs. As Mr. Guillory put it:

She set up a model where there's different options, whether it's the Mindset book club or whether it's open technology, there are several different options for staff...it's just created a different flexibility and options for staff.

According to the science department chair, both the opportunity to select sessions and the sessions themselves have been well received. Mrs. Mayberry, who teaches AP Physics at Green Mountain, also reported that having choices was a welcome change and gave her a new feeling of ownership over her professional growth.

I remember last year...it was just so frustrating for me, but [now] we have choices and options. We just have to pick throughout the entire year, and they tell us what's available, and we go to these things—and that ownership of what we are doing with our planning time is actually wonderful.

Part of the reason the PD has garnered praise is that Elizabeth has been thoughtful about selecting teachers to lead the sessions and coordinating their efforts. Elizabeth explained that she was able to propose topics, structures, and leaders for professional learning opportunities to make use of other colleagues' knowledge. In addition to drawing on people's different areas of expertise, Elizabeth noted that she was deliberate about including teacher leaders from different departments because she thought it was important that the presenters be representative of the staff as a whole. Elizabeth also worked with the presenters to help ensure that the sessions are consistent with their broader vision of effective teaching. Mrs. Spence, the science department chair, commented on how the consistency of the messages is an improvement over past years, and that it has not happened accidentally:

[Elizabeth] also meets with the other two [coordinators]. They all meet together to make sure that they're aligned. I know that within that she's also meeting with the administrative team, probably both individually and collaboratively with the other two [coordinators], to make sure that there is consistency across what administration is saying in terms of professional development and then there is consistency across what is actually happening with professional development. Because that has been a big concern in our school in the past.

Over the past few years as department chair, Mrs. Spence has worked to transform science department conversations so that they are more collaborative and teachers are able to work together to improve opportunities for students, and she said that Elizabeth has informally supported her efforts. One of the ways that Elizabeth has done so is by redirecting discussions so that they stay focused on student learning. Mrs. Spence described Elizabeth's redirection as subtle and natural, and it helps the department avoid getting off track:

It's nice for me...because I know for sure I have Elizabeth who is going to always be refocusing the group back to the ultimate goal, which is student learning. And there's a lot of ways the students can learn the same thing, we get that, but we've got to make sure that we're always focusing back on the real meaning of what we're doing.

According to the principal, Mr. Guillory, the science department has made more positive changes in its culture than any other department in the school, and he identified Elizabeth as one of the people leading the way. In part, this improved culture is due to the deliberate cultivation of these new norms. Mrs. Mayberry, the AP Physics teacher, described conversations among science faculty as much improved from their state two or three years ago, and she credited Elizabeth with modeling an attitude of professionalism that replaced earlier personal antagonism between some faculty members. To continue to improve the culture and productivity of department meetings, the science department began this year to pilot norms and protocols that Elizabeth suggested based on her KSTF experiences. Further, Mrs. Spence shared these resources with the other department chairs in the school with the hope that other departments will start using them next year.

This focus on student learning and effective teaching are indicative of Elizabeth's conversations with colleagues more broadly, whether in meetings or one-one-one. Mrs. Mayberry reported that Elizabeth had helped her change the labs in her courses to be more student-centered or, as she

described it, something “much more useful to students,” and inspired her to make them more inquiry based. She described her move toward more inquiry-based labs as follows:

I've been trying to change how I do labs because of Elizabeth, actually, and thinking about going more toward being inquiry based where you ask a question and then, based on that question, you give the students the materials and let them figure it out, as opposed to having them go down the list, 1,2,3 on a procedure.

Mrs. Spence noted that Elizabeth consistently attends to the student perspective in her conversations with other teachers:

If anyone goes and tries to have a conversation with Elizabeth about teaching, she will always spin it to get the person or herself to think about “Why are you really doing this? What is the underlying motivation for doing the lab? What is the underlying motivation for doing this lesson? Do you need to cover the content?”—but from the student perspective.

Elizabeth attributes KSTF with preparing her to work productively with colleagues by engaging with them as peers who have a shared goal of improving instruction rather than positioning herself as an authority who has the answers. Mrs. Spence alluded to the importance of such an approach, noting that teachers could find a well-spoken, accomplished teacher such as Elizabeth intimidating. She added that Elizabeth is open about having tried different ideas to see what worked and what did not in a way that makes her seem “real,” and therefore approachable. Elizabeth elaborated on her approach as follows:

So when I'm presenting to the other science teachers, it's almost never like, “Hey, this is what I do in my classroom and I think that all of you should do exactly the same thing.” It's more like, “This year in my classroom I tried having students build portfolios...here's what I did, and here's how it worked out, and here's some things I think I could do differently. I'm inviting you all into this conversation with me about portfolio work and whether we should pursue it, and what it should look like.”

Elizabeth and Mrs. Mayberry engaged in such a conversation about how to appropriately assign grades in their AP courses in a way that would give students more responsibility for their grades. Mrs. Mayberry described sitting with Elizabeth at lunch, talking about what was not working, and Elizabeth coming up with an idea that incorporated reflective journals that would account for 25 percent of the students' grades. Both teachers tried it, with variations, and at the end of the year came back together to talk about how it had worked and what changes they were going to make in the future. Because of the success of this experience, Elizabeth proposed a session for one of the district-wide science PD days with segments led by Elizabeth, Mrs. Mayberry, and Mrs. Spence so that they could share what they had learned with others in their district.

Elizabeth has also exhibited a willingness to open her classroom to other teachers in her school and district. The district science coordinator explained that one of her office's practices for supporting teachers is co-observing other teachers, and Elizabeth is a frequently used exemplar. The coordinator explained that she likes to highlight some of Elizabeth's student-centered instructional strategies, saying:

One of the things I like to draw attention to is her ability to remain quiet and allow the students to talk it out, to struggle with it, to come to their own understanding. She's a deep listener as well, so as students are verbalizing or engaging in discourse, she's able to take their thoughts and delve more deeply into them, or build with the students on their current understanding. So she's very flexible in her thinking and able to put herself next to the student, on the student's cognitive path, and not demand the students go down a particular predefined path.

