Building Networks
&
Enhancing Diversity
in the K–12 STEM Teaching Workforce

Smithsonian Science Education Center
HOWARD UNIVERSITY 1867
NSF

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About the Smithsonian Science Education Center

The Smithsonian Science Education Center is an organization of the Smithsonian Institution dedicated to Transforming K–12 *Education through Science™* in collaboration with communities across the globe. To achieve our mission, we have four goals: (1) we promote authentic, inquiry-based, integrated K–12 science, technology, engineering, and mathematics (STEM) teaching and learning; (2) we ensure diversity, equity, accessibility and inclusion (DEAI) in K–12 STEM education; (3) we advance STEM education for sustainable development (STEM4SD); and (4) we translate the research and collections of the Smithsonian into meaningful tools and convenings for K–12 teachers and students. We achieve our goals by: (a) building awareness for science education among school leaders; (b) promoting Leadership and Assistance for Science Education Reform (LASER); (c) supporting the professional growth of K–12 teachers and school leaders; (d) developing exemplary K–12 curriculum materials and digital resources (including our comprehensive research-based science curriculum programs, Smithsonian Science for the Classroom, Science and Technology Concepts for Middle School, and Smithsonian Science for Global Goals); and (e) engaging in research. At the heart of our work is the idea that all youth—regardless of gender, sexual orientation, geography, race, native language, ability, or socioeconomic status—should be given the opportunity to learn about the socio-scientific issues that challenge us. The Smithsonian, through the Smithsonian Science Education Center, plays an active role in sparking students' and teachers' interest in STEM to ensure a scientifically literate and sustainable planet.

About Howard University

Howard University is a private, doctoral university classified as a high research activity institution and one of the most diverse universities in the nation's capital. Howard University has more than 9,000 undergraduate, graduate, and professional students representing 50 states and territories and 66 nations. Howard is also a Historically Black College and University (HBCU). While the 101 existing HBCUs represent only 3 percent of postsecondary institutions in the nation, they enroll more than 10 percent of all African Americans enrolled in higher education. Approximately 20 percent of the nation's Black population who hold an undergraduate degree in STEM earned it at an HBCU. Committed to a diverse STEM and teaching workforce, HBCUs enroll about 10 percent of all African American college students, and graduate 27 percent of all African American STEM graduates (Bureau of Labor Statistics, 2020)[1]. Minority-serving institutions (MSIs) play a critical role in diversifying the teacher workforce. Howard University is among other MSIs graduating outstanding teachers of color in the STEM fields. Despite representing a small number of member institutions within the American Association of Colleges of Teacher Education (AACTE), HBCUs produced 11 percent of all African American teacher candidates and Hispanic Serving Institutions (HSIs) produced 23 percent of all Hispanic teacher candidates prepared by AACTE member institutions in the 2009–2010 academic year (AACTE, 2013)[2]. Because of the increasingly changing demographics, Howard recognizes the current need for intensifying the process for recruiting and hiring highly qualified STEM teachers of color.

About the NSF INCLUDES Planning Grant and DRK–12 Grant

Building Networks and Enhancing Diversity in the K–12 STEM Teaching Workforce is a planning grant that is jointly funded by the National Science Foundation's (NSF) Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES) planning grant and the Discovery Research PreK–12 (DRK–12) grant #2040784. The goal of INCLUDES grants are to systematically build a network that is mobilizing communities with evidence-based strategies for broadening participation in STEM fields, bringing renewed emphasis and resources to increase diversity across and within STEM fields at scale. The DRK–12 grant supports programs that enhance the learning and teaching of STEM and computer science by PreK–12 students and teachers, through research and development of STEM education innovations and approaches.

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1 Bureau of Labor Statistics. (2020, October 2). The employment situation—September 2020 (USDL-20-1838). https://www.bls.gov/news.release/pdf/empsit.pdf

2 American Association of Colleges of Teacher Education (AACTE). (2013). The changing teacher profession. Washington, D.C.

Preface

The nation faces challenges to achieve excellence in its science, technology, engineering, and mathematics (STEM) workforce, and the importance of fostering diversity in the STEM teaching workforce is fundamental to this success. Currently there is a large demographic discrepancy between students and teachers in K–12 schools, and the dearth of teachers of color is one of the reasons for the failure of public schools to provide students of color with opportunities to learn from teachers of diverse backgrounds and perspectives. Studies have highlighted the fact that a diverse teaching workforce benefits not only students of color but all students. Across the nation, there are programs that aim to increase the number of STEM teachers or programs to increase the number of teachers from diverse communities at large, but very few programs aim to do both at the same time.

Beginning in 2015, the Smithsonian Science Education Center has been trying to do just that. The effort has focused on bringing together individuals and organizations with the unique ability to foster change, through a series of activities designed to assist school districts in implementing systemic reform to increase diversity in their STEM teaching community. One identified activity was to bring together teams from across the country for a weekend to develop a logic model to serve as a plan of action focused on the problem of practice related to recruiting or retaining a STEM teacher workforce that is more racially and ethnically representative of the students in their classrooms. As a result, the first STEM Education Summit was launched.

Since 2017, the Smithsonian Science Education Center has hosted an annual STEM Education Summit, with the goal of building a coalition (built on collective impact) for attracting and retaining a diverse K–12 STEM teaching workforce. Teams of teachers and administrators representing 97 school districts, schools, and states across the country share their problems and develop a logic model to attract and retain a diverse K–12 STEM teaching workforce in their region, with annual support from a matched mentor.

Through the support of the NSF INCLUDES and DRK-12 planning grant, the Smithsonian Science Education Center, in collaboration with Howard University, was able to hold a workshop for alumni of the STEM Education Summits to learn from past participants about their challenges, successes, and lessons learned through the implementation of their logic models. This planning grant supported revisiting those former teams to better understand the dynamics of systems change through close examination of the successes and challenges outlined in their logic models, using the perspective of Cultural-Historical Activity Theory (CHAT).

