REBOOT

REDEFINING HUMAN RESOURCES' ROLE IN SUPPORTING GREAT STEM TEACHING

Best People Best Results

USHCA

URBAN SCHOOLS HUMAN CAPITAL ACADEMY

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EXECUTIVE SUMMARY

STEM (Science, Technology, Engineering, and Math) teaching and learning in the United States requires rethinking. As the need for STEM skills in the global marketplace grows, U.S. student performance on international indicators lag.[1] Ensuring a great STEM teacher for every student, every day provides a strong vision to reverse this troubling trend. Yet this vision is challenging to implement. Often, school systems' human capital practices work against building a highly effective STEM teaching workforce.

Human Resources (HR) departments in school systems can and should play a critical role in finding, growing, deploying, and retaining great STEM teachers. Unfortunately, today many HR teams function with a compliance and transactional orientation, often enforcing outdated and inflexible policies that negatively impact a school system's ability to attract and retain great STEM teachers. In short, **HR needs a reboot.**

With generous funding from the Carnegie Corporation of New York, the Urban Schools Human Capital Academy (USHCA), a national nonprofit working with school districts around the country to improve human resources and human capital practices, prepared this white paper to outline how HR can redefine its role to support great STEM teaching.

THE U.S. FINISHED 27TH IN MATH AND 20TH IN SCIENCE OUT OF 34 COUNTRIES.

In 2012, 34 countries participated in the Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA).

HOW CAN HR REDEFINE ITS ROLE?

A strong STEM human capital strategy incorporates what we know about STEM teachers' context and needs into unique goals and strategies to improve talent outcomes. As a central part of their function, HR teams can play a pivotal role in advancing STEM goals by focusing on three key areas: (1) Setting the direction for STEM talent through actionable human capital goals, (2) Leveraging data to prioritize and track human capital goals, and (3) Developing meaningful partnerships within and beyond the school system to support human capital improvement.

I. SET THE DIRECTION FOR STEM TALENT

HR teams are in a key position to align the school system's strategy to improve STEM teaching and learning to actionable human capital goals. At its core, the goals of a strong STEM human capital strategy should take into account the specific context and challenges STEM teachers face to improve in the following areas:

1. **Hiring the highest quality STEM teachers consistently –** Through more targeted and proactive recruitment practices, HR can build and hire an effective, diverse, and robust pipeline of STEM teacher candidates, especially in high-need schools. Some school systems have invested in a dedicated pipeline of STEM teachers. New Visions for Public Schools created a STEM Teacher Residency Program with Hunter College in New York City, and results demonstrate that the program is having strong, positive effects not only on teacher retention, but also on student outcomes.

2. **Growing STEM teachers' skills quickly and continuously –** HR can also support the establishment of effective induction offerings that accelerate the effectiveness of novice STEM teachers while strengthening the knowledge and practice of all STEM teachers. The NYC Department of Education partnered with the New York Academy of Sciences to develop a Scientist in Residence program to deepen teachers' content knowledge, while The New Teacher Center launched the Electronic Mentoring for Student Success Program (eMSS) as a scalable way to support new STEM teachers with content-specific induction.

3. **Deploying STEM teachers to schools and classrooms deliberately –** HR should consider designing policies and strategies to ensure that schools and students with the greatest needs receive equitable access to highly effective STEM teachers. One strategy is to create part-time, flexible roles so that schools can offer a variety of STEM courses to students. District of Columbia Public Schools is offering more flexible, part-time teaching positions in some of their highest-need schools in an effort to retain high-performing teachers.

4. **Retaining the best STEM teachers strategically –** HR can design system-level strategies and programs to keep great STEM teachers while supporting principals in implementing school-based retention strategies. Various recommendations from the field highlight effective yet low-cost strategies, such as teacher recognition programs and the identification and promotion of growth opportunities (e.g., fellowships, internships) outside of the classroom.

II. LEVERAGE HUMAN CAPITAL DATA

To drive STEM improvements, HR must bring data to the table. By collecting, analyzing, and sharing key data on STEM teachers with principals, partners, and stakeholders, schools can more effectively recruit, select, develop, and retain highly effective STEM teachers. Specifically, HR can take the following steps to improve its use of human capital data to improve STEM talent:

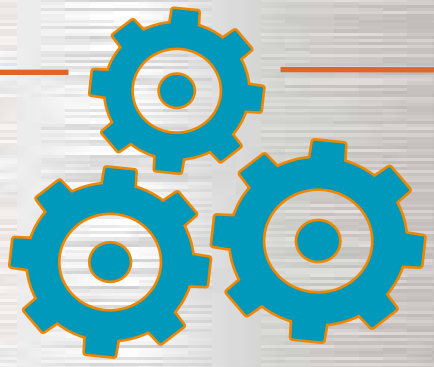
- Know what human capital data matters
- Engage stakeholders with data
- Build a data-driven culture

III. DEVELOP MEANINGFUL PARTNERSHIPS

Finally, HR teams should work with others to advance these goals as a critical component to their long-term success. HR can serve as a key partner to multiple stakeholders, such as teacher preparation programs and internal school system teams like Budget and Academics, but most importantly to school principals. As HR's key customer, it is essential that HR teams meet the needs of principals and align systemic efforts to support principals and their instructional learning goals that impact student results.

MOVING TO ACTION

To support this shift, the USHCA has developed a set of customizable tools and examples from the field to best support great STEM teaching for students. If HR teams can take steps to implement these ideas systematically and with fidelity, school systems will see a measurable and dramatic improvement in their STEM workforce, and ultimately, students' STEM learning.



INTRODUCTION

A light bulb goes on. Sparks fly. Jumbled equations with xs and ys begin to make sense. Every day in our nation's classrooms, the best and brightest teachers ignite learning for students. Perhaps you've experienced it yourself. Those early education experiences — and perhaps a star teacher — may even be a key influence on the career you have chosen.

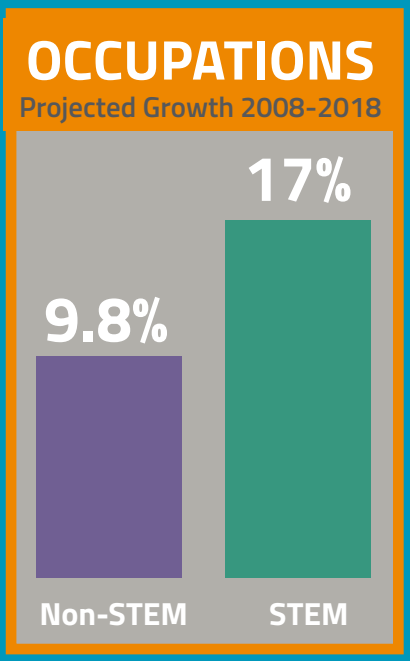
Nationally, our ability to innovate and compete in the global marketplace rests on providing every student with an effective teacher, every day. Arguably, nowhere is this more important than in the areas of Science, Technology, Engineering, and Math, commonly referred to as STEM. STEM workers offer solutions to many of our most pressing and challenging issues, and STEM job growth remains strong. A 2011 U.S. Department of Commerce brief shows that, "STEM occupations are projected to grow by 17.0 percent from 2008–2018, compared to 9.8 percent growth for non-STEM occupations."[3]

Yet, as the need for STEM skills grows, achievement in math and science in the U.S. lags. In 2012, among the 34 countries participating in Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA), the U.S. finished 27th in math and 20th in science, while spending more per student than most countries. These results highlight the deep and persistent disparities by socio-economic status.[4]

Altering the trajectory of U.S. students' academic performance in STEM requires rethinking our approach to teaching and learning in STEM disciplines. While the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS) are promising initial steps, their implementation and success hinges on effective teachers and school leaders with deep STEM content knowledge and pedagogical skills. Simply put, our best hope and investment to improve student learning in STEM is to focus on the quality and skills of our nation's approximately 3.3 million public school teachers.[5]

With generous funding from the Carnegie Corporation of New York, this paper outlines critical actions HR teams in school systems — both school districts and charter management organizations — need to find, grow, deploy, and keep highly effective STEM teachers. In particular, we target our recommendations for urban school systems, which all too often struggle disproportionately to staff their schools with highly effective STEM teachers.

> "Yes, we know the world is flat. But what are we going to do about it? We need to start educating kids today for the jobs of tomorrow. We need better math and science classes and more math and science teachers. We need to launch a national campaign to make math and science a national priority. And we need to act like our future depends on it. After all, it does."[2]
>
> – Tom Luce, Former CEO, National Math and Science Initiative



THE HUMAN CAPITAL CHALLENGES IN BUILDING A CADRE OF GREAT STEM TEACHERS

Great teachers make all the difference for students' STEM learning. Multiple research studies validate what common sense suggests: the quality of the teacher in the classroom, followed by the quality of the leader of the school, are the two most important school-level factors in increasing student achievement. When students learn from top tier teachers for three consecutive years, they outperform students taught by ineffective teachers during the same time period by 52 percentage points.[6] Providing every student with a great teacher is a major component in addressing our nation's STEM challenges.

FEW NEW STEM TEACHERS HAVE DEEP CONTENT KNOWLEDGE AND PEDAGOGICAL SKILLS

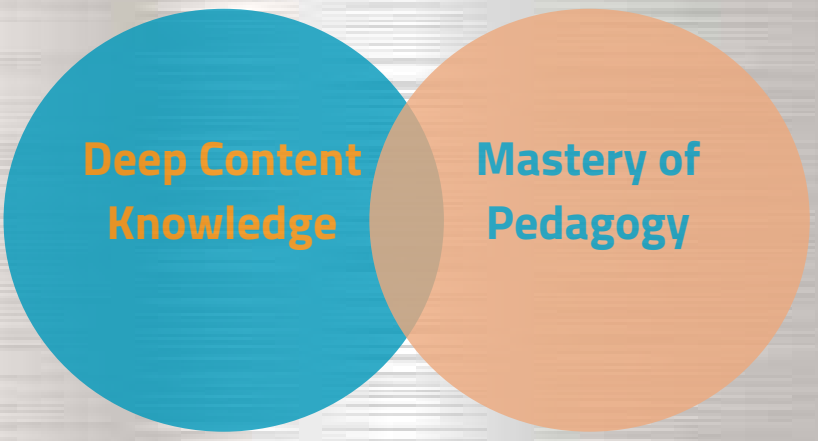
Teachers from traditional teacher preparation routes, such as university programs, may lack deep content expertise since on average, elementary school teachers are required to take only two college math classes.[7] Roughly 1/3 of public middle school math and science teachers have neither a college major in their respective subjects or a related field nor held teacher endorsement in the subject (which requires they demonstrate a baseline of content knowledge by passing content exams).[8]

Teachers prepared through alternative routes, like Teach For America or TNTP's Teaching Fellows program, often have significant and deep content expertise in STEM fields, but often lack pedagogical knowledge and time spent practicing teaching those other subjects.[9] In fact, 40% of all beginning science teachers — and to a lesser extent math teachers — had no practice teaching at all (compared with 21% in non-science fields) before taking their first assignment — resulting in higher levels of attrition than those with at least 12 weeks of practice teaching.[10]

In both circumstances, school systems, in collaboration with teacher preparation programs and alternative route programs, need to collaborate to develop the requisite content expertise or pedagogical knowledge needed to keep great STEM teachers and advance learning. With an estimated 25,000 new STEM teachers needed each year to replace teachers who retire or leave the profession, preparing new STEM teachers is no small undertaking.[11]

WHAT MAKES A GREAT STEM TEACHER?