Similarly, Mrs. Mayberry described how observing Elizabeth supported her movement toward more inquiry-based, less procedural, laboratory activities for her AP Physics course. Mrs. Mayberry observed a lab in which Elizabeth's students collected data and came up with a graphical representation of their data in small groups. Each group reviewed another group's data, looked for trends, and made a claim based on the data, such as "as temperature increases, reaction rates increase." Mrs. Mayberry planned to "steal" the idea of having students try to interpret each other's data to use in one of her own labs. She explained that even though the science content of her course and Elizabeth's course differed, the pedagogical strategy could be adapted for use in either course.

Mrs. Spence noted that Elizabeth is always willing to share her instructional materials with other teachers. For example, Elizabeth developed a lab-intensive curriculum for the school's advanced biology course for ninth and tenth grade students. When a newly hired teacher began teaching the course, she used Elizabeth's labs. This sharing of curricular materials has led to an ongoing collaboration between Elizabeth and the new teacher. As the new teacher has implemented the labs and other lessons, she and Elizabeth have collaborated to refine the activities based on students' responses and engagement.

KSTF Influences

Elizabeth's approach to engaging in conversations about teaching is one of shared inquiry, and she credits her KSTF experiences with cultivating both the general approach and some specific communication skills she brings to those conversations. At KSTF meetings, she engaged in reflective discussions about how people communicated, including the use of questions during conversations, assumptions that people make, and how people share their assumptions. Making these elements of communication explicit allowed her to practice deliberately using different elements during conversations in the KSTF community. She described her deliberate use of communication strategies as creating a demeanor that enhances the effectiveness of her conversations with others in her school community:

Now when I'm talking to an administrator or a colleague in a professional context, I have a particular demeanor and approach to the conversation that I think is non-threatening and non-confrontational, but allows for an exploration of a question or an issue or problem. That's not something that I could have developed nearly as well without KSTF.

Within her KSTF cohort, Elizabeth grew accustomed to sharing the results of new ideas she had tried out in her classroom. Those conversations helped her develop the belief that what she was doing was worth sharing, and a capacity for identifying which particular aspects of her instruction were most likely to be of interest to others. The KSTF experience also helped her ground her investigations into her practice in data—not only test scores, but data such as video clips, student tasks, or transcripts of meetings. As a result, she feels more comfortable and confident about opening up her practice to other teachers in her school.

In addition, Elizabeth saw the lab curriculum that she had developed as a product of the work she did during the first two years of the Fellowship developing her disciplinary content knowledge and science-specific pedagogical knowledge. She found that work useful for thinking critically about the resources she used in her classroom, particularly how the resources represented science to students and students' opportunities to engage in authentic science experiences. She also credits this experience with providing her with knowledge that enabled her to explain her strategies to her colleagues.

Sustainable Impacts

The Green Mountain faculty members were asked what impacts of Elizabeth's work in the school would be sustained if she were to leave. The AP Physics teacher was hopeful that the increased professionalism in science department meetings would be sustained, even if Elizabeth were to leave. Although it is too soon to tell whether the norms and protocols the department is trying out will become permanent, if they are successful the introduction of deliberate tools for conducting meetings would create a lasting change in the department's collaborative conversations.

More certainly, the department is moving toward more student-centered, inquiry-based instruction, and Elizabeth has contributed to that movement. Teachers in the department have adopted ideas that Elizabeth has implemented in her classroom and added them to their own courses. Elizabeth's labs for the advanced biology course, for example, are in active use by another teacher, as well as being codified in the curriculum materials Elizabeth created. Other teachers have changed their grading policies and their approaches to labs, even if they are not using Elizabeth's materials. The science chair described changes to departmental philosophies as permanent because they had become part of how people teach in the department:

A lot of her teaching methods and her teaching philosophy would sort of stick around because it's embedded in her classes, but it's also embedded now in many of the other classes that are being taught in the science department.

WOODROW WILSON HIGH SCHOOL CASE—CREATING COLLABORATIVE NETWORKS AT MULTIPLE LEVELS

Woodrow Wilson High School is a public, International Baccalaureate (IB) high school. Although located in a high-income county, the school serves a lower-income population, with half of Wilson's students qualifying for free or reduced-price lunch compared to less than one third of the county's students overall. The school's almost 2,000 students are diverse: approximately 35 percent are Hispanic, 25 percent are Asian American, 20 percent are White, and 15 percent are African American. Like the rest of the county, the school has a growing population of students with limited English proficiency, and almost one fifth of Wilson's students qualify for English language services.

Physics teacher Amber Carmody and biology teacher Jennifer Fredrickson joined the science department five years ago, when they were both in their second year of the KSTF Fellowship. Early in their careers at Wilson, both began to apply aspects of their KSTF experience to develop networks of teachers focused on improving student learning of science. In the ensuing years, both have taken on formal leadership positions that have facilitated these efforts.

During Amber's first year at Wilson, she taught a hands-on physics course designed for struggling students—a course that was taught at each of the county's high schools but rarely by more than one science teacher at any school. At the time, the course was generally considered an uninteresting course for both teachers and students; in fact, other teachers told Amber, "It's a class that kind of makes you want to hit your head against a wall." Amber was unsatisfied with the classroom culture in her own sections of the course, and wanted to be able to talk about ideas for improvement with fellow teachers.