The output of the Alumni Workshop is the production of this Sourcebook. It is intended to provide insights into the lessons learned from the field to support recruiting and retaining STEM teachers from diverse backgrounds. This Sourcebook provides some practical, research-based ideas to help teams develop logic models to implement systems change approach to addressing localized problems of practice related to recruiting and retaining a diverse K–12 STEM teacher workforce. We hope this resource supports schools and districts that are interested in engaging in this work in their own regions.

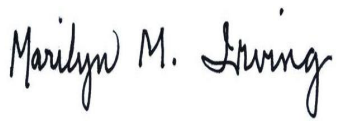
Dr. Carol O'Donnell
Director, Smithsonian Science Education Center

Howard University continues to maintain its long history of designing, implementing, and managing programs in STEM education and persists in addressing the critical issue of diversifying the teacher workforce in STEM areas. Howard University advocates for a diverse teaching workforce, particularly in the areas of science, technology, engineering, and mathematics. This is essential for ensuring excellence in America's educational system; importantly, a diverse teacher workforce benefits all students—not minority students alone.

Howard University applauds the Smithsonian Science Education Center (SSEC) for addressing the vital need to diversify the STEM teacher workforce and for systemically promoting civil dialogue to effect change. By convening interested individuals and encouraging them to discuss the issues related to creating a diverse teacher workforce, SSEC made significant contributions toward the complex process of recruiting and hiring STEM teachers of color. As a result of the SSEC Alumni Workshop, a Sourcebook was developed that reflects the deliberations of the workshop participants and the research-based recommendations for promoting change.

The partnership between Howard University and the Smithsonian Science Education Center provides valuable insights for education communities. We believe that the information gleaned from this Sourcebook will prove valuable for addressing the issues surrounding the recruitment and hiring of STEM teachers of color.

Dr. Marilyn Irving
Professor Emeritus, Howard University



Chapter 1

Why Is This Work Important?

Although American classrooms are becoming increasingly diverse, the teaching workforce, and particularly the STEM teaching workforce, has not kept pace. While there is no consensus definition of the STEM workforce and the many subfields that make it up, in this Sourcebook the STEM workforce refers to the self-identified STEM fields and occupations, such as computer sciences, engineering, mathematics, architecture, life sciences, physical sciences, health care practitioners and technicians, and the K–12 teachers, including those at the postsecondary level with a specialty in teaching science, technology, engineering, or mathematics with bachelor's degrees or higher, who make up the STEM teaching workforce.

Approximately 26 million jobs in the United States require STEM knowledge and skills. Training enough STEM workers to fill these jobs will require a teacher workforce equipped with the STEM knowledge, cultural understanding, and the skills to educate students of all backgrounds to pursue these careers. The terms "diversity," "minority," and "of color" in this Sourcebook refer to teacher candidates from communities that are currently underrepresented in the K–12 STEM teaching workforce (Hispanic, African-American, Native and Asian). When possible, the term used reflects the term used in the cited research.

In 2014, students of color outnumbered non-Hispanic White students for the first time (National Center for Education Statistics, 2019). Demographers say that by 2060, 36.4 percent of American children will be White; this number will begin declining from 49.8 percent in 2020 within the next decade (Nicholas et al., 2021). In contrast, the teaching population has become less diverse. The ratio of teachers of color to students of color was higher in 1954 (when there was an average of about one teacher of color for every 24 students of color) than it was in 2011 (when there was an average of about one teacher of color for every 50 students of color). This trend is expected to persist unless efforts are made to turn the tide.

The highly diverse student population, many of whom may matriculate through a K–12 system with some or few teachers of color, would benefit from teachers from racially and ethnically diverse backgrounds in similar ways all students benefit from diversity in the classroom.

Teachers of color matter. Recent evidence supports what educationalists, teachers, parents, school leaders, and students have been asserting for some time: Students benefit from having a same-race teacher (e.g. Harbatkin 2021; Lindsay & Hart, 2017; Wright et al., 2017). Nearly 80 percent of PreK–12 teachers are White, middle-class women. The PreK–12 student population is much more diverse; about half of students are non-White. While there has been an increase in the number of minority male teachers in the workforce, the proportion of minority students has increased more rapidly. This growth has also not been equally distributed across all types of schools. More than 40 percent of U.S. public schools have no teachers of color at all.

Why do teachers of color matter? A 2017 study from the Institute of Labor Economics (Gershenson et al., 2017), an independent economic research institute, found that an African American student assigned to a same-race teacher in third, fourth, or fifth grade performed better on standardized tests, had more favorable impressions of teachers, and was less likely to drop out. The need for racial diversity in schools, including among teachers, has important implications for student well-being.

The overall teacher diversity in school affects how effective teachers from diverse populations can be for students of color (Banerjee, 2018; Redding, 2019). Saft and Pianta (2001) found social and emotional

impacts in one study that suggested teachers felt closer to students whose race or ethnicity matched or were similar to their own.

Whether students derived benefit from this association often depended on the ethnicity and race of the teacher and student, as well as the overall diversity of the school environment, while controlling for a number of other variables (McGrady & Reynolds, 2013). Evidence supports that in general, all students benefit from having teachers of color, and Black, Indigenous, and Hispanic students in particular benefit from having teachers who share their racial or ethnic heritage (Egalite & Kisida, 2017; Egalite et al., 2015; Gershenson et al., 2016).

Background History of the STEM Education Summit

Students of color represent nearly 50 percent of the student population in the PreK–12 public education system (National Center for Education Statistics, 2021). Yet that diversity is not reflected in the teacher workforce, with nearly 80 percent of public school teachers identifying as White females (Taie & Goldring Westat, 2020). Research shows that there is a positive impact on student attitude, motivation, and achievement when their teacher shares the same race/ethnicity. Furthermore, teachers who share similar histories with their students may have more positive expectations of them (National Center for Education Statistics, 2019). As a respected entity within the Smithsonian Institution with a unique focus on formal STEM education and a mission of Transforming K–12 Education Through Science™ in collaboration with communities across the globe, the Smithsonian Science Education Center (SSEC) sought to address this lack of diversity in PreK–12 STEM classrooms.