As in other subjects, STEM teachers blend deep content expertise with masterful pedagogy. Rather than seeing content and pedagogy as discrete and disconnected elements of teaching, effective STEM teachers both know their subject deeply and understand how subject-specific learning develops, drawing on multiple strategies to help students understand key concepts and correct common misconceptions students encounter during the learning process.[12]



SCHOOL SYSTEM STRUCTURES, POLICIES, AND PRACTICES CAN NEGATIVELY IMPACT THE ABILITY TO RECRUIT, DEVELOP, DEPLOY, AND RETAIN GREAT STEM TEACHERS

Many school systems' HR practices focus more on compliance and transactional work than actively managing the quality and performance of the workforce to meet students' needs. Common human capital practices and policies that negatively affect a school system's ability to best manage its STEM teacher workforce — and its workforce overall — include:

- Hiring STEM teachers late, shortly before the start or during the school year
- Failure to support novice STEM teachers assigned to high-need student populations
- Providing limited and disjointed professional development
- Failing to make important career-related decisions (promotion, termination, retention, etc.) using multiple measures of a teacher's performance
- Lacking meaningful retention incentives and practices

When combined with rigid collective bargaining agreements that govern everything from hiring to assignment to compensation, a school system's explicit and implicit human capital strategy, at best, limits the potential of promising educators, and at worst, actively keeps the best and brightest from teaching the students who need them most.

THE ROLE OF HR IN ADDRESSING THE STEM CHALLENGE

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Established in 2011, the Urban Schools Human Capital Academy (USHCA) is a national nonprofit organization that works with HR leadership teams in urban school systems to drive measurable improvement in teacher and principal quality. Through our work with over 18 urban school districts across the nation, we see the challenges HR teams face in talent management – finding, growing, deploying, and keeping great teachers and leaders – particularly in STEM subjects. As the team largely responsible for finding, growing, deploying, and keeping great teachers and leaders across a school system, it is critical that HR lead and develop an intentional and strategic focus on how to improve the quality of the STEM workforce.

Yet, many of these HR teams who should be driving a talent management strategy operate more with a transactional and compliance orientation. For far too long, district principals have often worked around their HR departments to find and keep the talent they need. Some districts have even created entirely new departments focused on human capital efforts to circumvent their own HR teams. Without highly functioning HR teams facilitating strategic work, there is a strong possibility that any infusion of new talent and initiatives aimed at providing effective teachers will not be sustainable.

To better support schools and advance student learning, HR teams can fundamentally change their ways. In short, HR needs a reboot. This will require HR to thoughtfully re-examine its current activities and the value they add to improving a school system's workforce quality. We believe that focusing efforts in three key areas will pay dividends long-term, especially for the STEM teaching workforce and the students they serve.

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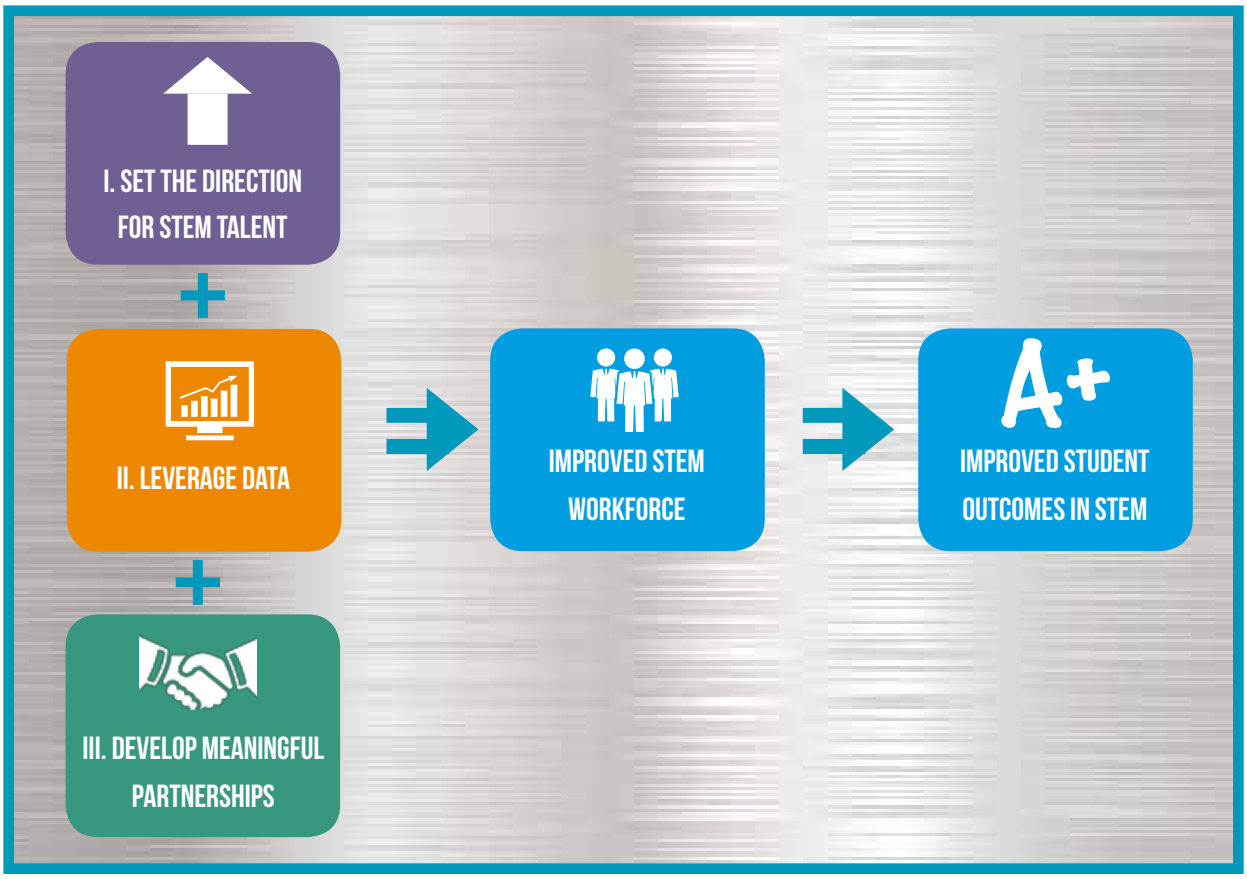

Figure 1 - HR's Role in Supporting Great STEM Teaching

I. SET THE DIRECTION FOR STEM TALENT

HR teams are in a key position to align the school system's strategy to improve STEM to actionable human capital goals. At its core, the goals of a strong STEM human capital strategy should take into account the specific context and challenges STEM teachers face to improve in the following areas:

1. Hiring the highest quality STEM teachers consistently
2. Growing STEM teachers' skills quickly and continuously
3. Deploying STEM teachers to schools and classrooms deliberately
4. Retaining the best STEM teachers strategically

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HR can serve as a key partner to multiple stakeholders, such as teacher preparation programs and internal school system teams like Budget and Academics, but most importantly to school principals. As HR's key customer, it is essential that HR teams meet the needs of principals and align systemic efforts to support principals and their instructional learning goals that impact student results.

I. SET THE DIRECTION FOR STEM TALENT

A strong STEM human capital strategy incorporates what we know about STEM teachers' specific context and needs into a differentiated plan of action for everything from how we find STEM teachers to how we retain them.

At its core, the goals of a strong STEM human capital strategy should take into account the specific context and challenges STEM teachers face to improve in the following areas:

1. **Hiring the highest quality STEM teachers consistently –** Build and hire an effective, diverse, and robust pipeline of STEM teacher candidates. Support high-need schools with enhanced services and supports that help them to attract top STEM talent that fits their needs.
2. **Growing STEM teachers' skills quickly and continuously –** Collaborate with stakeholders to develop more effective induction and differentiated professional development offerings that accelerate the effectiveness of novice STEM teachers and continuously strengthen the knowledge and practice of all STEM teachers.
3. **Deploying STEM teachers to schools and classrooms deliberately –** Design policies and strategies to ensure that schools and students with the greatest needs in the district receive access to highly effective STEM teachers.
4. **Retaining the best STEM teachers strategically –** Design system-level strategies and programs to keep great STEM teachers and support principals in implementing school-based retention strategies, better results occur.

First and foremost, there must be a common definition for what makes a great STEM teacher supported by a rigorous and reliable process to determine a teacher's effectiveness. It would be difficult to understand if HR's strategy is yielding great STEM teachers without a clear and explicit understanding of what constitutes an effective STEM teacher and how to measure performance towards effectiveness. While each school system makes its own determination, USHCA recommends that any definition of STEM teacher effectiveness include multiple measures of performance that are based, at least in part, on student learning.

Across these goals, it is also critical to have strong communication structures with STEM teachers and candidates that enable early and frequent interaction through multiple channels. HR should target messages to potential and existing STEM teachers so they understand why they should teach in the district, why they should stay, how to apply, and how to access supports. A strong mix of face-to-face, web, print, and social media presence, and two-way forms of communication will allow STEM teachers to increase their ownership and voice.

First and foremost, there must be a common definition for what makes a great STEM teacher supported by a rigorous and reliable process to determine a teacher's effectiveness.

GOAL 1: HIRING THE HIGHEST QUALITY STEM TEACHERS CONSISTENTLY

Recruiting and hiring the best teachers is the core work of any HR department. A strategy to ensure a strong pipeline of teacher talent across all subject areas can improve the quality of the teaching corps. Since STEM candidates are often in short supply, and higher rates of turnover lead to higher replacement needs, school systems that have systems in place to effectively source, recruit, and hire great STEM teachers are able to hire the best teachers early.[13] Keys to implementing these strategies are working collaboratively with principals to make the best hires for their schools based on their unique needs, and using data to better understand the systems' current recruitment needs.

Key Findings

1. **Within STEM, some subjects are more difficult to fill than others.**
   Districts and CMOs reported a greater shortage of quality candidates in chemistry, physics, computer science/technology education, than in biology. This reinforces the need to understand each local school system's critical shortage areas within STEM subjects.

2. **High-need schools have a greater challenge finding math and science teachers.**
   The pool of quality STEM candidates is unevenly distributed, resulting in a limited supply of teachers in certain locales and schools. A significant number of schools — about one third — report serious problems in filling their math and science openings each year. Often, these schools have high-poverty, high-minority student populations and experience persistent challenges in finding math and science teachers, compared to other teachers.[14]

3. **STEM undergraduates need early and targeted exposure to teaching as a career option.**
   A 2012 Teach for America (TFA) study to learn more about STEM millennials found that many STEM undergraduates are not introduced to teaching as a viable career option by faculty advisors or career service centers on campus. Moreover, STEM millennials tend to make the decision early about what career they will pursue — 80% choose the industry they want to work in before age 20, compared with 68% of non-STEM millennials.[15]

4. **Inflexible and outdated state certification requirements are barriers to STEM recruitment.**
   Certification requirements vary across states and are often rigid, requiring candidates to have majored in the exact subject they are teaching. It is often unrealistic for career switchers or alternate route candidates to go back to school to complete coursework if they already have a firm grasp of the content and can pass a rigorous content examination.

   In New York State, "degrees in engineering, computer science, and other fields not focused exclusively on the subject taught in high school [i.e., math or science] and reflecting the title of the certificate" are not acceptable for certification.[16] Certain states require semester hours of both pedagogical and/or subject-specific coursework, making it difficult to transition into teaching. Other state certifications have also struggled to keep up with the changing nature of STEM disciplines. Many certifications are out-of-date and omit emerging fields, such as robotics and forensics.

Recommendations

By focusing on three key areas, HR can help to drive improvements in the number and quality of STEM teachers in the pipeline. We recommend a mix of short-term and long-term strategies to build a strong pool, increase early hiring and track the effectiveness of new hires.