Inspired by the KSTF IB Physics group she was in, Amber proposed starting a cohort to do PD and planning around the hands-on physics course. She was supported by Mr. Perce, another KSTF Fellow in the county who understood the cohort concept from his own KSTF experiences. The idea was approved and together with another teacher from Wilson, Amber led a community of about

a dozen teachers from various schools in weekly online meetings. Using norms and protocols like those in the KSTF IB Physics group, Amber and her colleagues focused on improving student engagement in the course, creating shared lesson plans and assessments for the entire year, and developing a clear online record of their work.

The cohort was a success in terms of improving the course and as a strategy for PD. Mrs. Vogel, an assistant principal at Wilson described the physics course as one that now engages all students who take it. She credited Amber's work with the cohort for the change, saying:

She, through working with people, has completely turned that [course] around to make it a fun class, a class where kids are really doing lots and lots of experiments.

The hands-on physics cohort itself has continued, because teachers are able to access materials developed in earlier years. Amber is no longer part of the cohort, but a colleague at Wilson who helped her establish the cohort has taken over leadership of the group. Since the hands-on physics cohort was started, Mr. Perce, now the county's High School Science Specialist, has used the cohort as a model for science PD in the county. As a result, countywide cohorts have developed for specific courses or for examining particular teaching strategies. As Mr. Perce described:

The [hands-on] physics group that she helped start has been a model that we have attempted to recreate with a variety of other types of teacher groups. And the current PD model that I run for all the teachers in the county is based on that model.

While this county-level collaborative network was taking off, faculty collaboration within Wilson was strained. As Mrs. Vogel, the assistant principal who oversees the science department, put it, "before Jennifer and Amber came, we used the name professional learning community, but we didn't know what the heck it was." Science department meetings at the time focused primarily on communicating administrative deadlines, and although the school's departments were organized into "collaborative teams" based on content areas (e.g., physics, biology), collaborative team meetings were infrequent.

Because of a mandate for the use of common summative assessments across sections of the same course, teachers reluctantly worked together to create common assessments, but they did not coordinate their classroom activities. Faculty recalled the biology team's infrequent meetings as contentious occasions that sometimes resulted in tears. A teacher in the department shared:

There are horror stories about people fighting about curriculum, fighting about word choice on tests, and then teaching their own thing in the classroom. Then coming together and fighting about assessments.

In this contentious environment, the school also implemented a requirement that teams meet to discuss the assessment data, providing an opportunity for faculty to talk about ways of improving student learning opportunities. Both Jennifer and Amber have been instrumental in making this process work. Jennifer, as a member of the biology team, began developing allies who were interested in talking about teaching. When she became the team leader, Jennifer sought to address the culture of team meetings. She attributes her approach to using inquiry skills and thinking of change as an iterative, step-by-step process, habits she learned through KSTF. Some of the steps were small, such as an example she gave about getting people's attention during their team meetings:

You're not going to fix everything, but you say, "Okay, now I'm going to focus on why people aren't paying attention. Well, maybe I should try having them close their computers."

To make meetings more productive, Jennifer used KSTF protocols as the foundation for how she leads the team meetings. She said that although not every meeting is run 100 percent KSTF style,

with practice, the team has gotten better at following a protocol. She also set up structures for sharing the meeting agenda and minutes, and she ends meetings with time to talk about what the group would like to accomplish at the next meeting. Her fellow biology teacher, Mr. Eklund, thinks these organizational structures are an important factor in changing the way the biology team works together:

A lot of times when you meet as a group of teachers during the school day and you're not organized, then a lot of time is wasted when you try to spin the wheels or complain or whatever people do. So I think if there's one specific thing, it's her being very, I guess, thoughtful about meeting—even just as far as setting up a calendar invitation with links and an agenda, and facilitating the meeting in a very structured way—that's really helpful.

Mrs. Vogel, the assistant principal, added:

Because of Jennifer and Jennifer's personality, [it] is working now. People are working together. She sees the strength in different people and then supports that strength. That wasn't happening before.

The team meetings have focused increasingly on substantive issues of instruction in ways that are leading to a stronger sense of the team as a community. Jennifer built on the requirement for common assessments as a way to motivate discussions about common goals and the logical flow of topics in courses. Amber described this progression as “a big win, because it got the team talking about actual content and how they want to teach it.” Jennifer has found that the common assessments have enabled the team to look together at student data, and looking at the data has led them to discuss interventions and think as a team about all of the biology students. She related this change to the principal's goal of having teams think of themselves as collectively responsible for all of their students:

We're just in the stages of being able to talk about the interventions, and think about ways we can do that and be sustainable as a team—dividing and conquering and thinking about them as all of our kids....So even though I teach honors, I should be helping to remediate the kids in ESOL [English for Speakers of Other Languages] biology, because those data at the end of the year with the state test—that's everybody's kids. So I don't know if all teams across the school are really taking that to a heart, but that's been the thing for the new principal within this last year and a half.

The efforts of the biology team gained greater momentum when Amber became department chair. In addition to the focus each subject team had on common assessments and examining data, Amber initiated a department-wide effort to develop a vertical articulation of skills across courses. This effort has fostered the development of common language among the faculty and helped ensure that students are developing the skills in introductory classes to take more advanced courses. As Mrs. Vogel described:

She was trying to develop vertical articulation within the Department. That's what they're working on...Obviously, biology and geosystems systems are not the same, but making graphs is something that everyone, that is a skill that they need. So what they worked on in their department meetings, which I've sat through, is “What are those skills that are necessary for the kids to be successful in science classes? And what level should the 9th grade teachers be working on [it], the 10th grade, the 11th grade?”