In 2015, a steering committee was formed and, with the generous support of Shell Oil Company, this committee leveraged the Teach to Lead model to create the STEM Education Summit: Building a Coalition to Attract and Retain a Diverse STEM Teaching Workforce—a convening of teams from schools, school districts, and state education agencies that are supported in developing a logic model (see Chapters 3 and 4) to increase the number of STEM teachers in their network with diverse backgrounds. Teams consist of teachers, school and district administrators, human resources staff, and community partners, to ensure the different perspectives of key stakeholders are represented in their plan. With the support of a mentor, teams work on identifying their problem of practice and creating a goal related to attracting or retaining teachers with diverse backgrounds. Then, for 18 months following the summit, teams continue to receive mentor support to implement and improve upon their plans.

The inaugural summit was hosted at Howard University in Washington, D.C., in 2017 and 2018, with subsequent summits held at Xavier University of Louisiana (in New Orleans) in 2019, 2020, and virtually in 2021 in response to the coronavirus pandemic. Both are Minority Serving Institutions (MSIs), which are crucial to the success of this work (see Chapter 2). To date, the SSEC has supported 97 teams, 60 unique districts, and hosted teams from 26 states, the District of Columbia, and Puerto Rico. Through this initiative, the lives of more than 16.5 million students have been affected.

After five years of the STEM Education Summit, the SSEC, in collaboration with Howard University, held the first Alumni Workshop in July 2021, inviting the former participants of the 2017–2020 summits and their extended partners, to provide time to reflect and share experiences of implementing their action plans and to articulate a shared vision of diversifying the K–12 STEM teaching workforce. This Sourcebook contains some of the information that was shared during the Alumni Workshop. It outlines the strategies for systems change (see Chapter 5); and, it discusses the importance of developing a shared vision for diversifying the K-12 STEM teaching workforce and the role of partnerships in complex activity systems (see Chapter 6). We hope you find this information useful as you work to broaden participation in STEM education in your school, district, region, or state.

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Chapter 2

What Do We Know from Higher Education?

The past several U.S. censuses have shown marked demographic changes within the United States. As the population of the United States becomes increasingly diverse, teacher populations are often not representative of the overall student population. While a report from the Albert Shanker Institute (2015) found that the minority share of the American teacher workforce grew from 12 percent to 17 percent in nine U.S. cities, overall progress has not kept up with recent demographic changes.

The role of Minority Serving Institutions (MSIs) can help broaden participation for those groups historically underrepresented in STEM fields and teacher preparation programs, such as African Americans, Hispanics, Native Alaskans, Native Americans, Native Hawaiians, Pacific Islanders, persons with disabilities, women and girls, and persons from economically disadvantaged backgrounds. MSIs are institutions of higher education that serve minority populations. They are unique both in their missions and their commitments to serving vulnerable populations. MSIs are poised to meet widespread demand for higher education by minority students, especially in the STEM fields. According to a 2018 report by the American Association of Colleges of Teacher Education (AACTE) (King & Hampel, 2018), nearly 90 percent of the institutions in the business of educating teachers are two-year and four-year colleges and universities. The remaining are school districts, nonprofit organizations, and other entities that run state-approved alternative teacher preparation programs.

Methods

An Institutional Higher Education Survey included in the planning grant focused on the diversification of the STEM teaching workforce and the role of MSIs in carrying out this task. The data from this survey will be used to underscore the urgent need to increase the supply of teachers from diverse populations in STEM fields and people from diverse populations in STEM careers, and offer recommendations for achieving these goals. The survey will help identify successes, challenges, and opportunities that will help to address the diversification of the STEM teaching workforce and the role it plays in diversifying the wider STEM workforce. Institutions were eligible to participate in this survey if they are classified as MSIs either through self-classification or through the U.S. Department of Education.

To complete the survey, conducted by Howard University, each respondent had to identify as an administrator, faculty, staff, or coordinator of a teacher preparation program in an Institution of Higher Education (IHE). The IHE had to be involved in some aspect of teacher preparation—some STEM teachers are drawn from the ranks of teacher preparation programs, although preparation routes of STEM teachers vary greatly. The survey was administered in Qualtrics, with an expected completion time of 20 to 30 minutes. The response rate was approximately 50 percent. Participants' perceptions of how to diversify and increase the number of STEM teachers of color was measured. A subset of survey participants was selected to participate in a workshop to share the role they play in contributing to diversifying the STEM teaching workforce. The research was approved by Smithsonian's Institutional Review Board.

Table 2.1 shows the number of MSIs the survey was sent to. Figure 2.1 identifies all the ways schools, colleges, departments, and/or programs prepare teachers, including STEM teachers. Respondents were asked to select all the formats used by their IHE, school, college, department, or program to prepare educators. In the survey sample, the majority of institutions (25 percent) were traditional teacher education programs. Approximately 14 percent were programs that simply offered coursework for STEM programs

throughout the university, and 11 percent were classified as alternative teacher preparation programs. According to the AACTE, colleges and universities organize their academic programs in a variety of ways, and some education programs may not be formally organized as a college or school of education (King & Hampel, 2018). This turned out to be the case in this sample. Teachers, including STEM teachers, were being prepared in programs with a number of different formats, including online programs and partnership arrangements.