Recommendations	Short-Term Strategies	Long-Term Strategies
Build a Strong Pool	A. Project and communicate hiring needs by STEM subject area B. Tailor recruitment messages to STEM candidates C. Forge new partnerships to leverage untapped sources of talent	D. Develop or partner with alternative certification providers to increase supply of STEM candidates E. Strengthen partnerships with Institutes of Higher Education F. Work to change state-level certification requirements G. Differentiate compensation to attract those with STEM expertise
Increase Early Hiring to Improve Quality	H. Offer early contracts to promising STEM teachers	I. Accelerate the timeline for hiring STEM teachers
Track the Effectiveness of New Hires	J. Analyze effectiveness and retention of STEM teachers by pathway	K. Provide feedback to institutions of higher education and alternative certification providers on the quality of the STEM teachers

Table 1: Hiring the Best STEM Educators: Short and Long-Term Strategies

Build a Strong Pool

Strategy 1.A: Project and Communicate STEM Hiring Needs by STEM Subject Area

HR's strategy for recruitment and selection of STEM teachers begins by accurately projecting the organization's need for STEM teachers using historical data (e.g., dismissals, promotions, resignations, retirements) and input from Academics and schools. STEM course needs may change over the years, making it essential for HR to partner with the Academics team to understand projected staffing needs for STEM courses over a 3-5 year time horizon. This is particularly essential for STEM magnet schools or STEM focused programs.

Furthermore, HR can engage principals to understand the year-to-year needs of STEM teachers in their buildings. This work begins as early as September to anticipate any potential vacancies in STEM for the following school year so that recruitment and hiring efforts are aligned.

Strategy 1.B: Tailor Recruitment Messages to STEM Candidates

Once a school system understands the key subject areas in which STEM teachers are needed, it can further target its recruitment messages and outreach. For example, **New York City Department of Education (NYC DOE)** has a dedicated STEM section on their recruitment website, TeachNYC. In general, STEM candidates are looking for work that will challenge them and a workplace that will give them the resources and support to be successful mathematicians and scientists.[17] STEM millennials use the words "smart" and "innovative" to describe the company or organization where they would most like to work.[18] School systems should tailor their recruitment communications based on an understanding of what attracts STEM candidates. [Note: This information should also be used to inform strategies once STEM teachers are employed in the school system.] Specific ideas might include:

- Highlighting STEM programs, specialty schools and unique partnerships
- Profiling new and experienced STEM teachers doing innovative work

- Showcasing growth and leadership opportunities available to STEM teachers
- Emphasizing any additional pay STEM teachers might receive by subject area or school

Strategy 1.C: Forge New Partnerships to Leverage Untapped Sources of Talent

One of the most effective strategies for school systems is to tap into the networks of their current STEM teachers. **Achievement First CMO** found their current STEM teachers to be the most valuable source in finding new STEM candidates for their schools. Furthermore, school systems should also partner with national and regional STEM organizations to identify potential teaching candidates. Working in partnership with these groups, HR could launch annual campaigns and host specific recruitment events to increase the number of applicants to STEM disciplines. Depending on the STEM subject areas needed, potential partnerships include:

- Societies of STEM professionals such as the National Society of Professional Engineers
- National Society of Black Engineers and Society of Hispanic Professional Engineers
- STEM student clubs on college campuses
- Other K-12 organizations like Math for America, Breakthrough Collaborative, STEM Americorps, Encorps Teachers, and Citizen Schools
- Substitute teachers, retired teachers, teaching assistants, and after school program staff and volunteers (e.g., Citizen Schools)
- Local STEM-focused industry staff to complement and support STEM teachers in real-world application of STEM knowledge
- Deans at local universities in math, science, engineering, and technology fields
- Programs such as Troops to Teachers for military personal beginning new careers

Strategy 1.D: Develop or Partner with Alternative Certification Providers to Increase Supply of STEM Candidates

Many school systems find that alternative certification programs provide a critical pipeline of STEM candidates. In 2007, approximately 20% of math and science teachers entered teaching through alternative certification programs.[19] Alternative certification programs can be effective in encouraging strong STEM candidates to pursue teaching, off-setting the costs of obtaining a traditional certification by allowing them to work full or part-time in the classroom, while pursuing their certification simultaneously. Recent research finds that STEM teachers who have at least 12 weeks of training in teaching methods and pedagogy — especially practice teaching, observation of other classroom teaching, and feedback on their own teaching — were far less likely to leave teaching after their first year on the job.[20] **Aspire Public Schools** established the Aspire Teacher Residency (ATR), a four-year program in partnership with the University of Pacific, to establish and grow a dedicated pipeline of STEM teachers. Alternative certification programs can take many forms, but districts and CMOs commonly follow these approaches:

- Develop a Residency Program that allows candidates to practice teaching skills under the guidance of a master teacher while also taking coursework for certification
- Develop a district alternative certification program
- Partner with a local Institute of Higher Education (IHE) that runs an alternative certification program
- Partner with an alternative certification provider like TNTP, the Urban Teacher Residency Program or TFA.

Strategy 1.E: Build Partnerships with IHEs to Source STEM Candidates

Rather than waiting on STEM candidates, school systems can take a proactive approach in "finding" STEM candidates. One strategy is to deepen partnerships with schools of education to source promising STEM candidates. Another is to expand efforts through promising programs like **UTeach**, a 100kin10 partner. UTeach is designed to help undergraduate science, math, and computer science majors qualify to teach without having to formally enroll in an education school. With the growth of such programs, school systems are beginning to forge new partnerships with STEM departments and career services' offices at local colleges and universities to attract strong STEM undergraduate and graduate students.

Strategy 1.F: Work to Change State-Level Certification Requirements

While states have an obligation to ensure a standard level of quality for incoming teachers, they also need to be aware of barriers they have created that prevent potentially strong STEM candidates from entering the profession. Allowing promising candidates who did not major directly in math or science, but who nonetheless have deep content knowledge, to demonstrate their expertise in various ways, including passing a rigorous content exam is critical. Additionally, it is incumbent upon states to continue to provide for alternative certification programs in STEM teaching, streamline certification requirements (e.g. ensuring reciprocity of certifications from other states), and provide financial incentives to encourage more students to choose careers in STEM teaching. Within HR, the Director of Certification can work with the State education department to keep them informed of the district's needs, including the need for updated certification and license areas.

Strategy 1.G: Differentiate Compensation to Attract those with STEM Expertise

While pay is often not the most critical issue impacting school systems' abilities to hire the best STEM teachers, it remains an important consideration for prospective and current teachers alike. In a 2012 TFA study, STEM graduates were more likely than non-STEM graduates to seek a career with higher pay.[21] And research has shown that science teachers, more than math teachers cite pay as a top reason for leaving the teaching field.[22] Differentiated compensation proves to be a multi-faceted tool to recruit, deploy, and retain teachers. By differentiating pay to be more competitive in STEM subjects, school systems reflect the market-based reality that teachers with STEM expertise have multiple career options available to them. For example, **Douglas County School District** in Colorado implemented a new market-based pay structure beginning in the 2012-13 school year. Paying teachers differently, however, is a huge cultural shift in a profession long known for its egalitarian ideals. This may require deep and ongoing work with teachers unions and teachers.

Increase Early Hiring to Ensure Quality

Strategy 1.H: Offer Early Contracts to Promising STEM Teachers

Based on projected and anticipated needs, HR plays an important role in offering early contracts to STEM teachers. Early contracts are the best way to secure quality teachers early in the spring, prior to vacancies opening. Principals are an important partner for HR — as they assess many student teachers over the course of a school year — and can identify high quality STEM teachers that should receive early contracts. It is important to ensure contracts state if the early contract hire does not find a position within 6-8 weeks of school opening, the teacher can substitute until a full-time vacancy opens.

Strategy 1.I: Accelerate the Hiring Timeline for STEM

Because the supply of STEM teachers is more limited and research shows that teachers hired earlier are more effective ,[23] it is critical for school systems to have early hiring timelines in place to provide principals with the best opportunity to make great STEM hires. In general, districts typically have much later hiring timelines than CMOs due to certain budget processes, so districts in particular need to push these timelines up in order to be competitive. Acknowledging the importance of early hiring, many districts have worked with budget and finance to move-up hiring timelines to allow principals to make hires in critical shortage areas, like STEM, as early as March and April.

Track Effectiveness of New Hires

Strategy 1.J: Analyze Effectiveness and Retention of STEM Teachers by Pathway

HR departments that track the effectiveness and retention of STEM teachers by pathway (e.g. school of education, alternative certification provider) and analyze this data allow school systems to understand from which routes their most effective STEM teachers come, as well as highlight which routes produce teaching candidates most likely to stay. Ultimately, this data can be used to inform hiring efforts and provide feedback to teacher preparation programs (see Strategy 1.K below).

Strategy 1.K: Provide Feedback to Schools of Education and Alternative Certification Programs

Together with other school system leaders, HR should consider meeting twice a year with their counterparts at IHEs and alternative certification programs to review the data on new hire performance and to discuss ongoing trends in professional development needs among STEM new hires. In addition to discussing performance, school systems should also review retention patterns of STEM teachers from each program and consider preparation elements that may have an impact on retention. The **New York City Department of Education** produced Teacher Preparation Program Reports outlining key data by teacher preparation program for all subjects – not just STEM – to begin a dialogue about the preparation of new teachers.

GOAL 2: GROWING STEM TEACHERS' SKILLS QUICKLY AND CONTINUOUSLY

Research shows that strong induction support for new teachers has been linked to improved student achievement and increased retention rates.[24] In most school systems, Academics departments are responsible for providing induction to new teachers; however, there is a critical role for HR teams to play in partnering with Academics to support new teachers. HR can and should ensure that induction or mentoring programs utilize highly effective teachers and, where possible, match STEM teachers with mentors and coaches within their subject area.

In addition, because veteran STEM teachers also cite a lack of professional development as a main driver of turnover, HR can partner with Academics to ensure the ongoing development and support of all STEM teachers, particularly those who are high performing.[25]

Key Findings

1. **It is challenging to balance content- and pedagogy-focused PD for STEM teachers.**
   Many school systems emphasized the need for content-based professional development for STEM teachers, particularly with the advent of the Common Core and Next Generation Science Standards. Research has found that a lack of content-focused professional development is a key driver of why math and science teachers leave their schools,[26] and data show that some math and science teachers, particularly at the elementary and middle school levels, lack deep content backgrounds. However, research from Ingersoll also points to the need for pre-service training in pedagogy for beginning STEM teachers. These findings link the lack of pedagogical training and teaching exposure to higher turnover in the first year.[27]

2. **The pool of high-quality STEM mentors and coaches is limited.**
   Given the general shortage of STEM teachers, many districts struggle with pulling STEM teachers out of the classroom for roles as mentors or coaches. And, given the evolving nature of STEM disciplines, it is difficult to provide matches for all of the STEM content areas. The problem is particularly acute in high-need schools. Researchers have found that just 28% of new teachers in low-income, secondary schools are matched with a mentor in the same subject and grade.[28]

3. **Teachers in specialized STEM subjects lack intra-school collaboration opportunities.**
   In some cases, STEM teachers may be the only forensics or robotics teacher in a school or in the entire district, limiting their opportunities to observe and collaborate with peers. These job-embedded opportunities are essential for continued professional growth.[29]

4. **Elementary teachers often lack sufficient content knowledge in math and science.**
   The National Council on Teacher Quality's 2014 Teacher Prep Report highlighted the overall weakness of elementary preparation programs, with few doing enough to ensure that their candidates have sufficient content knowledge in math and science. The National Science and Engineering Indicators also found elementary teachers felt the least confident in their ability to teach science.[30]

Recommendations

By focusing on three key areas, HR can help to drive improvements in the number and quality of STEM teachers in the pipeline. We recommend a mix of short-term and long-term strategies to build a strong pool, increase early hiring and track the effectiveness of new hires.