Amber has used the articulation and alignment of curricular goals across teams, particularly students' development of lab skills and understanding of data analysis, to build connections among the subject teams and to continue to foster a department-wide culture of reflective practice. This year, teams

have begun to share student data at department meetings to build a common understanding of what students do in each grade. As she described:

We're still learning how to do this, and it's still new, so it's not like a beautifully well-oiled machine yet, but so far we've had two different teams bring student work to our department meetings which we've never had happen. I don't think my school does it at all anywhere else. So the biology team started, they were able to share, "This is what student lab work looks like when we're working on labs in science. And as a reference, this is the area of the rubric we're working on, and we can show you what it looks like." And then we have a protocol, we use the data protocol, like, "I noticed this...I wonder this..." and ask questions about it. Then the physics team was able to share. We're working towards having all the teams have different opportunities to share.

This process has been well received so far, with teachers expressing interest in what others are doing and starting to see how they can build on each other's work. Amber described teachers' reactions to the data sharing meetings:

People are saying things like, "Well, it's really nice to see what you actually do." Then our conversations, a lot of times, they end with, "So I saw what you do. So that means we can take exactly what you're doing and the students would recognize it."

KSTF Influence

Both Amber and Jennifer described gaining confidence in their knowledge as a result of their KSTF experiences. Each had also participated in valuable PD experiences that were made possible by KSTF grants.

KSTF's influence is also evident in Amber's and Jennifer's visions for collaborative team work—for example, Amber described her vision for the department meetings as "professional development that was kind of KSTF-y." Both used KSTF protocols as tools for leading meetings in their school contexts. This shared use of meeting tools allowed them to build on one another's work, with the biology team serving as a model for other teams.

Developing as a leader was part of each Fellow's fifth-year KSTF inquiry project, and they received support for their projects from KSTF staff and other Fellows. Jennifer found that the iterative, step-by-step nature of the inquiry process prepared her for tackling issues in team meetings one at a time. She explained:

I was encouraged, even though it wasn't always aligned with whatever the KSTF yearly focus was, to really use the skill of my inquiry to be really honing in on my leadership role for the team. Collecting data around that early on, KSTF really allowed me to be thoughtful about not only how we did our agenda, but how I interacted with the other teachers.

In addition, the countywide hands-on physics cohort that Amber started was inspired by a KSTF IB Physics group that Amber belonged to, and she adopted some of the KSTF group's practices for the cohort. Further, she received support for starting the cohort from Mr. Perce, another KSTF Fellow in the district.

Sustainable Impacts

When asked about lasting impacts of Amber's and Jennifer's work at the school, Mrs. Vogel was certain that there were lasting changes in the way teachers in the science department collaborate. She highlighted the use of data as a practice that would be maintained—although she noted that it

might be difficult for someone to move into Amber's role if Amber were to leave. She also indicated that Jennifer has worked to develop leadership skills among the teachers on the biology team, and thought that people would feel comfortable stepping up to take over her responsibilities. Jennifer's colleague, Mr. Eklund, thought the structures she had put into place would help sustain the biology team's collaboration, and described the results of collaborating as sufficient motivation for people to persist:

The way that we go about the collaborative team meetings and interactions will persist, I think, because we've seen the fruits of it. I think it takes a lot to convince teachers that 45 minutes of their planning time every other day is worthwhile...but you can see the dividends of how it affects the experience for all of your students and even for you.

New initiatives often falter when a founder leaves, but the hands-on physics cohort has continued without Amber this year. Mr. Perce thought that the group had become self-sustaining, in part because the need for it was so great:

It's a really big need. [Hand-on physics] teachers have a really tough class to teach and usually there is only person at a school doing that. So they really need a group to collaborate with to help them plan for instruction, assessment, etc.

SUCCEED ACADEMIES CASE—CHANGING THE SYSTEM: BUILDING CAPACITY FOR EFFECTIVE SCIENCE INSTRUCTION

The Succeed Academies School District is a growing system of public charter schools in a large city. The system, which is organized like a traditional school district, has been recognized nationally for its excellent student results. The district emphasizes college-readiness, and roughly three-fourths of its alumni are currently enrolled in college or have completed a college degree. Almost all of the district's students are minority students, and over 80 percent are economically disadvantaged.

Clarissa Westfall joined Westlake High School, part of the Succeed Academies district, as a first-year teacher during the first year of her KSTF Fellowship. Initially a full-time biology teacher, Clarissa has taken on new leadership roles each year, first within her school and then for the district. In her second year of teaching, she became the grade-level chair, responsible for handling administrative functions including dealing with student discipline. This experience helped her realize that she preferred to focus on improving science instruction. As a result, in her third year, she became an instructional support specialist at Westlake, supporting teachers by co-planning instruction, observing their teaching, and giving them feedback. The following year she was one of the school's Deans of Instruction, teaching a reduced load and providing increased support to teachers. Her duties involved coaching teachers of every subject, including areas outside of science, and providing them with feedback, one-on-one support, and school-based PD.

Last year, Clarissa moved to a district-level position as a Content Specialist for science. In this role, she was responsible for supporting science teachers across the district. In course-specific teams, Clarissa worked with teachers and other district staff discussing topics such as how to best support student learning and how to set grading criteria, and sharing resources that they found to be effective. This year, as the science Content Director, she sets the vision for district science teaching practices, supervises the Content Specialists, writes and reviews curriculum materials, and plans several PD days each year for the approximately 80 science teachers in the district. All of which is on top of continuing to teach an Advanced Placement (AP) Biology course.

Clarissa is committed to providing high-quality, inquiry-based science instruction that addresses science practices as well as concepts. Since becoming a district-level leader last year, her mission

has been to use her knowledge of science instruction to refine the district's science curriculum materials, support teachers' effective use of the materials, and develop other teacher leaders' skills for supporting teacher development.