Table 2.1. Number of MSIs Surveyed in the Sample*

Type of Four-Year Institution	Total
Asian American and Native American Pacific Islander-Serving Institutions (AANAPISI)	25
Tribal College or University (TCU)	25
Historically Black College or University (HBCU)	75
Hispanic Serving Institution (HSI)	25

**A few institutions have multiple MSI designations and thus may appear in multiple MSI types.*

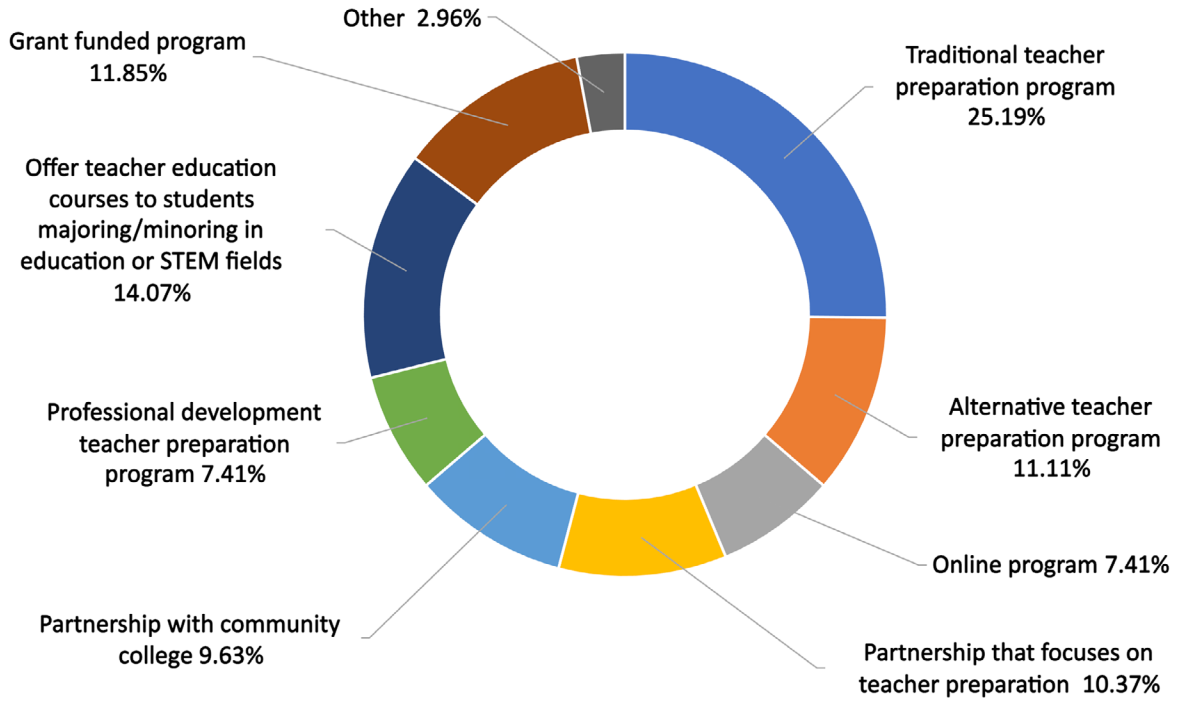

Figure 2.1. All the ways teachers are prepared in responding institutions

Findings from the MSI Survey

Researchers used a conventional open coding method and coded the unstructured data obtained from the sources listed in Table 2.1. The researchers used three types of analysis: manual coding with pencil and paper; Qualtrics for survey development and descriptive analysis; and code landscaping with Wordle, a data visualization program. The survey identified a number of challenges and opportunities in regard to the role of MSIs in diversifying the STEM teaching workforce.

The MSIs in this survey indicated that diversification of the STEM teaching workforce was a high priority in their institutions. When asked which guiding documents in their institution reflected the priority of diversifying the STEM teaching workforce, approximately 26 percent reported that the strategic plans

reflected this priority, 22 percent reported that the assessment plans incorporated this strategic priority, and 20 percent stated that it was also reflected in vision statements. (Note that respondents could check all that applied.)

However, only 8 percent of MSIs reported that budget documents reflected such a priority. Despite identifying a number of current and planned initiatives that their school, college, or departments planned to implement to diversify the STEM teaching workforce, many reported that financial supports and scholarships were needed. In addition, MSIs noted that they needed improved collaboration, early engagement, and leadership development. Figure 2.2 illustrates what programs, initiatives, and/or practices would help teacher preparation programs improve the recruitment, support, and/or preparation of STEM teacher candidates from diverse backgrounds. While many felt that connections to K–12 schools were strong, some noted that they could also be strengthened to help increase the pipeline of STEM teachers from diverse backgrounds.

Figure 2.2. Needed supports

The challenges the MSIs identified are shown in Figure 2.3, and include recruiting, supporting, and preparing STEM teacher candidates of color. These challenges triangulated with results from the scholarly literature (Samayoa, 2018; Toldson & Washington, 2015), as well as with results from other questions on the IHE survey. Providing financial incentives and helping candidates prepare for state licensure exams were the top two concerns and needed supports cited by the MSIs. Recruiting diverse candidates was the third most pressing concern, as illustrated in Figure 2.3.