Key Focus Areas	Short-Term Strategies	Long-Term Strategies
Increase Effectiveness and Retention of Novice STEM Teachers	A. Match STEM teachers with effective, content-specific mentors	B. Implement and prioritize differentiated induction taking into account the backgrounds of STEM teachers
Increase Effectiveness of all STEM Teachers	C. Connect STEM teachers across schools for professional learning	D. Leverage innovative partnerships with STEM organizations to develop strong in-service STEM professional development focused on content and taught by knowledgeable professionals E. Work on improving math and science content expertise of elementary teachers from a recruitment and development perspective

Table 2: At-a-Glance: Recommendations for Growing STEM Teachers' Skills Quickly and Continuously

Increase Effectiveness of Novice STEM Teachers

Strategy 2.A: Match STEM Teachers with Effective, Content-Specific Mentors

The strongest factors for retaining beginning teachers is same-field mentoring and common planning periods.[31] HR needs to work collaboratively with schools and Academics to match new STEM teachers to content-specific mentors and ensure that these mentors are effective teachers. HR might lead the selection of mentor teachers or provide guidance to schools on how to conduct rigorous selection processes. Further, HR and Academics may partner to be sure that mentors are properly trained to provide the support needed in these roles. If the pool of high-quality, content-specific mentors is limited, the district may consider ways to partner with other organizations or use technology to provide same-field mentoring to all STEM teachers. For instance, the **New Teacher Center** (Santa Cruz, California) launched the Electronic Mentoring for Student Success Program (eMSS), to provide new STEM teachers with content-specific induction support through an online program that matches novice teachers with master STEM teachers from across the country.

Strategy 2.B: Implement and Prioritize Differentiated Induction/Support Taking into Account the Backgrounds of STEM Teachers

We know that STEM teachers are less likely to come through traditional education programs and have less exposure to pedagogical preparation, either through a traditional or alternative program.[32] We also know that deep content knowledge is critical for great STEM teaching. School systems that understand the education and pre-service backgrounds of their STEM teachers can better differentiate induction and professional development supports. As a first step, HR departments might consider meeting with the team leading the induction program to review current supports provided to STEM teachers, and with alternative certification and pipeline providers to better align induction support with pre-service supports. When considering budgets for induction, school systems should prioritize induction and support of STEM teachers given the higher costs of replacing them compared to other subject areas.

Strategy 2.C: Connect STEM Teachers Across Schools for Professional Learning

It is important for all STEM teachers to have opportunities to work with STEM colleagues to improve their teaching. In cases where there are limited numbers of STEM teachers in particular schools, and in certain STEM disciplines, HR needs to take a proactive role in working with Academics and principal supervisors on inter-school collaboration plans that allow STEM teachers to observe and get feedback from other STEM teachers on their practice. HR plays an important role in creating conditions and policies that allow for this type of inter-school collaboration. HR can also work with Academics to create other ways for STEM teachers to connect across schools – including creation of message boards and portals, online Professional Learning Communities, or sponsoring events and convenings that allow STEM teachers to connect with one another.

Strategy 2.D: Leverage Innovative Partnerships to Develop Strong In-service STEM PD Focused on Content and Taught by Knowledgeable Professionals

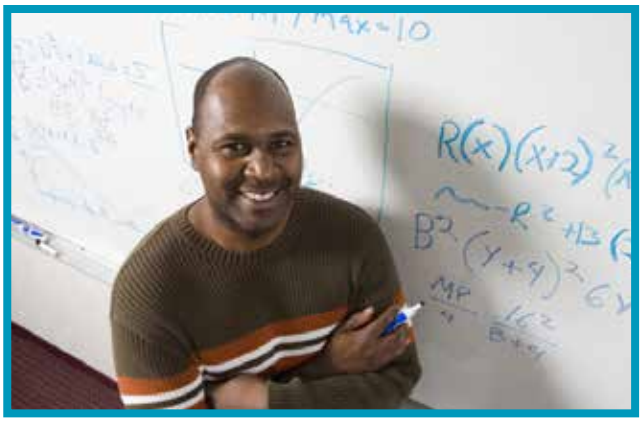
Because high-quality professional development is important to retaining and leveraging great STEM teachers, it is necessary to partner with Academics to ensure that opportunities exist for STEM teachers, particularly high-performing STEM teachers, to continue to develop. Partnerships with outside organizations — such as museums or high-tech companies — can be particularly effective in providing high-quality, ongoing and job-embedded professional development support, including pairing STEM teachers with STEM professionals and/or other content experts in the field. HR should also make sure that there is alignment between the professional development offerings for STEM teachers and the instructional framework used in the evaluation system and that principals understand the professional development offerings available and how to recommend those to STEM teachers based on their needs.

Strategy 2.E: Work on Improving Math and Science Content Expertise of Elementary Teachers from a Recruitment and Development Perspective

HR cannot view this as solely a recruitment or induction issue, but is able to address this challenge from both angles. From a recruitment perspective, HR should have ongoing conversations with the State Education Department and teacher preparation programs to ensure that math and science content requirements are rigorous, but realistic – particularly given the implementation of the CCSS and NGSS. Further, in the hiring and selection process, HR should screen specifically for elementary candidates' understanding of math and science content or work with principals to integrate this into their school-based selection. From an induction and development perspective, HR can partner with Academics to ensure that appropriate support is provided in math and science for elementary school teachers.

GOAL 3: DEPLOYING STEM TEACHERS TO SCHOOLS AND CLASSROOMS

HR departments play an important role in ensuring high-performing STEM teachers are staffed equitably across schools and classrooms. First, HR should consider working with principals and Academics to understand how STEM teachers are assigned and deployed with schools and across the system to make strategic policy decisions about how and when to encourage and incentivize high-performing STEM teachers to seek assignments where they are most needed. Additionally, HR teams can provide guidance to principals to ensure teachers within schools are also deployed in a strategic and deliberate way to most benefit student needs.



Key Findings

1. **Access to effective, experienced STEM teachers is unequal, with new teachers often assigned to the most challenging classes and schools.**
   While we did not find data disaggregated by STEM subjects, research shows that, all too often, across subject fields, novice teachers are assigned to teach the students with the most need or in the toughest schools in an effort to reward more senior teachers or appease parents. Specifically, low-achieving, low-income, and minority students are exposed to less experienced and less effective teachers at higher rates than their higher-achieving, affluent, and white counterparts.[33] In fact, schools with the highest enrollment of African-American and Latino students are almost twice as likely to employ new teachers — those in their first or second year.[34] While school systems and principals do not often assign new teachers to the most challenging assignments by choice, this practice reflects a systematic breakdown in how effective, experienced STEM teachers are sourced, staffed, and incentivized to teach in schools and classrooms that need them most.

2. **High-need schools experience the highest percentage of STEM teacher turnover.**
   Recent data from the National Science and Engineering Board found that secondary math and science teachers have higher attrition rates than other secondary teachers and elementary teachers.[35] And schools with a concentration of high-poverty and high-minority student population have among the highest rates of teacher turnover.[36] Compounding this challenge, as mentioned earlier, these higher-needs schools also face the most challenges in filling STEM vacancies.

3. **Teachers are sometimes assigned to teach outside of their areas of expertise.**
   Estimates suggest anywhere from 10-20% of math and science teachers at the secondary level are teaching out-of-field, which suggests that they may have limited content expertise in the out-of-field subject.[37]
   When teachers are assigned to teach subjects outside of their areas of expertise, it goes against what we know about great STEM teachers — that they have deep content expertise and knowledge of pedagogy specific to their area of expertise. Again, while principals do not often assign teachers out of field by choice, this practice reflects a systematic breakdown in how effective STEM teachers are sourced and staffed.

Recommendations

Unfortunately, our research and experience yields few examples of practices in districts and CMOs that have been successful in getting STEM teachers to the schools with the greatest need. Highly effective STEM teachers have a choice — they are in high demand and they can choose to teach in classrooms with students already achieving at high levels, or in schools with more attractive working conditions. As a result, some of the recommendations included here are based on best practices for all teachers, not just STEM teachers.

Key Focus Areas	Short-Term Strategies	Long-Term Strategies
Increase STEM Candidates for High-Need Schools	A. Provide high-touch recruitment services to STEM candidates to teach in high-need schools B. Survey effective STEM teachers who transferred into and out of high-need schools to understand why	C. Provide high-need schools with autonomy in hiring and priority access to STEM teachers D. Create STEM teacher leadership roles specifically for high-need schools E. Create monetary incentives for highly effective STEM teachers to teach in high-need schools
Ensure Highly Effective Teachers in High-Need Schools	F. Limit assignment of novice teachers to high-need schools and classrooms	G. Create more flexible positions by allowing for part-time roles in particular STEM disciplines, including working with the State on certification waivers, where needed. H. Extend the reach of high-performing STEM teachers through technology

Table 3: At-a-Glance: Recommendations for Deploying STEM Teachers to Schools and Classrooms Deliberately

Increase STEM Candidates for High-Need Schools

Strategy 3.A: Provide Targeted Recruitment Services to Attract Candidates to High-Need Schools

Poor, minority, and urban public schools have among the highest mathematics and science turnover levels, both for those moving to other schools and those leaving teaching altogether.[38] HR should provide targeted supports to its highest-need schools to attract and hire great STEM teachers and partner with principals to support them in their recruitment and selection efforts. Many school systems have dedicated recruiters that provide support to high-need schools and high-need subject areas, such as STEM.

Strategy 3.B: Survey Effective STEM Teachers Who Transferred In/Out of High-Need Schools

To better understand the underlying reasons why effective STEM teachers move out of or into high-need schools, HR should ask their STEM teachers, either through surveys or focus groups, and disaggregate trends by STEM subject areas. Surveys need not be long and should seek to understand the top 2-3 reasons why teachers moved into or out of a high-need school for each STEM subject area. Once a school system determines the key reasons for teacher movements, they are able to move swiftly to address those reasons.

Strategy 3.C: Provide High-Need Schools Autonomy in Hiring and Priority Access to STEM Teachers

High-need schools receive a disproportionate number of teachers placed at their schools from another school due to student enrollment loss, budget cuts, or program changes. Often, these placements are not the best fit for high-need students.[39] These placements are often taken without the consent of the receiving principal and can often be a less than

ideal fit for the transferring teacher. High-need schools should be exempt from ever taking a placement they do not feel will be a fit for their team. All placements should be made through mutual consent hiring. Additionally, where possible, we recommend that high-need schools receive priority access to new or transferring candidates to level the playing field.

Strategy 3.D: Create STEM Teacher Leadership Roles in High-Need Schools

Many school systems are creating teacher leader roles in their highest-need schools. Creating teacher leader roles in these schools serves two important goals. First, it encourages high performing teachers to work in these schools in these new, expanded roles and second it leverages their expertise to support instructional improvement of all teachers in the school. Some districts, such as **Houston Independent School District (TX)** and **Washoe County (NV)**, are using funds from the Department of Education's Teacher Incentive Fund to create teacher leadership roles with additional compensation specifically for STEM teachers in high-need schools as both a way to better recruit and retain STEM teachers in those schools.

Strategy 3.E: Create Monetary Incentives for High Performing STEM Teachers to Teach in High-Need Schools

Research suggests that incentives can help school systems attract high performing teachers to low-performing, high-need schools.[40] In TNTP's 2014 report, *Shortchanged*, they recommend that school systems consider offering performance-based bonuses for teachers in high-need schools and subjects, including STEM. They caution that if districts are going to offer additional compensation, they ensure that only high performing teachers be eligible and ongoing rewards are contingent on strong performance in the classroom in high-need schools.[41] In some school districts, this may require collaboration and an agreement with unions or teacher associations.

Ensure Highly Effective Teachers in High-Need Schools

Strategy 3.F: Limit Assignment of Novice Teachers to High-need Schools and Classrooms

New teachers, just learning their craft, should not be given the most challenging assignments. When no other option exists beyond a novice, they should receive additional mentoring for at least the first two years of their career. At the school level, HR teams are best able to work with principals to think through how to best assign novice teachers for both the teacher's growth and the students' learning needs.

Note: This strategy works best if coupled with strategies to incentivize more experienced teachers with proven track records to seek opportunities at high-need schools and in high-need classrooms.