As the main biology curriculum writer for the district, Clarissa is able to infuse opportunities for students to engage with science practices in the curricular materials. She described her focus on the science practices as stemming from her experience teaching AP Biology and attending the AP Biology Leadership Academy with other KSTF Fellows. At the time, she was in a school-level leadership role, and shared what she had learned about the practices within the school. When she moved to a district leadership position last year, Clarissa initiated a district-wide push to develop resources for three science practices, along with suggestions for ways that teachers could use the resources. This year the curriculum developers are working on resources for another two practices.

Relatedly, Clarissa has also promoted inquiry-based strategies, through the use of the 5E⁵ instructional model and interactive labs. Ms. Sepulveda, a science Content Specialist, described Clarissa as very knowledgeable, innovative, and committed in terms of inquiry-based instruction. She added that Clarissa also has the ability to envision curricular improvements outside her own content area:

Biology is her specialty, but she's able to think of a physics lab and still come up with a way to make it very inquiry-based, and to make it engaging to students and authentic learning.

To support teachers' understanding and use of these various resources, Clarissa plans district PD sessions. A district-wide PD day is held every five weeks, and the day is divided into time for course teams to meet and time for teachers to select sessions based on their interests and needs. The science practices have been addressed during course team meetings and in optional sessions. For example, during one meeting the biology team looked at student work samples related to one of the practices, and then discussed strategies to develop students' skills related to the practice. Ms. Sepulveda described some of the ideas addressed in an optional PD session that Clarissa developed to support teachers' use of modeling:

There are different kinds of models; we don't always have to think of a model always as a 3-D object. And we have to be teaching kids not only to utilize these to create their own models, but to critique them—to say, "What are advantages of these models and what are limitations of these models?"

Teachers are also provided PD to support their use of inquiry. For example, the district offered two sessions on lab experiences for students to address the different needs of beginning and experienced teachers. Beginning teachers could choose a session that covered basic skills for setting up and managing a lab, while more experienced teachers could attend a concurrent session that Clarissa facilitated about boosting inquiry in labs. Clarissa's supervisor, Ms. Greenlee, described the PD related to labs as successful because it enabled teachers to conduct labs more frequently and skillfully:

Clarissa spends a lot of time at PD doing best practices on labs for students, and the teachers have given a lot of positive feedback that [the PD], in turn, gives them the knowledge, confidence, and skills to implement labs correctly and more often.

⁵The Biological Science Curriculum Study (BSCS) developed the "5E" instructional model consisting of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. For additional information, see <http://www.bsccs.org/bsccs-5e-instructional-model>

As part of this work, Clarissa has highlighted the importance of engaging students in productive struggle. Ms. Sepulveda, a Content Specialist, observed that although many teachers have been receptive to the idea in theory, encouraging students to struggle runs counter to the district's traditional view of good instruction. She explained that Clarissa, the other Content Specialist, and she work to convey the utility of struggle as part of the learning process. They think this message is important for teachers, as well as individuals who evaluate teachers, to understand:

We are still working very hard at changing the mindset of instructional leaders and people who evaluate teachers so they realize that when you walk into a room and you see students not understanding things, that's not always a red flag. You have to look deeper into what's going on—do [students] not understand things because the teacher is not doing a good job in setting expectations and they're confused on the directions? Or are they just grappling with the content, having to work through some issues? That's not a bad thing—don't dock them for that. Teachers should feel safe to be able to provide those experiences, and students should feel safe to be confused in the classroom.

For Clarissa, building capacity for effective science instruction involves ensuring that everyone in the district who supports science teachers is prepared to do so. Clarissa works regularly with Course Facilitators, who work with the course teams on the district's PD days, to deepen their knowledge of effective science teaching, develop facilitation skills, and prepare them to lead various activities. As Clarissa said:

What we do during that is professional development for [the Course Facilitators] related to their own thinking about science education and their ability to work with other teachers—related to that. So if they're going to be working on looking at student work together, we'll spend time in that PD ahead of time, helping them think through, "What are productive things to do when you're looking at student work, and how to get people engaged?"...sometimes using protocols like we do at KSTF.

Mr. Sheldon, a biology teacher and biology Course Facilitator, described the PD he receives for his leadership role as extremely useful. Clarissa has also supported his development as a PD facilitator in other ways. For example, she showed him how to tailor the generic "course team meeting agenda" to address the biology team's needs, and she sometimes sits in on part of a meeting so that she can provide feedback later. Teachers are surveyed about the quality of the PD after content days, and Clarissa shared the biology team's survey responses with him to provide feedback about his facilitation.

The teacher leaders Clarissa works with most frequently are the two science Content Specialists, and she described expanding their leadership as a "big focus" for her. Ms. Sepulveda, one of the Content Specialists, called Clarissa the best manager she's ever had, saying, "I think it's because she's very oriented to my growth." Ms. Sepulveda listed a variety of ways Clarissa has supported her growth, from reading and discussing research articles to helping figure out how Clarissa and both Content Specialists could attend the National Science Teachers Association's annual conference. She sees Clarissa as a role model for her as a leader, as a science educator, and as someone who can tackle new challenges. As Ms. Sepulveda described:

She's just doing a fantastic job of kind of going into new territory and making it happen. And it's really cool, and it inspires me to not be afraid of new challenges...I am not a physics specialist and when I was told this year that I had to support physics, I was so nervous. She was able to say, "You don't have to be a physics expert to support these physics leaders and teachers. You're great at teaching and you're great at leading teachers and getting them to think about their content in a more creative way. That's what you need to focus on." So she goes and does her job and also inspires me and my counterpart to do that as well

Ms. Sepulveda went on to say that Clarissa has built a trusting relationship with her, one in which it is safe to reveal her vulnerabilities and bring up concerns. That relationship makes it possible for her to seek Clarissa's advice when she encounters challenges, furthering her professional growth. As she put it:

She's created such a safe atmosphere that I can confide in her, professionally, anything that I need, and she's going to be super levelheaded about it and help me work through my issues or my challenges....She cares about people and she cares about people feeling empowered in their jobs.