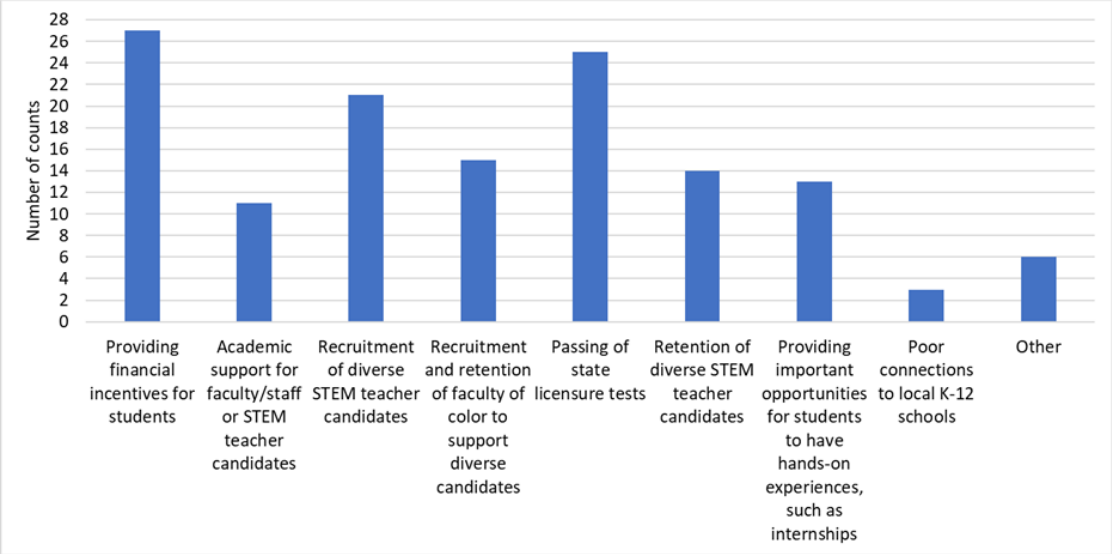

Figure 2.3. Challenges to the diversification of STEM teacher candidates

Conclusion

MSIs have strong commitments to educating low-income and minority students, despite resource constraints. Teacher preparation programs at MSIs are equally committed to diversifying the teacher workforce, even while federal identification of and funding for enrollment-based MSIs requires that these institutions keep their costs low and quality high. While the majority of respondents reported that they partner with K–12 schools to help prepare STEM teachers, many have sought innovative partnerships to accomplish this goal. Collaborative and innovative partnerships are an emerging trend for MSIs to continue to be engines of upward mobility for underrepresented minorities.

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Chapter 3

Using a Logic Model to Outline a Solution

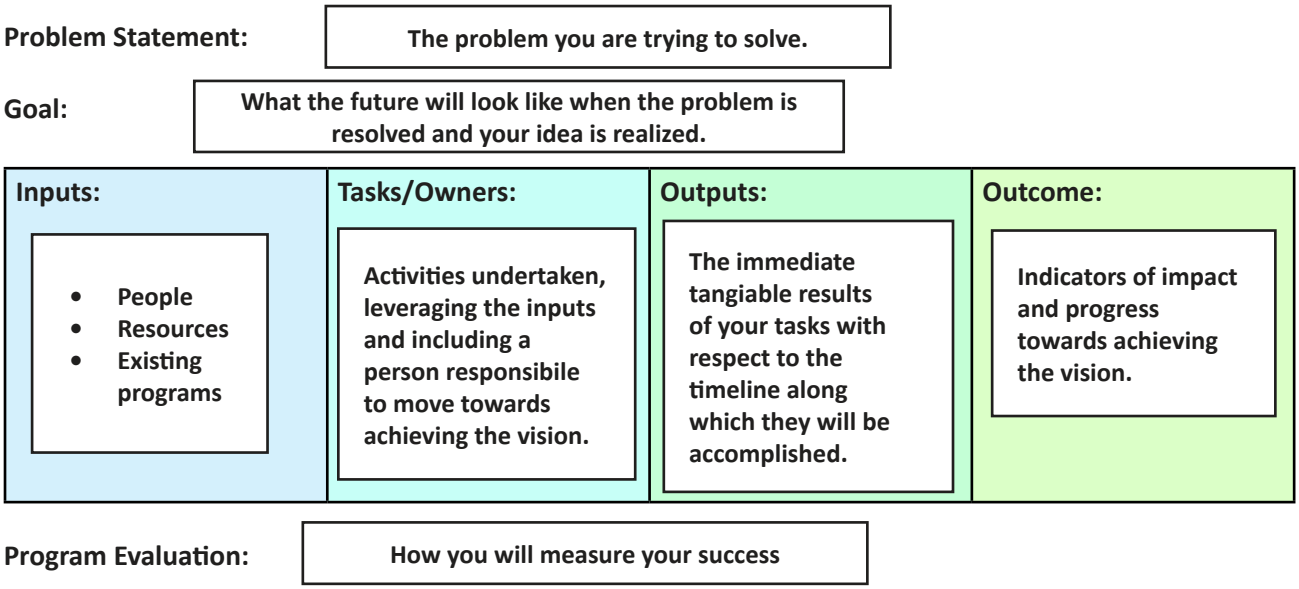

Figure 3.1. Logic model

Why Use a Logic Model?

Change of any kind requires action, but without a strategy, the actions you take may not result in the desired outcome. That is when a logic model is useful. A logic model, also referred to here as an action plan, is an organizing tool that clearly communicates a problem you are trying to solve and a goal that attempts to fix it. Additionally, logic models enable you to build a logical flow from activities to outcomes, to explain how you will reach your stated objective and how your success will benefit others.

All these elements make logic models ideal for marketing/communicating a solution, as well. Implementing systems change in education requires collaboration among various stakeholders, who have diverse perspectives, ideas, and needs, so a logic model helps them understand what your priorities are and what responsibilities they can take on. Prioritizing is important when developing a logic model because an effective plan considers the limitations of the resources available to you. Therefore, this tool asks you to be intentional in your planning process. Regarding evaluation, logic models are structured to help you determine which metrics you can evaluate to identify causal relationships between inputs and outcomes.

How to Use the Logic Model Template

There are seven sections in this logic model: problem statement, goal, inputs, tasks and owners, outputs, outcomes, and program evaluation (Figure 3.1).

The **problem** is what needs to change. It is the challenge that prevents the system from operating at its full potential. The problem is the roadblock that has created unfavorable conditions for the individuals connected to the system. It is important to note that the way a problem is defined does affect the solutions

you choose. This is why a problem statement should include more than an informal observation or a hunch; whatever you define as your problem should be based in data.

Finally, your problem should focus on the root cause that is creating the undesired condition, not a symptom. For example, imagine you are a school principal and your student demographic is 70 percent English learners (EL), 30 percent non-EL. You notice that you typically see the same few parents show up to school events. You observe that because many parents work late into the evening, you should offer events in the morning and evening, but when you implement this, you do not notice a significant difference in attendance. Then your staff suggests that you translate communications for parents and caregivers into their home languages. When you do, you realize that attendance increases by 60 percent. Your problem wasn't that families were unavailable; it was that language barriers made communications from the school inaccessible to most of the school community.