Strategy 3.G: Create Flexible Part-Time Positions for STEM Disciplines That Are Hard to Fill

In some cases, schools may have just enough students to fill one advanced placement physics class, but do not have a teacher with the right education and experience who can teach physics. In these cases, HR departments need to support schools in creating part-time, flexible roles so that schools can still offer these STEM courses to students. In addition, HR should work with the State on issuing waivers for part-time instructors (not licensed) to teach advanced STEM courses, such as physics or calculus. For example, the **Arkansas Department of Education** issues one-year permits to experienced STEM professionals to teach one or two advanced classes per semester. Districts, such as the **District of Columbia Public Schools**, are also beginning to offer more flexible, part-time teaching positions in a limited number of their highest-need schools in an effort to retain high-performing teachers. These teachers should not be required to complete cumbersome licensure requirements, especially if they are already teaching at the university level.

Strategy 3.H: Expand the Reach of High Performing STEM Teachers Through Technology

HR and the Department of Academics should consider developing a strategy that leverages technology to provide students with opportunities to take STEM courses, even if an individual school does not have enough students that make providing the course financially feasible. The district or state may consider using remote teachers who are high performing STEM teachers or working with third-party online course providers that can offer additional STEM courses. In 2013 the **State of Louisiana** launched a **Supplemental Course Academy** course access program that provides substantial funding to schools and districts so that they can offer individualized courses to high-school students. These courses include such as advanced STEM, AP®, world language and college-credit courses that may not be offered at the school due to limited resources. Many of these courses are delivered online and all count towards a students' graduation requirements. HR should work specifically to address any certification or other staffing requirements that might make this strategy more difficult. Public Impact is also exploring these non-traditional models through its **Opportunity Culture work in Charlotte-Mecklenburg Public Schools.**

GOAL 4: RETAINING THE BEST STEM TEACHERS STRATEGICALLY

We have found that most HR departments do not believe retaining great STEM teachers falls within their purview[42]. They see retention primarily as the responsibility of their principals. Because of the inter-connectedness to finding the best STEM teachers and HR's role in ensuring a high-quality workforce, HR can play an active role in driving overall retention strategies in the district, while also working to build principals' skills in implementing school-level retention strategies. This is especially true for STEM teachers, given higher turnover rates for STEM teachers and increased costs of replacing them. HR teams need to lead the strategy around targeted retention for effective STEM teachers. The overall strategy should include both principal and district-level actions to improve targeted retention.

Key Findings

1. **STEM teachers have high rates of turnover, but the drivers for turnover differ by STEM discipline.** Overall attrition rates are higher for STEM teachers and they are more than likely than teachers of other subject areas to leave the teaching profession all together, due to job dissatisfaction.[43] Research suggests that there are common drivers among STEM teachers for why they leave, as well as some differences. Common drivers cited as important by both math and science teachers are student discipline issues at school and a lack of useful content focused professional development. There are also differences: math teachers cited a lower degree of autonomy in their classrooms as a key driver impacting their decision to leave, while science teachers cited teacher salary as the strongest factor influencing their decision to leave or stay.[44]
2. **School systems lack an organizational strategy to retain high-performing teachers, including STEM teachers.** Many school systems are just starting to focus on retaining teachers, now that they can identify their high performing teachers through more robust evaluation systems. However, many districts lack strategies and resources for how they will improve teacher retention, and where strategies do exist, they are not differentiated across subject areas. Furthermore, HR has not traditionally seen retention as their role and, as such, many HR Departments do not have people on their teams who are dedicated to improving teacher retention.[45]

Recommendations

Key Focus Areas	Short-Term Strategies	Long-Term Strategies
Targeted Retention	A. Understand the drivers of turnover and retention of STEM teachers, disaggregated by STEM subject area B. Celebrate high-performing STEM teachers who stay C. Bring together community of high-performing STEM teachers regularly	D. Provide direct services and support to principals in improving or exiting low-performing STEM teachers E. Create leadership opportunities for STEM teachers F. Provide STEM teachers with opportunities outside the classroom to develop

Table 4: At-a-Glance: Recommendations for Retaining the Best STEM Teachers Strategically

Targeted Retention

Strategy 4.A: Understand the Drivers of Turnover and Retention of STEM Teachers – Disaggregated by STEM Subject Area

Effective HR teams use data to analyze the turnover and retention of STEM teachers to understand what the key drivers are for STEM teachers who stay, move, and leave the district. These patterns should be linked to STEM teacher performance. To better understand the reasons why STEM teachers leave the district, effective school systems manage an exit survey, with potential follow-up for high-performing STEM teachers who left. A complementary strategy is to meet with high-performing teachers who stay in the district (or move schools) to understand why they stay and discuss challenges related to retaining STEM teachers overall. The bottom line: HR needs to first understand why STEM teachers' stay and leave and then develop a differentiated retention plan based on this information. They may find that certain policy changes or strategies will be more impactful for science teachers, than math teachers.

Strategy 4.B: Celebrate High-Performing STEM Teachers that Stay

TNTP's report, *The Irreplaceables*, found that while some longer-term items like compensation and work schedules may need to be addressed to better retain top-performing teachers, there are simple things that school systems can do — like being intentional about recognizing high-performing teachers — that go a long way for teachers.[46] This includes publicly recognizing high-performing teachers through newsletters or emails or by giving them simple awards and perks, like flexibility to attend professional development sessions or conferences. HR departments can create district-level ways to recognize high-performing teachers, such as teacher excellence awards. In addition, HR needs to work with principals to identify the STEM teachers that they want to retain and support them in developing school-level strategies that help to celebrate them and retain them in their schools.

Strategy 4.C: Bring Together High-Performing STEM Teachers

Bringing together high-performing STEM teachers across the district is a powerful way to develop a sense of community among STEM teachers. HR should partner with Academics to make sure this is done intentionally and provides a way for these teachers to give feedback to HR about schools, school leaders, and curricular content, so that this feedback informs professional development and support for principals.

Strategy 4.D: Provide Direct Services and Support to Principals in Exiting Low-performing STEM Teachers

A targeted retention policy should not focus exclusively on retaining high-performing teachers, but also focus on providing support and guidance to principals on removing low-performing teachers, including low-performing STEM teachers. HR departments may find that principals are more reluctant to counsel out or exit low-performing STEM teachers because these positions tend to be more challenging to fill. HR can be helpful in providing support to principals in this area, while ensuring that there is a pool of quality STEM candidates who principals can select from to fill these vacancies. In some cases, HR might need to call in additional content experts to observe low-performing STEM teachers in the classroom to improve and/or document poor performance.

Strategy 4.E: Create Teacher Leadership Opportunities for High-Performing STEM Teachers

Teachers have a desire to advance their careers like other professionals, but in the past this has often meant leaving the classroom to become an administrator. Now school systems are looking at creating advancement opportunities for teachers by creating leadership roles that allow teachers to take on additional responsibilities at their schools or within the district and compensating them, without requiring them to leave the classroom. As school systems consider ways to pilot or rollout new teacher leadership programs, they should consider starting with teachers in STEM fields. Opportunities include:

- Hosting student teachers or interns
- Becoming mentors or coaches for new STEM teachers
- Specializing in STEM at the elementary level
- Supervising teams of teachers in STEM subjects
- Identifying a selection process and pathway to math and science specialist positions
- Facilitating professional learning communities or other STEM community activities
- Leading STEM professional development — in school, or across regions or district
- Leading district-wide committees or working groups on curriculum or STEM innovations

Strategy 4.F: Provide STEM Teachers with Opportunities Outside the Classroom to Develop

STEM teachers tend to identify as scientists, mathematicians, and engineers, in addition to identifying as teachers.[47] HR departments should consider working with Academics to develop summer internships, sabbatical opportunities, or fellowships with math and science organizations, locally or nationally. This strategy can be useful in helping the STEM teacher stay current on the latest findings in their field, in addition to serving as a way to retain them in the district. HR needs to be knowledgeable about partnerships with business and community organizations to support these kinds of experiences for STEM teachers.

II. LEVERAGE HUMAN CAPITAL DATA

To provide meaningful insights and feedback to partner programs and internal stakeholders, HR must bring data to the table. HR is in a unique position to connect the system's HR data with key performance data, such as teacher evaluations, value-added data, and satisfaction surveys, to support key decisions and actions in managing STEM talent. With access to this information in a timely and actionable way, schools can more effectively recruit, select, develop, and retain highly effective STEM teachers.

Know What Data Matters

Part 1: As school systems experience increases in the volume and complexity of data, it is critical to focus and prioritize collection and analysis efforts. Within each human capital goal area is a set of questions that help to drive improvement in the quality of the STEM teacher workforce. These questions are not comprehensive — HR should also be posing other questions around key issues such as absenteeism and turnover — but they align to critical activities and outcomes that could yield the most impact. An example of questions and data elements for Goal 1 is below. The full set of questions can be found in **Appendix 3**.

Table 5: Know What Data Matters Part 1— Example Questions to Support with Data (Goal 1)

Goal 1: Hiring the Best STEM Teachers Consistently		
Key Focus Areas	**Driving Questions**	**Key Data Elements**
Build a Strong Pool	▪ What is the quantity and quality of the STEM teacher pool? How does this convert to new hires? ▪ Are hiring managers satisfied?	▪ Vacancies, by subject ▪ Applicants, by subject ▪ Satisfaction with hiring (principal, principal manager survey)
Increase Early Hiring	▪ When in the season are STEM teachers being hired?	▪ Hires, by month
Track Effectiveness of New Hires	▪ How does the performance of new STEM teachers compare to prior cohorts and other subject areas?	▪ New teacher performance (year 1 to 3) ▪ New hire pathway

Part 2: After identifying the key questions and data to better understand the STEM teacher workforce, the next step is to define metrics and benchmarks to track progress towards goals. An example for Goal 1 is included below. The full set of metrics and benchmarks for each goal area can be found in **Appendix 4**.

Table 6: Know What Data Matters Part 2 — Example Goals, Metrics and Benchmarks (Goal 1)

Example Goals, Metrics and Benchmarks – Goal 1		
Key Focus Areas	**Metrics to Monitor**	**Recommended Benchmarks**
Build a Strong Pool	▪ Ratio of STEM applicants to vacancies, disaggregated by STEM subject ▪ Principal satisfaction with the quality of the STEM applicant pool	▪ Math/science (5:1), specialized subjects – e.g., Physics, Computer Science (3:1) ▪ 90% of principals satisfied with the quality of the applicant pool
Increase Early Hiring	▪ % of STEM teachers hired by month	▪ Mar (50%), Apr (65%), May (75%), Jun (95%)
Track Effectiveness of New Hires	▪ % of STEM new hires rated effective or higher, after years 1 and 2, by teacher preparation program	▪ Improvement over time in % of STEM hires rated effective or higher, w/benchmark of 90% rated effective or higher after year 2

Engage Stakeholders with Data

Effective school systems go beyond simply identifying the right data to track and measure. They then identify key stakeholders inside and outside of the organization with whom to share the data. These may be principals, internal departments such as Academics or Budget, or external partners such as schools of education or service providers. They then use data to engage stakeholders in meeting shared goals.

Below are a few key strategies to engage different stakeholders with data:

Key Strategies to Engage Stakeholders

1

USE DATA TO INFORM KEY INTERNAL HR PROCESSES.

Internal HR teams, such as recruitment and hiring, can greatly benefit from understanding goals and metrics around the size and quality of the STEM applicant pool, the timing of hires made, and the satisfaction of principals and principal managers with the recruitment, hiring, and selection process.

2

SUPPORT PRINCIPALS TO BECOME BETTER HUMAN CAPITAL MANAGERS.

HR's role is to support principals as talent managers by providing easy access to data regarding the quality and performance of their staff. By providing timely and user-friendly data on hiring, retention, improvement, absenteeism, and evaluation.

3

SHARE DATA WITH LEADERS IN ACADEMICS, PROFESSIONAL DEVELOPMENT AND INDUCTION.

A commonly missed opportunity is for HR to collaborate with teams responsible for the development, growth, and support of STEM teachers. For example, induction programs for new teachers could greatly benefit from data on the performance and retention of the teachers they serve.

4

PROVIDE FEEDBACK TO PREPARATION AND PIPELINE PROGRAMS.