In addition to her work with the district's current science leaders, Clarissa is striving to develop a pipeline of teachers to serve as leaders in the future. As part of this effort, Clarissa has asked teachers who are not designated content leaders to lead PD sessions. She explained that their involvement was a form of PD for them. Sometimes, Clarissa and the Content Specialists develop a session and coach a teacher to lead it; at other times, they include another teacher in the planning of a session, as well as the facilitation.

KSTF Support and Influence

KSTF's support and influence are apparent in Clarissa's emphasis on inquiry-based instruction and the science practices, themes that are evident in KSTF's PD for Fellows. The AP Biology Leadership Academy, which Clarissa received a KSTF grant to attend, was her biggest influence for delving into the science practices and applying them to different content areas and grade levels. Clarissa also incorporates into her work other strategies and ideas she learned through activities that KSTF provided or funded, such as POGILs, the 5E instructional model, and addressing student misconceptions. She also found that her KSTF work around science stories and developing a concept over time helped her evaluate and select resources. This knowledge also enabled her to align student activities with course goals and common assessments. Mr. Sheldon, a Course Facilitator, commented on how these resources have helped him support teachers:

She gives us amazing resources. But they're not just resources that she creates on-the-fly, they are completely aligned...so that the unit plans flow together. There is a blueprint, so we know what is to be expected from each common assessment...so all of the resources she makes are very aligned and very detailed, which makes it easy for me to facilitate the team.

Clarissa also talked about the importance of the supportive, non-evaluative environment KSTF cultivated. She explained that KSTF culture of sharing and giving feedback helped her develop skills that she could bring to her work outside KSTF. That sharing culture exposed her to ideas other Fellows were trying out, as well as providing her with what she called a "safe space" to try out new skills. As she described the support she received:

I think part of developing a capacity for leadership is feeling comfortable trying something new—whether that something new is giving a presentation for the first time or writing an article and sharing it with a broader audience—and KSTF encourages you to do that, and suggests it. But they also give you some of the internal support to try it where you feel safer before you go do it at a national conference.

Sustainable Impacts

When asked about lasting impacts of Clarissa's work, Ms. Greenlee, Clarissa's supervisor, highlighted the common assessments that Clarissa has advocated for, and helped to develop, as well as her work on curriculum materials. Regarding the curriculum materials, she said:

Well, Clarissa has reviewed and given feedback on all of our centralized materials for courses, grades 6 through 12, and those stay with us and get passed from teacher to teacher as years go by. And a lot of those best practices are resources that would live on.

Like Ms. Greenlee, Ms. Sepulveda pointed to the bank of resources that Clarissa has developed as a lasting impact. In addition, she thought that Clarissa had generated enough momentum around the science practices that people would continue to use the existing resources and develop new resources, saying:

I think the articulation and the language about science practices would stay. The resources that have already been created would stay. I also think that the process of picking ones to focus on and creating new resources for those every year would stay.

Ms. Sepulveda did express concern about whether Clarissa's push to change the culture of the district, to one in which it is expected that students will engage in productive struggle as they learn, could be maintained if Clarissa were to leave, even though Ms. Sepulveda herself would try to continue the effort. In her words:

I think what would leave with Clarissa is this language that we have on the science team that struggle is a good thing. We want kids to struggle and we want to be giving them tasks that they're not getting right off the bat. We want...them to walk away with science skills because that's what's going to carry them into college. So I think that messaging and that push would leave if Clarissa wasn't there. And if I'm still around, I'm going to be pushing for those things because Clarissa has influenced me so much to believe that that's the best thing for kids.

CROSS-CASE FINDINGS

The four features of social capital identified by Coburn and Russell (access to expertise within the network; the structure of the social network; trust among members of the network; and the content of teachers' interactions) were used as an analytic lens for a cross-case analysis. The goals of this analysis were to identify patterns in the Fellows' leadership work, and provide illustrative examples of how KSTF's theory of action is playing out in different contexts.

It is important to note that the four features of social capital are not completely independent. For example, the structure of a social network can be affected by the level of trust among its members, trust can be influenced by the content of the interactions, and those interactions can be a function of the available expertise. In presenting findings, the features are presented independently to better illustrate how each is manifested in the work of the Fellows. It is also important to note that the examples used in this section are illustrative, not exhaustive.

Fellows increased access to expertise within the network

The results indicated that all of the Fellows increased access to expertise within their school networks in a variety of ways. One way they did so was by directly sharing their own expertise with other teachers as they worked together. For example, Joseph provided instructional coaching to another teacher, and was able to offer him specific suggestions for improving his teaching, such as building time into lessons for students to ask questions about an activity shortly after launching a task.

Fellows also reported sharing expertise and resources they gained through KSTF (or KSTF-sponsored PD experiences) such as Patterns physics and POGILs, as well as pedagogical approaches such as the 5E instructional model. In one case, Jessica, who was supported by KSTF to attend a summer POGIL training, led a session for her department on what she learned and shared a number of online POGIL

resources. Her work to get other teachers interested in POGILs succeeded, and other members of the department incorporated these activities into their teaching, and developed new POGILs of their own. Sometimes Fellows provided access to external expertise in less formal ways, such as when Rob posted a colleague's queries to an online KSTF group and then shared the group's responses with his colleague.

In other cases, Fellows leveraged the expertise of others in their district to cultivate improvements at the school level. For example, Michelle, after working with a district-level team developing curriculum guidelines and expectations for students in different biology courses, shared the findings with the biology PLC in her school.

Fellows' work in this area has taken place through a variety of formal and informal mechanisms. To illustrate, several Fellows, including Clarissa and Elizabeth, led formal PD sessions for their department, school, or district. Fellows also served as coaches, working with teachers one-on-one to strengthen their expertise. Jessica and Elizabeth initiated inquiry groups, meeting informally with small groups of their colleagues to further their professional knowledge.