The **goal** is what you will do in response to the problem to improve conditions. Remember, the way your problem is defined will have an impact on the goal you set. But there are also other factors to consider when developing a clear goal—sometimes referred to as a SMART goal. SMART is an acronym that stands for specific, measurable, attainable, relevant, and time bound. Goals that are specific use clear and concise language and therefore can be communicated to a broad audience. Because your goal is a potential marketing tool, it is critical that prospective stakeholders and investors understand your plan. Goals must also be **measurable**, which means they should be something you can evaluate; otherwise progress may be difficult to track. Your goal should be **attainable**. While it may be tempting to completely rebuild an entire system, in most cases this is impractical. Change takes time and patience. It also takes resources—which often are limited—so your goal must align with the resources available to you. A goal that is relevant aligns with your identified problem and will lead you to solving it. Making your goal time bound is necessary because work cannot go on indefinitely; you must have a clear beginning and end point.

Inputs are what you already have. This could include existing programs, materials, supplies, technology, financial resources, and even human resources. The key takeaway here is that an input is a resource that is reasonably accessible to you.

Tasks and **owners** are the actions needed to reach a goal and the people who are assigned these responsibilities. Tasks answer the question, "How will this goal be accomplished?" Owners answer the question, "Who will do these tasks?" It is where the inputs and investments are leveraged alongside the people who will take ownership of each task; in many cases your success requires the support of many individuals.

Outputs are the immediate or direct results of completing an activity. The intention of the activities you choose means that you anticipate specific results, which are defined by your outputs. In other words, if you do X, then you expect Y to occur.

Outcomes are the ways conditions for your target audience improve. They communicate the indirect consequences of you achieving your goal. They are your impact, and can be categorized as short-term and long-term. Your outcomes can also assist you in determining which metrics will be most useful in establishing a causal relationship between the tasks you've chosen and your desired results.

Program evaluation is how you will determine your success. Once you've determined what you want to do and the effects you anticipate, you need to be able to ensure that the change is a result of your actions and not some other event.

See Appendix 1 for a logic model template, and Appendix 2 for an example of a logic model.

Chapter 4

Implementing a Logic Model in an Activity System

Once your team has created a logic model that defines your action plan, it is time to implement it in your school, district, or region. When it is being implemented, however, you may encounter various factors that can hinder your plans. Some of them may be due to internal reasons, such as a time conflict or lack of confidence to lead an action, but you will also find that many of the barriers are external and are interwoven with one another. This is because you are part of an activity system.

An activity system is a group of people who share a common object and work together over time using tools to act on that object (Engeström, 1987). Human activity within this system can be defined as engagement to achieve a shared common goal—an objective. The activity changes over time and is affected by the interactions of the individuals in the system. The roots of the concept of an activity system can be found in the work of psychologists Lev Vygostsky (1978, 1986) and Aleksei Leontiev (1978, 1981), who tried to understand human activities as systemic and socially situated phenomena.

Cultural-Historical Activity Theory (CHAT), or simply activity theory, describes human activities in a social and cultural context. CHAT explains human activity using six elements: subject, tool, object, rules, community, and division of labor (Engeström, 1987). The **subject** is the collective participants within the system, so it is you and your team members. The **object** is the goal your team wants to achieve. An example of a **tool** is the logic model that helps your team define your goal and action plan. You are in a **community** that is built with **rules** and common norms, within which individuals play their roles (**division of labor**). There is also an outcome that results from the activities (Figure 4.1).

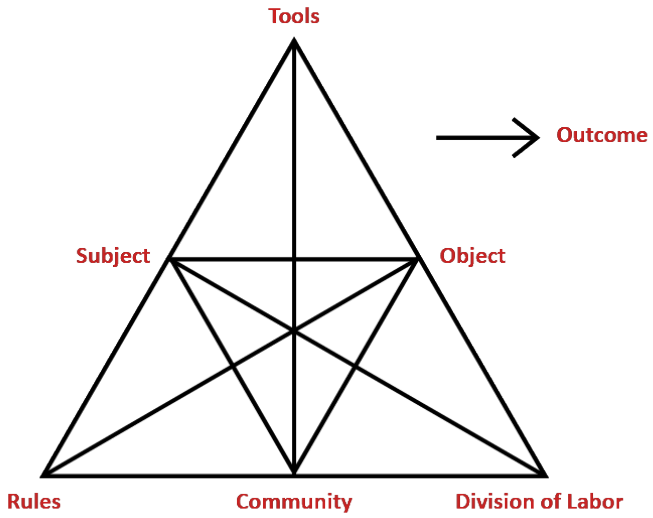

Figure 4.1. General model of an activity system (Engeström, 1987)

How your team's activities can be explained with the CHAT model is summarized in Figure 4.2 (Lee et al., 2021). When you and your team members come together (such as at the Smithsonian's annual STEM

Education Summit), you and your team members (subject) should work together to identify issues and plausible solutions using a logic model (tool), define your team's goal, and develop an action plan to move forward for diversifying the K–12 STEM teaching workforce (object). Afterwards, you and your team members may integrate other tools, such as conducting a survey, to specify your team's action plan and modify your team's goal. When the logic model is implemented, however, you may encounter many factors, such as administration policies, common norms among people, cultural context, and formal or informal rules that have been built up consciously or unconsciously. You are in a school, district, state, or region (community) that has its own characteristics. For example, a community could be urban or rural, and school parents in one community may be more willing to support a particular plan than those in other communities. The division of labor looks at who will be responsible for doing what and how to carry out the plan.

All these elements are related, so when you change one thing in a system, it will affect the whole system. You and your team members may face tension between these elements or within the elements. For example, is your community supportive of your team's object? Will your team be able to communicate well with your community? Are there any challenges or obstacles because of administrative processes or policies? Are your stakeholders responsible for their work to support your team's plan? There are many more questions you can think about that will affect your activity system when implementing a logic model.