School systems that have strong partnerships with preparation and pipeline programs often exchange data on potential and newly hired teachers to ensure that the right needs are being met. For example, by sharing updates on forecasted hiring needs by subject area, local universities and pipeline programs can adjust their own processes to ensure that they are addressing the hiring needs of the school system. School systems can also share data and feedback on the performance and retention of graduates of these programs to inform the design and delivery of their programs moving forward.

A common challenge across many school systems is the lack of dashboard systems and tools to display and share information to key users. While this is an important investment to make, it should be noted that all of the above strategies could be achieved through more basic reporting processes at the early stages.

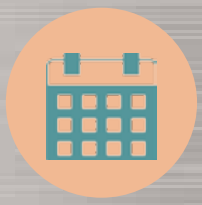
Build a Data-Driven Culture

To sustain these practices, effective school systems employ a few key structures, habits, and routines around the use of data.

Below are a few key actions that HR leaders can implement:

Key Actions That HR Leaders Can Implement

Establish clear definitions and business rules. A strong foundation begins with having clear and consistent definitions and business rules for data key data elements. For example, if employee data reports only categorize STEM secondary teachers as either "math" or "science" teachers, it is difficult to understand the performance and needs of Biology teachers versus Chemistry teachers.



Map data-driven decisions and milestones on a timeline. Important human capital decisions take place everyday in every school, but there are mission-critical decisions that require the right information at the right time. Effective HR teams make explicit plans to analyze and share data to support key talent decisions, such as hiring and selection, mentor assignments, and contract renewal.

Leverage data-driven protocols to guide the team's use of data. While schools have been leveraging data-driven protocols to improve instruction, rarely does this occur within central office teams and departments to improve services to schools. It is particularly useful for teams with limited comfort and experience with data to use simple protocols to establish a common language and process for using data. One example is the Results Meeting Protocol, an action-oriented process for brainstorming, reflecting and taking action based on data.[48]

Allocate people and resources to the improvement of data. School systems, both large and small, with strong data-driven practices have one thing in common: they dedicate people and resources to the improvement of data. Depending on the needs of the organization, the focus and skills of these individuals may vary from technical to analytical and strategic. Regardless of how teams or roles are structured, a dedicated leader is critical to moving the data agenda forward.

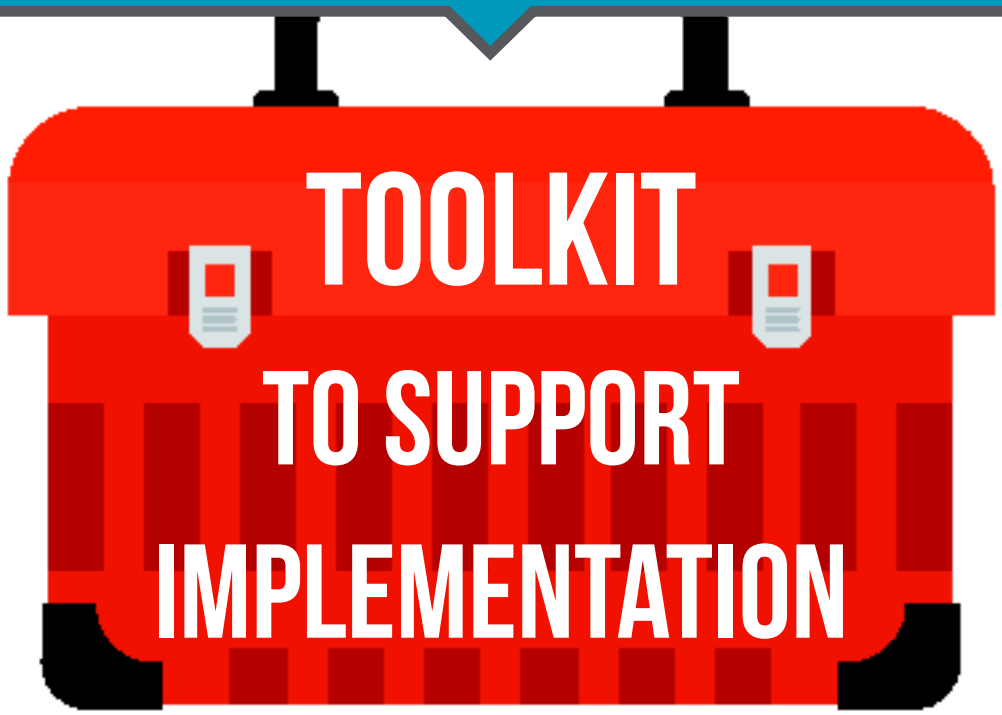
Many of these practices enable the use of data to improve the effectiveness of all teachers — not just STEM teachers. But it is important to leverage data on teachers across different subjects and in different stages of their career, as much of the research indicates that patterns in hiring, development, and retention for STEM teachers can vary from teachers in general. Furthermore, separate patterns emerge between math and science teachers, and millennials and more experienced teachers. [49] The bottom line is to build this level of detail into the ongoing improvement of HR systems, people, and processes.

III. DEVELOP MEANINGFUL PARTNERSHIPS

HR departments that focus as much on how they work, as well as in what areas they work are more effective. How HR teams partners and collaborates to advance these goals is critical to their long-term success. Key partners include teacher preparation programs, teachers groups, and internal school system teams like Budget and Academics, and most importantly school principals. As HR's key customer, it is essential that HR teams meet the needs of principals and align systemic efforts to support principals and their instructional learning goals.

- **Collaborate with other internal teams, being sure to understand the needs of STEM teachers –** When HR works as a facilitator and partner within the school system, especially with departments of Academics, Professional Development, Communications and principal supervisors to ensure that the overarching strategy on talent is aligned, there is greater coherency to meet the teachers' needs. This might require HR to be the leader or facilitator, or more likely, HR plays the role of linking various programs and activities (investments) to results and outcomes (retention, performance, growth, engagement). **Whether HR plays a lead or supporting role, it should always be a strong advocate and voice for talent.**
- **Partner with external organizations –** HR should find, maintain, and promote strategic and external partnerships focused on STEM that improve the supports for STEM teachers and that increase the brand of the district as an employer of choice, particularly for STEM candidates.
- **Support principals as human capital managers –** Principals are HR's most important customers. HR can develop and provide tools, training, data, and supportive policies and procedures to ensure that principals can attract and retain STEM talent. HR having roles within the Department that are dedicated to supporting principals assists principals in becoming human capital mangers.

HR can ensure that the contracts, policies, and procedures are all aligned to the needs and strategies of the system and that they function to help, not hinder, the system's effort to improve the quality of the teacher workforce overall, and theSTEM teacher workforce specifically. For example, some union contracts hinder the retention of effective STEM teachers by requiring that all layoffs or downsizing be done based on years of experience (seniority) alone, without regard to a teacher's effectiveness. This will require school systems to work collaboratively with teachers unions or associations, State Departments of Education, as well as with school boards, and other internal school system offices.



ACTION AREA	TOOLS
Set the Direction for STEM Talent	▪ **HR STEM Assessment:** Assessment to diagnose areas of strength and growth in managing STEM teacher talent across the school system. ▪ **Resource Bank:** A library of examples in practice, resources and reports to support the development of a STEM human capital strategy.
Leverage Human Capital Data	▪ **STEM HC Data Toolkit:** Tools to help identify key metrics, set supporting business rules and processes, plan and prioritize analyses, and lead data-driven meetings.
Develop Meaningful Partnerships	▪ **STEM Partnerships Toolkit:** Tools for HR to build and maintain strong internal and external partnerships that support the improvement of STEM talent.

CONCLUSION

There is a clear and significant role for HR teams in school systems to advance STEM learning for students and support great STEM teaching. HR teams can step into a pivotal role to advance these goals by focusing on three key areas:

In most cases, this will require a significant shift in how HR operates and envisions its role. As HR teams begin to focus on each of these areas, there is a greater chance to ensure maximum impact and sustainability of these efforts to improve the STEM workforce long-term. The context and current state of the work in a particular school system — as determined by the metrics included here — will play an important role in determining how to prioritize and sequence the implementation of these recommendations.

While every student may not choose to pursue STEM as an academic major or career, HR plays an important and fundamental role in ensuring that the STEM workforce is of high quality and is prepared to help students gain the skills necessary to enable them to pursue STEM studies and future careers. Our one best hope to improve our students' performance and prospects is to provide every student, every day, with access to a great STEM teacher.

APPENDIX 1: STAKEHOLDER INTERVIEWS CONDUCTED

Organization	Individual Interviewed, Role
Achievement First (CMO)	Hadley Kornacki, Director of Recruitment Outreach
Aspire (CMO)	Kristin Gallagher, Director of Teacher Residency
Boston Public Schools	Amanda Preston, Director of Recruitment
Chevron	Janet Auer, Director of Partnerships
District of Columbia Public Schools	Jessica Heard, Director of Teacher Recruitment
Hillsborough County Public Schools:	Scott D. Richman, Supervisor, Professional Development
Los Angeles Unified School District	Debi Ingnagi, Assistant Chief Human Resources Officer
Louisiana State Department of Education	Dave Lefkowith, Assistant Superintendent
Montgomery County Public Schools	Inger Swimpson, Director of Certification and Continuing Education
National Math and Science Initiative	Gregg Fleischer, Chief Academic Officer
New York City Department of Education	Ban Moo, Recruitment Manager – STEM Lead
San Francisco Unified School District	Scott Gaiber, Director of Recruitment
Teach for America	Melissa Moritz, Vice President of STEM and Education Initiatives
The New Teacher Center	Lynn Kepp, Sr. VP Professional Services
TNTP	Jaime Heath, Program Manager, TNTP Shelby County Tennessee
United States Geological Survey	Richard Ridky, Director of Educational Programs
University of Chicago Center for Elementary Math and Science	Michael Lach, Director STEM Policy & Strategic Initiatives
University of Maryland U-Teach	Dan Chazan, Director Mathematics Education

APPENDIX 2: STRATEGIES IN ACTION

Hiring the Best STEM Teachers Consistently	
Tailored Recruitment Messages for STEM teachers	**New York City Department of Education (NYC DOE)** has a dedicated STEM section on their recruitment website, TeachNYC. The section highlights STEM teachers working in New York City schools and the partnerships with STEM organizations that provide STEM teachers with opportunities to interact with scientists in the field. They also highlight leadership opportunities that are available to STEM teachers in NYC because they have found that to be of particular interest to STEM teachers.[50] **Achievement First (CMO)** highlights in their marketing materials the emphasis that their schools place on math education and how it is celebrated across their network of schools as a targeted way to attract strong math applicants.
District Developed Alternative Certification Program	In 2009, **Hillsborough County Public Schools** created the Science and Mathematics Accelerated Readiness for Teaching Program (SMART). SMART is a two-year alternative certification program that allows participants to receive their certification while teaching full-time in Hillsborough County schools. Over the course of the two-year program, participants take pre-service and in-service courses designed and taught by Hillsborough County math and science teachers. Mentoring support is also provided for all SMART teachers in their first two years of teaching to assist in furthering these teachers' pedagogical skills. Since the start of the program, retention rates overall have been high – with 90% of participants who completed the program remaining in the district.
Teacher Residency Program	In 2012, **New Visions for Public Schools** created a STEM Teacher Residency Program with Hunter College in New York City. Previously, New Visions had STEM embedded with other subject areas in a general residency program, but made the decision to separate STEM so they could focus deeply on changing the way STEM teachers are trained – putting more emphasis on inquiry-based practices and deep pedagogical content knowledge – with the ultimate goal of transforming the way STEM is taught in all of their classrooms. Their partner, Hunter College, restructured the coursework for participants in the program and works with STEM Departments in the schools that host residents to change the way STEM is taught, so they are prepared to fully support residents and model innovative practices in STEM education. After graduating from the two-year program, candidates receive job-search support and are paired with a coach for their first three years in the classroom to continue to develop their skills.