In addition to sharing expertise "in person," many of the Fellows have created curriculum materials that could be used by others. These materials embody the expertise in an enduring form that can be shared with teachers who do not have direct ties to the Fellows. These materials range from isolated lessons to whole courses, and have been used at Fellows' schools as well as across schools in their districts. For example, Elizabeth developed a series of labs for a biology course that has now been adopted by another teacher at her school. Joseph developed a mathematics lesson with a former colleague, who in turn passed it down to his replacement when he left the school. Rob co-developed a unit using Mars Lander data to teach about acceleration and force that is used in several physics courses, including his own. Clarissa has developed biology materials, as well as reviewed and edited materials for other content areas, which are used district wide.

Fellows increased network ties

In order for teachers to benefit from the expertise of others in their departments, schools, or districts, they must have functioning connections to those with that expertise. The cases illustrate a number of ways in which Fellows helped establish or strengthen connections among teachers to make the expertise within the system more accessible. Many of the Fellows built on existing structures established by their schools, such as course or subject teams. For example, Jessica initiated collaboration with her course-team partner on lessons, formative assessments, and grading policies. This collaboration led to a much stronger tie than was the norm for her department, where the only requirement for course teams was that they develop and use common summative assessments. The apparent benefits of their relationship encouraged other teachers in the department to collaborate more closely in their own course teams. Similarly, Jennifer and Amber were able to strengthen ties across course teams by having teachers work together to examine artifacts of teaching (e.g., laboratory lesson plans, student work) during biology-team meetings and department meetings, respectively. In this case, the focus on how the artifacts provided evidence of student mastery of skills that applied across courses created ties among the teachers across the course teams.

Less commonly, Fellows established new structures for collaboration. For example, Amber worked with a KSTF Fellow who held a district position and a fellow teacher to establish a course team that connected teachers across schools. Each school in the district offered one or two sections of a physics course for struggling students, and the teachers of this course rarely had opportunities to collaborate with each other. This group allowed teachers to develop ties with their colleagues across the district through regular online meetings. In another case, Rob helped establish a "three-minute observation club" in which teachers across the department were given a common focal question to guide brief observations of another teacher's class, coming together later to discuss what they

observed. Participating in the club has deepened ties among teachers, both within and across different content areas in the department.

Fellows increased network ties more informally, as well, as illustrated in multiple aspects of Jessica's work. Jessica has served as an informal mentor to teachers who were new to the school, and in that role she helped the new teachers establish ties with others in the department. She also initiated an inquiry group with a small group of teachers with a common interest in inquiring into their teaching practices. The group's meetings strengthened ties among the four teachers, and Jessica indicated that the model may be extended to include additional teachers in the future.

Fellows developed trust within the network

Fellows repeatedly brought up the importance of the trusting and supportive environment of KSTF for their development as teachers and leaders, and they worked to develop trusting relationships within their school contexts as well. One common strategy that Fellows used was to open their own teaching practice to others, a move that many described as possible only because of the confidence they developed through sharing their practice with KSTF colleagues. Fellows opened their classrooms to others in a variety of ways. For example, Rob invited his colleagues to observe his teaching to help launch the three-minute observation club. In Jessica's case, a colleague new to a course they were both teaching observed Jessica's class almost daily for a large part of a school year. In other instances, Fellows shared with their colleagues challenges they were facing in their teaching.

Importantly, Fellows were not opening their practice to others with the intent of serving as exemplars of good teaching for others to emulate. Rather, they offered their own lessons as instances of practice on which to base conversations about how to better reach students. These observations and the ensuing conversations modeled a way of respectfully working together to improve one's teaching practice. By revealing their own vulnerabilities and examining their own challenges, as well as strengths, Fellows encouraged others to feel safe in revealing theirs as well, fostering an attitude of mutual trust. Another important element in developing trust was Fellows' humility and their attitude that they, like their fellow teachers, were always seeking to improve their teaching practice. The approach of shared inquiry that Fellows practiced when discussing their own classrooms is a manifestation of this attitude, and it extended to other discussions. Elizabeth described this attitude as part of KSTF culture, and the shared inquiry approach was evident in many instances that Fellows and their colleagues described. For example, Jennifer discussed the power of sharing lessons that did not go as planned with colleagues. She explained that these lessons provided opportunities to learn about practice, and to acknowledge that not every day is perfect.

Relatedly, Fellows honored the experiences and expertise of their colleagues, exhibiting a trust in their colleagues' judgment. For example, in her role as the leader for a course-based PLC, Michelle noted other teachers' strengths and asked them to lead meetings on topics that aligned with their areas of expertise. Similarly, Elizabeth has planned PD sessions for teachers throughout the school, and she has strategically invited teachers from various departments to lead sessions based on their strengths.

Another way Fellows fostered trust was by helping to establish norms in their teams. These norms encouraged sharing and constructive feedback and discouraged criticisms that could be taken personally. Elizabeth, for example, strove to redirect conversations in department meetings to focus on student learning when discussions got off track. Similarly, several Fellows have used KSTF protocols during meetings to encourage respectful, data-driven interactions that inspire openness and trust. For example, Clarissa has trained her district's PD facilitators to use KSTF protocols, as she sees them as effective tools for having teachers reflect on how instructional activities provide opportunities for student learning.

Fellows focus attention on student learning

Unless teachers interact with one another about instruction—as opposed to topics like why the copier isn't working, social events, or the school's sports teams—their collective expertise, connections to one another, and trust will not have an impact on their teaching. Throughout their work, Fellows concentrated on getting their colleagues to think and talk about instruction and its impacts on students.