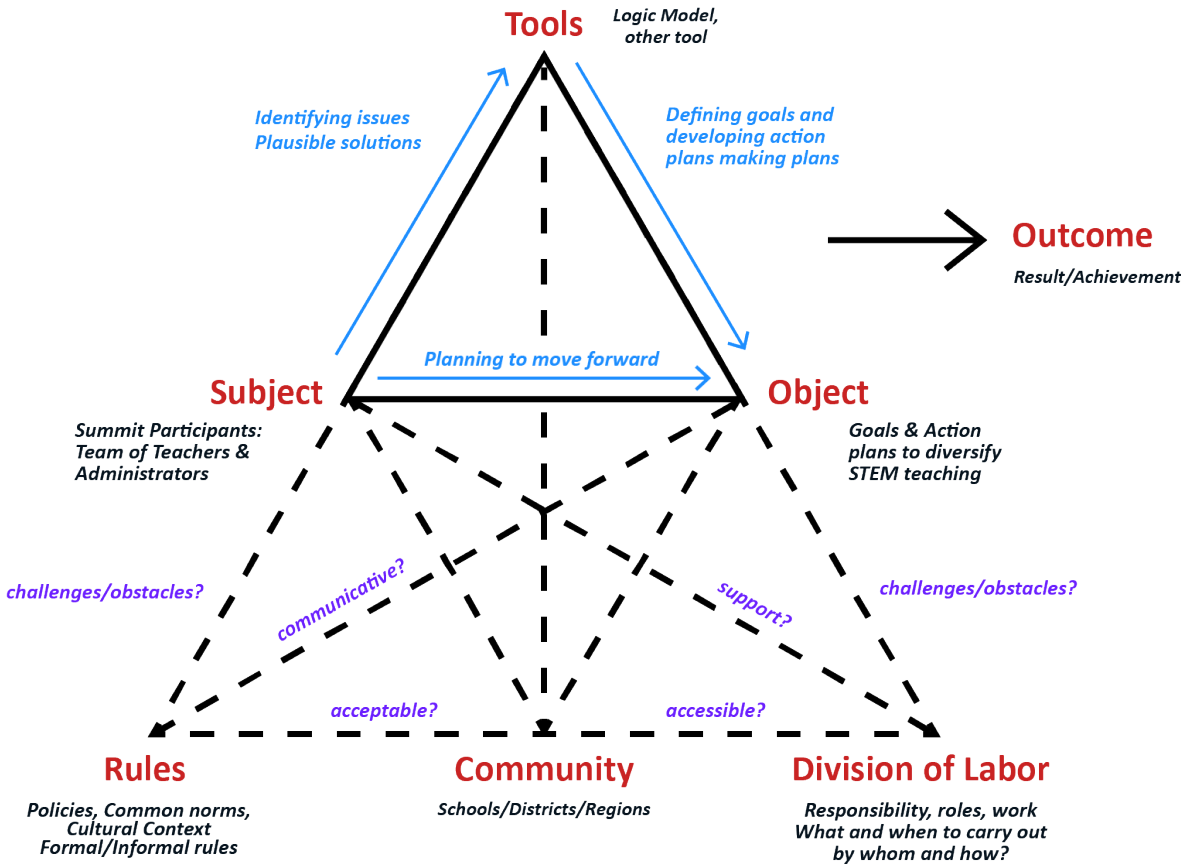

Figure 4.2. An example of an activity system implementing a logic model (Lee et al., 2021)

An individual team has its own object. For example, your team may want to focus on retaining in-service teachers of color, while another team may want to focus on recruiting new teachers of color in their school. However, although your teams are from different activity systems with different goals, you all share an overarching shared object, which is to enhance K–12 STEM teaching workforce diversity (Figure 4.3).

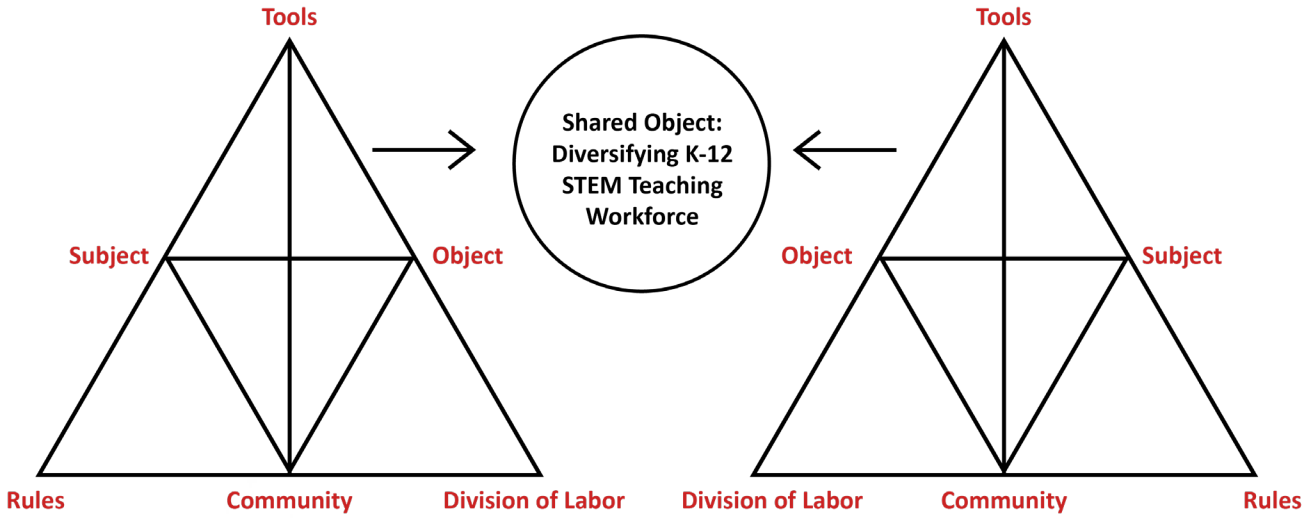

Figure 4.3. Each activity system shares the same object.