Hiring the Best STEM Teachers Consistently (cont.)	
North Carolina: Alternative Licensure	The North Carolina program, **NC STEP**, a 100kin10 partner, is an alternative licensure program that streamlines the licensure process for mid-career professionals and college graduates who majored in STEM fields. Program participants are given a stipend and free-tuition for courses and are placed in school-based internships where they receive instructional feedback and team centered mentoring. Candidates who have completed the NC STEP program agree that they will teach for at least three years in an approved high-need secondary school. North Carolina also established "lateral entry," an alternative route to teaching for qualified candidates who are not education-trained. Lateral entry individuals obtain a teaching position and begin teaching right away while working to acquire a professional educator's license. North Carolina endorses this lateral entry individual on a provisional basis. The candidate then affiliates with an approved teacher education program or with a North Carolina Regional Alternative Licensing Center that is managed by the state department of education.[51]
Indiana: Incentivizing Candidates to Pursue STEM Teaching	In 2012 the **Indiana** state legislature established a $9.7 million STEM Teacher Recruitment Fund that encourages the recruitment and retention of teachers in STEM fields. Managed by the Indiana Education Roundtable, this fund provides grants to universities, businesses, and school districts to increase the number of STEM teachers and also to provide to current teachers with pre-service and in-service around integrated pedagogy and project-based learning. This fund also expands opportunities for high school students to have internships and work-based learning opportunities to engage students in STEM careers early.[52]
Douglas County School District	Beginning in the 2012-13 school year, Douglas County School District in Colorado implemented a new market-based pay structure that aimed to pay teachers based on the realities of the market, rather than a traditional step and lane structure in use in most school districts. The market-based pay structure recognizes the differences in the ability to attract and retain positions that may be harder or easier to fill and adjusts teacher pay accordingly. Now, teachers in harder to fill subject areas, like math and science, receive higher base pay. Early evidence suggests that the shift is yielding results in terms of attracting a more experienced group of teachers to DCSD.

Grow the Skills of STEM Teachers Quickly and Continuously	
Using Technology to Match Content-Specific Mentors	In 2002, the **New Teacher Center** (Santa Cruz, California) launched the Electronic Mentoring for Student Success Program (eMSS), to provide new STEM teachers with content-specific induction support. eMSS is a comprehensive online induction program that matches new STEM teachers with master STEM teachers from across the country. Through eMSS, mentors support a group of up to 5 new teachers in the same content area. Mentees are able to get feedback on their lesson plans and reflect on their teaching experiences with the mentor and their fellow mentees. Mentors also work with their mentees on three, 8-week Exploration Courses, which provide mentees with a facilitated curriculum focused on a particular aspect of STEM teaching, such as introduction to science of engineering and design. Additionally, eMSS provides a national community of content and grade-alike educators to share best practices and resources. The content and resources are vetted and curated by a group of content experts.
Partnerships with STEM Institutions	The **NYC DOE** has formed partnerships with the Urban Advantage (UA) and the New York Academy of Sciences to collaborate with teachers to promote teachers' and students understanding of science. With the New York Academy of Sciences, the NYC DOE has created a Scientist in Residence Program in a subset of schools where they pair scientists from research institutions in New York City with a STEM host teacher in a New York City public school. The scientist in residence comes into the classroom as the content expert and the teacher serves as the pedagogical expert to partner together on how to deliver engaging science lessons to students. These partnership have not only helped New York City STEM teachers deepen their content knowledge and better understand the latest trends in a particular discipline, but it also provides an authentic classroom experience for STEM professionals who may be interested in teaching. The NYC DOE also highlights these partnerships in their recruitment of STEM teachers, to showcase the opportunities for advancement available to STEM teachers in the city. **Project Lead the Way** provides training and ongoing support to STEM teachers interested in teaching a new discipline that is in high-demand by students (such as forensics and robotics). Given the breadth of STEM across multiple disciplines, school systems should engage external partners to ensure that STEM teachers have the resources and support they need in a field that continues to evolve.

Deploy STEM Teachers to Schools and Classrooms Deliberately	
New York City Department of Education	The NYC DOE provides support to high-potential STEM candidates who are traditionally certified through their SelectRecruits Program. STEM candidates are selected into the program based on their interest in working in high-need schools and a rigorous interview process. Select Recruits are provided with direct referrals to schools for open positions, attend special recruitment events and are promoted to principals through the district's online application system. They also have direct access to a recruiter who is working to find them a high-quality match. NYC has found that Select Recruits are much more likely to be hired by principals than other applicants — 90% were hired in the SY 2013-2014.
Newark Public Schools	In 2012, teachers ratified a new contract that dramatically changed the way teachers are compensated in the district, including additional compensation for working in a high-need school and in a hard-to-staff subject area, like STEM. High performing STEM teachers can earn an additional $2,500 for teaching a hard-to-staff subject and an additional $5,000 if they choose to work in a high-need school.
Guilford County Public Schools, North Carolina	STEM teachers who teach in high needs schools "Mission Possible Schools" are eligible for performance bonuses from $5000 to $10,000, depending on their performance. STEM teachers receive an additional $5,000 for working in a hard-to-staff position. The Mission Possible Program appears to be helping with retention of teachers in these schools – the overall retention rate of teachers in Mission Possible schools has improved by 19% since the beginning of the program.

APPENDIX 3: KEY QUESTIONS TO SUPPORT WITH DATA

Goal	Driving Questions	Key Data Elements
Goal 1: Hiring the Best STEM Teachers Consistently	▪ What is the quantity and quality of the STEM teacher pool? How does this convert to new hires? ▪ When in the season are STEM teachers being hired? ▪ How does the performance of new STEM teachers compare to prior cohorts and other subject areas?	▪ Vacancies, by subject ▪ Applicants, by subject ▪ Satisfaction with hiring (principal, principal manager survey) ▪ Hires, by month ▪ New teacher performance (year 1 to 3) ▪ New hire pathway
Goal 2: Growing STEM Teachers' Skills Quickly and Continuously	▪ What is the quality of the induction and PD support provided to teachers? ▪ How do these supports correlate to retention and improved effectiveness?	▪ New teacher retention, by performance ▪ STEM mentor matches ▪ STEM mentor evaluation/ effectiveness ratings ▪ Satisfaction with PD & growth opportunities (teacher survey) ▪ Teacher performance
Goal 3: Deploying STEM Teachers to Schools and Classrooms Deliberately	▪ What is the distribution of STEM teacher performance across high and low-need schools? ▪ What is the movement of STEM teachers in and out of high-need schools?	▪ Compare data for each school by need (high-need, low-need, etc.) ▪ Teacher performance ▪ Transfers in and out, by school ▪ Teacher experience (novice, etc.) ▪ Forced placements ▪ Student assigned to teachers
Goal 4: Retaining the Best STEM Teachers Strategically	▪ Where are our highest STEM performers, and at what rate are we retaining them? ▪ How many of our lowest-performing teachers have improved or exited the system?	▪ Teacher retention, by performance ▪ Teachers with improvement plans ▪ Teachers non-renewed

APPENDIX 4: GOALS, METRICS, AND BENCHMARKS

Hiring the Best STEM Teachers Consistently		
Key Focus Areas	**Metrics to Monitor**	**Recommended Benchmarks**
Build a Strong Pool	▪ Ratio of STEM applicants to vacancies, disaggregated by STEM subject ▪ Principal satisfaction with the quality of the STEM applicant pool	▪ Math/science (5:1), specialized subjects — e.g., Physics, Computer Science (3:1) ▪ 90% of principals satisfied with the quality of the applicant pool
Increase Early Hiring	▪ % of STEM teachers hired by month	▪ Mar (50%), Apr (65%), May (75%), Jun (95%
Track Effectiveness of New Hires	▪ % of STEM new hires rated effective or higher, after years 1 and 2, by teacher preparation program	▪ Improvement over time in % of STEM hires rated effective or higher, w/benchmark of 90% rated effective or higher after year 2
Growing STEM Teachers' Skills Quickly and Continuously		
Key Focus Areas	**Metrics to Monitor**	**Recommended Benchmarks**
Increase Effectiveness and Retention of Novice STEM Teachers	▪ Retention of new (1st, 2nd, 3rd) year STEM teachers by effectiveness ▪ % of new STEM teachers matched with mentor in same grade and subject area ▪ % of 1st and 2nd year STEM teachers with effective or higher ratings at mid-point and end of year ▪ % of STEM mentors and coaches rated highly effective (100%)	▪ 90% retention of effective or higher new teachers ▪ 100% of new STEM teachers matched w/mentor in same grade/subject area ▪ 90% of 1st and 2nd year STEM teachers with effective or higher ratings at mid-point and end of year ▪ 100% of STEM mentors and coaches rated highly effective
Increased Effectiveness of all STEM Teachers	▪ % of STEM teachers citing satisfaction with professional growth opportunities ▪ % of STEM teachers rated effective/highly effective	▪ 90% citing satisfaction with professional growth opportunities ▪ 90% rated effective/highly effective

Deploying STEM Teachers to Schools and Classrooms Deliberately		
Key Focus Areas	**Metrics to Monitor**	**Recommended Benchmarks**
Increase STEM Candidates for High-Need Schools	▪ Ratio of applicants to vacancies in high-need schools ▪ # of STEM teacher transfers in and out of high-need schools	▪ Ratio of Math/Science (5:1), specialized subjects — e.g. Physics, CS (3:1) ▪ Ratio of transfers in/ transfers out of high-need >=1
Distribution of Highly Effective Teachers at High-Need Schools	▪ % of effective STEM teachers across high and low-need schools ▪ % of novice teachers in high-need schools ▪ % of teachers forced placed into high-need schools w/out mutual consent ▪ % of high-need students taught by a highly effective STEM teacher	▪ High and low-need schools <=10% on % of effective STEM teachers ▪ 0% (low as possible) w/decreasing novice teachers in high-need schools ▪ 0% forced placements into high-need schools ▪ Ideally 100%
Retaining the Best STEM Teachers Strategically		
Key Focus Areas	**Metrics to Monitor**	**Recommended Benchmarks**
Targeted Retention	▪ % of STEM teachers retained in schools by performance level, disaggregated by STEM ▪ Improvement of low-performing STEM teachers	▪ % of high performers retained > low-performers retained ▪ 100% of low-performing STEM teachers on improvement plans/exited if no progress within one year