Elizabeth, for instance, consistently brought up student-centered, inquiry-based instruction when talking with individual teachers, and redirected discussions toward student learning in department meetings. Rob and Elizabeth both engaged colleagues in discussions about their grading policies, highlighting the policies' effects on students' motivation and empowerment. As a result, both Fellows worked with their colleagues to come up with grading strategies that fostered better student outcomes. In another case, Jennifer shaped the content of discussions within her biology team by starting with the common assessments that were required by their administration. She asked her colleagues to consider the learning goals the assessments were intended to address, and then to examine the classroom activities related to those goals. This approach allowed the teachers to begin discussing instruction and its impacts on students.

The use of KSTF protocols, particularly protocols for discussing student data, was one strategy that reinforced attention to student learning. Amber and Jennifer are among the Fellows who have incorporated these protocols into meetings at their school. Looking together at student work has helped teachers understand what students are doing in different courses, so that they can design instruction that builds on students' earlier experiences. Similarly, Clarissa has included joint examination of student work as part of the PD sessions she developed for teachers. In addition, she has worked to spread the use of these techniques by others in her district through her training of other PD facilitators.

Developing Social Capital: Sustainable Impacts

Fellows are working with their colleagues in a variety of ways to build the social capital of their local networks—through providing access to expertise, increasing network ties, developing trust within the department/schools, and focusing attention on student learning. Although many impacts can be traced to a Fellow's ongoing, and often intense, effort, the hope is that the work will be sustained, even if the Fellow were to leave the school/district. Colleagues of the Fellows were asked what they believed would be sustained from the efforts of the Fellow; several themes emerged from the responses.

One impact likely to be sustained in some of the schools is the shift in instructional practices for which Fellows advocated, e.g., toward student-centered, inquiry-based, or project-based instruction. In places where these instructional practices are poised to continue, a "critical mass" of teachers had adopted them and using these practices had become a departmental norm. In contrast, some Fellows have not yet been able to change the prevailing attitude about instruction in the school or district, and in this type of situation, the practice was not likely to continue without the Fellow's continued efforts.

A second area resulting from the Fellows' work that is likely to be sustained if the Fellows were to leave the school is how people collaborate. In a few schools, the Fellow had influenced the nature of interactions among teachers, shifting the culture to be more collaborative and professional. In these schools, the norms and protocols to support collaboration that the Fellows introduced were identified as important factors in the sustainability of these collaborations.

The three-minute observation club that Rob initiated and the hands-on physics cohort that Amber helped to establish are also likely to be sustained. Both of these groups have strong teacher

support—the observation club because teachers have a positive attitude towards it and the physics cohort because there is a need for it. In addition, other teachers have taken over some or all of the leadership of each group, making its continuation less dependent on the Fellow.

Finally, resources that Fellows developed are very likely to have a lasting impact on what teachers do in the future. For example, instructional materials that Fellows created have been adopted and used by other teachers. Fellows also worked to redesign curriculum and develop common assessments, both of which will influence instruction for students for some time in the future.

CONCLUSIONS

Participating in KSTF activities engages Fellows in a network with strong social capital. KSTF meetings and KSTF-facilitated PD helped each Fellow highlighted in these cases build a strong and broad network of other Fellows, KSTF staff, and experts they encountered because of KSTF. Engaging in this network provided Fellows with a vision for collaborative teaching that many of them worked to replicate in their schools.

Fellows also attributed the development of their own knowledge and skills, in part, to their KSTF experiences. For example, KSTF-supported PD experiences deepened their disciplinary and pedagogical content knowledge and understanding of inquiry-based instruction, as well as their expertise related to POGILs, project-based learning, and the 5E instructional model, among other topics.

Fellows credited KSTF's efforts to create a trusting environment in which Fellows and other KSTF community members share with and support one another as a key enabler of their efforts. Fellows indicated developing confidence and willingness to share their ideas and expose their teaching practices to others through their interactions with trusted KSTF colleagues. The KSTF community also served as a sounding board for Fellows' ideas, which pushed their thinking and also allowed them to hone presentation skills.

In addition, the Fellows highlighted how KSTF routinely engaged them in conversations about how to encourage trust and effective communication. These conversations provided Fellows with ideas they could use in their schools to build trust. For example, several of the Fellows incorporated KSTF protocols and norms into their school interactions, and reported that trust among their school colleagues increased as a result of doing so. KSTF's inquiry model in which collaborators approach an issue as peers with a shared goal of improving instruction, rather than positioning one person acting as an authority, was also cited as an approach some Fellows used in their schools, resulting in productive conversations that contributed to trust.

Several Fellows recognized the support and ideas for their leadership activities that they received through their fifth-year KSTF inquiry projects as integral to their leadership work. Fellows found that KSTF helped them understand that it was possible to engage in small acts of leadership while remaining a classroom teacher, such as sharing one's practice and working in a lesson-study group. Fellows used such ideas in their efforts to build stronger, more collaborative teaching environments.

Although the stories of the Fellows in these cases are overwhelmingly positive, two interrelated themes about challenges emerged from the Fellow interviews that are not represented in the case stories. These themes indicate areas in which KSTF may want to consider providing additional support to Fellows in the future. One is a concern about maintaining an appropriate work-life balance, which is an issue faced by teachers in general. This tension was particularly salient to the Fellows facing the competing demands of starting a family. The Fellows clearly wanted to continue to be change agents in their schools, living up to the KSTF ideals, but realized that, to some extent,

they needed to pass the torch to others. The other theme was that a number of Fellows sought out their current schools after working in other ones that they felt presented too great of a challenge to their becoming the collaborative teachers and change agents that they hoped to be. Although these moves do not diminish the work of these Fellows, they raise the question about under what conditions the KSTF model is effective, and whether there are ways KSTF can support Fellows to have similar impacts in these more challenging environments.

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