1. Organisation for Economic Co-operation and Development. 2012. United States – Country Note – Results from PISA 2012. http://www.oecd.org/pisa/keyfindings/PISA-2012-results-US.pdf
2. 2014. National Math + Science Initiative. http://www.nms.org/Blog/TabId/58/PostId/10/quotable-quotes-about-math-science.aspx
3. Langdon, David, George McKittrick, David Beede, Beethka Khan, and Mark Doms. 2011. *STEM: Good Jobs Now and For the Future*. Vols. Issue Brief #03-11. Prod. Department of Commerce. July. http://www.esa.doc.gov/Reprts/stem-good-jobs-now-and-future. p 1.
4. Organisation for Economic Co-operation and Development. 2012. United States – Country Note – Results from PISA 2012. http://www.oecd.org/pisa/keyfindings/PISA-2012-results-US.pdf
5. 2014. "National Center for Education Statistics 2014." *U. S. Department of Education, National Center for Education Statistics.* Institute on Education Sciences. http://nces.ed.gov/fastfacts/display.asp?id+28. *Even those teachers without clear STEM roles can play a supportive role assigning readings focused on STEM and exploring the history of STEM in society.*
6. Sanders, William and Rivers, June. 1996. *Cumulative and Residual Effects of Teachers on Future Academic Achievement.* Knoxville: University of Tennessee Value-Added Research and Assessment Center; Loeb, Susanna and Reininger, Michelle. 2004. *Public Policy and Teacher Labor Markets. What We Know and Why It Matters.* http://eric.ed.gov/?id=ED485592.; Goldhaber, Dan. 2002. ""The Mystery of Good Teaching." *Education Next* 2 (1): 50-55.; Seashore Louis, Karen, Leithwood, Kenneth, Wahlstrom, Kyla, Anderson, Stephen. 2010. *Learning from Leadership: Investigating the Links to Improved Student Learning.* University of Minnesota and University of Toronto, Final Report of Research to the Wallace Foundation. http://www.wallacefoundation.org/knowledge-center/school-leadership/key-research/Documents/Investigating-the-Links-to-Improved-Student-Learning.pdf.
7. Education, Committee on Highly Successful Schools or Programs for K-12 STEM. 2011. *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering and Mathematics.* National Research Council, Washington, D. C.: The National Academies Press. http://www.stemreports.com/wp-content/uploads/2011/06/NRC_STEM_2.pdf.
8. 2012. National Science Foundation. http://www.nsf.gov/statistics/seind12/c1/tt01-08.htm.
9. Ingersoll, Richard, Merrill, Lisa, May, Henry. 2014. *What are the Effects of Teacher Education and Preparation on Beginning Teacher Attrition?* University of Pennsylvania, Philadelphia: Consortium or Policy Research in Education. http://www.cpre.org/sites/default/files/researchreport/2018_prepeffects2014.pdf.
10. Ingersoll, Richard, Merrill, Lisa, May, Henry. 2014. *What are the Effects of Teacher Education and Preparation on Beginning Teacher Attrition?* University of Pennsylvania, Philadelphia: Consortium for Policy Research in Education. http://www.cpre.org/sites/default/files/researchreport/2018_prepeffects2014.pdf.; Ingersoll, Richard, Merrill, Lisa and May, Henry. 2012. "Retaining Teachers: How Preparation Matters." *Educational Leadership* 69 (8): 30-34. http://www.gse.upenn.edu/pdf/rmi/EL-May2012.pdf
11. 2010. *Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future.* Washington, D. C.: U. S. Department of Education. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stemed-report.pdf
12. Shulman, Leo. 1986. "Those Who Understand: Knowledge Growth in Teaching." *Educational Researcher* 15 (2): 4-14. http://coe.utep.edu/ted/images/academic_programs/graduate/pdfs/matharticles/Knowledge%20Growth%20in%20Teaching%20Shulman.pdf
13. Ingersoll, Richard and Perda, David. 2010. "Is the Supply of Mathematics and Science Teachers Sufficient?" *American Education Research Journal* http://aer.sagepub.com/content/47/3/563.full.pdf+html?ijkey=YFUXEgizdJbrw&keytype=ref&siteid=spaer
14. Ingersoll, Richard. 2011. "Do we produce enough mathematics and science teachers?" *Phi Beta Kappan* 92 (6): 37-41. http://www.cpre.org/do-we-produce-enough-mathematics-and-science-teachers.
15. 2012. *TFA Chicago Solutions Session Presentation, Melissa Moritz*, Teach for America. http://www.100kin10.org/system/uploads/files/000/000/049/original/2012-09-18_Chicago_Solution_Session_Presentation_Teach_For_America_Melissa_Moritz.pdf?1350398058
16. http://www.highered.nysed.gov/tcert/certificate/stem.html
17. Lach, Michael, University of Chicago Center for Math and Science, interview by Susan Marks. 2014.
18. 2012. *TFA Chicago Solutions Session Presentation, Melissa Moritz*, Teach for America. http://www.100kin10.org/system/uploads/files/000/000/049/original/2012-09-18_Chicago_Solution_Session_Presentation_Teach_For_America_Melissa_Moritz.pdf?1350398058
19. 2014. *Science and Engineering Indicators.* National Science Foundation. http://www.nsf.gov/statistics/seind14/
20. Ingersoll, Richard, Merrill, Lisa , May, Henry. 2014. *What are the Effects of Teacher Education and Preparation on Beginning Teacher Attrition?* University of Pennsylvania, Philadelphia: Consortium for Policy Research in Education. http://www.cpre.org/sites/default/files/researchreport/2018_prepeffects2014.pdf.
21. 2012. *TFA Chicago Solutions Session Presentation, Melissa Moritz*, Teach for America. http://www.100kin10.org/system/uploads/files/000/000/049/original/2012-09-18_Chicago_Solution_Session_Presentation_Teach_For_America_Melissa_Moritz.pdf?1350398058
22. Ingersoll, Richard and May, Henry. 2010. *The Magnitude, Destinations, and Determinants of Mathematics, and Science Teacher Turnover.* CPRE Research Report # RR-66, The Consortium for Policy Research. http://www.cpre.org/sites/default/files/researchreport/833_math-and-science-teacher-turnoveringersoll-and-may-2010final-web-ready.pdf.
23. Levin, Jessica, Quinn, Meredith. 2003. *Missed Opportunities: How We Keep High-Quality Teachers Out of Urban Classrooms.* The New Teacher Project. http://tntp.org/assets/documents/MissedOpportunities.pdf?files/MissedOpportunities.pdf.
24. Sun, Chris. 2012. "NASBE Discussion Guide: Teacher Induction - Improving State Systems for Supporting New Teachers." National Association of State Boards of Education. http://www.newteachercenter.org/products-and-resources/policy-briefs/nasbe-discussion-guide-teacher-induction-improving-state-system.
25. Ingersoll, Richard and May, Henry. 2010. *The Magnitude, Destinations, and Determinants of Mathematics, and Science Teacher Turnover.* CPRE Research Report # RR-66, The Consortium for Policy Research. http://www.cpre.org/sites/default/files/researchreport/833_math-and-science-teacher-turnoveringersoll-and-may-2010final-web-ready.pdf.
26. Ingersoll, Richard and May, Henry. 2010. *The Magnitude, Destinations, and Determinants of Mathematics, and Science Teacher Turnover.* CPRE Research Report # RR-66, The Consortium for Policy Research. http://www.cpre.org/sites/default/files/researchreport/833_math-and-

science-teacher-turnoveringersoll-and-may-2010final-web-ready.pdf.
27. Ingersoll, Richard, Merrill, Lisa , May, Henry. 2014. *What are the Effects of Teacher Education and Preparation on Beginning Teacher Attrition?* University of Pennsylvania, Philadelphia: Consortium for Policy Research in Education. http://www.cpre.org/sites/default/files/researchreport/2018_prepeffects2014.pdf.
28. Moore -Johnson, Susan M. Kardos, David Kauffman, Edward Liu, Morgaen L. Donaldson. 2004. "The support gap: New teachers' early experiences in high-income and low-income schools." 12: 1-25. http://files.eric.ed.gov/fulltext/EJ853526.pdf.
29. Croft, A., Coggshall, J.G., Dolan, M., Powers, E., Killion, J. 2010. Job-embedded professional development: What it is, who is responsible, and how to get it done well. National Comprehensive Center for Teacher Quality. http://learningforward.org/docs/pdf/jobembeddedpdbrief.pdf?sfvrsn=0
30. 2014. *Science and Engineering Indicators.* National Science Foundation. http://www.nsf.gov/statistics/seind14/index.cfm/chapter-1/c1s3.htm
31. Ingersoll, Richard and Strong, Michael. 2011. "The Impact of Induction and Mentoring Programs for Beginning Teachers: A Critical Review of the Research." *Review of Educational Research,* 81 (2): 201-233.
32. Ingersoll, Richard, Merrill, Lisa , May, Henry. 2014. *What are the Effects of Teacher Education and Preparation on Beginning Teacher Attrition?* University of Pennsylvania, Philadelphia: Consortium for Policy Research in Education. http://www.cpre.org/sites/default/files/researchreport/2018_prepeffects2014.pdf.
33. Kalogrides, D., Loeb, S., & Beteille, T. 2013. Systematic sorting: Teacher characteristics and class assignments. *Sociology of Education*, 86(2), 103-123. http://cepa.stanford.edu/sites/default/files/Class%20Assignment%20Final%20Submitted%20Paper.pdf
34. 2014. *Office of Civil Rights.* http://www2.ed.gov/about/offices/list/ocr/docs/crdc-2012-data-summary.pdf.
35. 2014. *Science and Engineering Indicators.* National Science Foundation. http://www.nsf.gov/statistics/seind14/index.cfm/chapter-1/c1s3.htm
36. Ingersoll, Richard and May, Henry. 2010. *The Magnitude, Destinations, and Determinants of Mathematics, and Science Teacher Turnover.* CPRE Research Report # RR-66, The Consortium for Policy Research. http://www.cpre.org/sites/default/files/researchreport/833_math-and-science-teacher-turnoveringersoll-and-may-2010final-web-ready.pdf.
37. Education, Committee on Highly Successful Schools or Programs for K-12 STEM. 2011. *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering and Mathematics.* National Research Council, Washington, D. C.: The National Academies Press. http://www.stemreports.com/wp-content/uploads/2011/06/NRC_STEM_2.pdf.
38. Ingersoll, Richard and May, Henry. 2010. *The Magnitude, Destinations, and Determinants of Mathematics, and Science Teacher Turnover.* CPRE Research Report # RR-66, The Consortium for Policy Research. http://www.cpre.org/sites/default/files/researchreport/833_math-and-science-teacher-turnoveringersoll-and-may-2010final-web-ready.pdf.
39. Levin, J., Mulhern, J., & Schunck, J. 2005. *Unintended Consequences: The Case for Reforming the Staffing Rules in Urban Teachers Union Contracts*. New York, NY: The New Teacher Project. http://tntp.org/assets/documents/UnintendedConsequences.pdf
40. Glazerman, Steven., Protik, Ali, Teh, Bing-ru., Bruch, Julie., Max, Jeffrey. 2013. *Transfer Incentives for High-Performing Teachers: Final Results from a Multisite Randomized Experiment.* (NCEE 2014-4003)., Institute for Education Sciences, U. S. Department of Education, Washington, D. C.: National Center for Education Evaluation and Regional Assistance. http://ies.ed.gov/ncee/pubs/20144003/pdf/20144003.pdf.
41. 2014. TNTP. *Shortchanged: The hidden costs of lock-step teacher pay.* http://tntp.org/assets/documents/TNTP_Shortchanged_2014.pdf
42. Finding based on USHCA STEM Survey and USHCA's work with 16 urban school districts.
43. Ingersoll, Richard and May, Henry. 2010. *The Magnitude, Destinations, and Determinants of Mathematics, and Science Teacher Turnover.* CPRE Research Report # RR-66, The Consortium for Policy Research. http://www.cpre.org/sites/default/files/researchreport/833_math-and-science-teacher-turnoveringersoll-and-may-2010final-web-ready.pdf.
44. Ingersoll, Richard and May, Henry. 2010. *The Magnitude, Destinations, and Determinants of Mathematics, and Science Teacher Turnover.* CPRE Research Report # RR-66, The Consortium for Policy Research. http://www.cpre.org/sites/default/files/researchreport/833_math-and-science-teacher-turnoveringersoll-and-may-2010final-web-ready.pdf.
45. Finding based on USHCA STEM Survey and USHCA's work with 16 urban school districts.
46. TNTP. 2012. *The Irreplaceables. Understanding the Real Retention Crisis in America's Urban Schools.* http://tntp.org/assets/documents/TNTP_Irreplaceables_2012.pdf
47. Lach, Michael, interview by Susan Marks. 2014.
48. Results Meeting Protocol is a resource from Paul Bambrick-Santoyo's *Driven By Data: A Practical Guide to Improve Instruction*
49. Ingersoll, Richard and May, Henry. 2010. *The Magnitude, Destinations, and Determinants of Mathematics, and Science Teacher Turnover.* CPRE Research Report # RR-66, The Consortium for Policy Research. http://www.cpre.org/sites/default/files/researchreport/833_math-and-science-teacher-turnoveringersoll-and-may-2010final-web-ready.pdf.
50. Note that TFA's survey also found that STEM millennials are looking for careers with growth and progression in the first 3-5 years.
51. STEM Education and Leadership. http://www.ncpublicschools.org/stem/overview/
52. IN.Gov. http://www.in.gov/edroundtable/2424.htm