CHAT is a theoretical framework that explains how human activities are interrelated and are affected by the systems around them. The CHAT framework can also be used as an analytic tool to troubleshoot your activity system. A CHAT template is included in Appendix 3. It is for you and your team to identify the elements of your activity system and find any tensions in the implementation of a logic model within the system.

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Chapter 5

Strategies for Systems Change

The traditional pathway to becoming a teacher in the United States is well known. Guided by a variety of factors--including their own experiences with schooling, subject matter, and teachers--students make the decision to pursue a career in teaching and enroll in a university teacher preparation program. This path to teaching, while perhaps once the most common route**,** is now a road less traveled, with an overall decline in participants of more than one-third in teacher education programs from 2010 to 2018. The decline in participation by Black and Latinx teacher candidates is only somewhat less—25 percent (Partelow, 2019).

Diversifying the Pathways to STEM Teaching for K–12 Students

When it comes to STEM teaching, the traditional road has been all but abandoned. Just 0.43 percent of all high school students identified by the ACT in 2017 as "STEM interested" planned to major or pursue a career in math education. Even fewer (0.17 percent) expressed plans to become science educators. In raw numbers, these are 5,839 individuals who might potentially have become STEM teachers (ACT, 2017).

Ultimately, when supply is short and demand is high, school districts fill STEM classrooms with whomever they can find, relegating efforts to promote diversity and inclusion in the STEM teacher workforce to a secondary level of concern. One Alumni Workshop participant stated, "[The] struggle to get ANY teachers removes focus on recruiting teachers of color."

What, then, can be done within the K–12 context to broaden the appeal of STEM teaching as a career for any student, and especially for underrepresented students? Workshop participants, reflecting on their own initiatives to diversify STEM education, identified concerns and possibilities to consider that are applicable to the challenge of promoting STEM teaching as a potential career choice for K–12 students. They are quoted below.

Challenges and Constraints

- **Attention span.** Conditions in the broader world, such as the COVID-19 pandemic and in the conflicting demands placed on schools, challenge educators to maintain a steady focus on STEM education.
    - "Too many competing goals. We need to prioritize."
    - "District-level competing priorities"
    - "Pandemic has slowed the pathways"
- **Fixed mindsets and fixed variables.** Certain ways of thinking and conditions common to school operations are perceived to be beyond the control of STEM-focused educators.
    - "Planning time and teacher buy-in"
    - "Lack of equity in programs and resources"
    - "The focus on testing still pushes a comprehensive STEM agenda to the back burner."
    - "State and local control"
- **Finances.** Lack of monetary support to schools and teachers limits the ability of educators to provide STEM education and the desirability of teaching as a career.
    - "Lack of funding to schools and no increase in teachers' salaries for several years"
    - "Budget constraints"
    - "We have to offer a comparable salary if we want to attract and retain teachers."
    - "State guidelines on STEM pathways and courses that qualify for funding"

- **Administrative support.** Educators need clear and consistent support from local and state administrators to provide effective STEM education to K–12 students.
    - "Fluctuation in state guidelines regarding STEM endorsements for graduation"
    - "Lack of cohesive vision at district level"
    - "The priorities for each school/district may prevent K–12 STEM pathways from being emphasized."

Strategies and Recommendations

- **Build your team or join one.** Workshop participants recognized and emphasized the value of collaboration at multiple levels of their local and the broader STEM learning ecosystem.
    - "Individual capacity for STEM implementation is growing, making scalability more likely."
    - "There are many IHEs in the area that we could partner with."
    - "Strong support from local businesses who need STEM workers"
    - "The SSEC can be a repository of practices that can be used to create a unified agenda"
    - "Collaborative networks of STEM learning foster the skills and growth mindsets among stakeholders that lead to lifelong learning and opportunities for STEM education."
    - "STEM ecosystem relationships"
- **Communication is key.** Workshop participants recognize that the viability of STEM teaching as a career can be thwarted by mixed, incomplete, or absent messaging to K–12 students, their parents/guardians, and the community at large. It can also be enhanced with clear and recurring messaging.
    - "Clearly communicating the opportunities available to all students so that they have a clear vision of STEM possibilities and the pathways"
    - "Need to get the word out on career paths, especially teaching at the fourth- and fifth-grade levels"
    - "Making the vision of opportunities more visible to all"
    - "Internal teacher support to encourage and promote the education track in the human services pathway"
- **Clarify the K–12 STEM pathway.** Workshop participants recognized the importance of clarifying the educational pathway from K–12 STEM education to a future career as a STEM educator.
    - "Encourage students to choose challenging STEM courses"
    - "Industry internships"
    - "Recognize barriers along the K–12 pathway where students fall off and are eventually excluded from opportunities"
    - "Expanding advanced STEM courses and tutoring programs for interested students"
    - "Creating the pathway creates the opportunity."

Exemplary Cases

By the time the typical K–12 student begins to explore careers in earnest, they have experienced teaching in greater depth than any other profession. They will have unintentionally job-shadowed dozens of teachers for thousands of hours. These experiences can have a significant influence on children's willingness to consider teaching as a profession. Following are some strategies found in the literature and exemplary cases about diversifying the pathway in the broader STEM ecosystem.

Improve the unintended apprenticeship. When it comes to identifying with teaching as a career, perception matters. Wong (1992), for example, found that seventh- and eighth-grade students who have poor perceptions of the school/classroom environment were not likely to express interest in teaching as a career.

The formula for high-quality STEM learning experiences is well known and has been articulated in the Smithsonian Science Education Center's theory of action (Smithsonian Science Education Center, 2021) and

in criteria for STEM school certification such as those developed by the Georgia Department of Education (STEM/STEAM Georgia, 2021).

Richland Two School District in South Carolina, supported by a Magnet Schools Assistance Program grant through the U.S. Department of Education, has developed an elementary through high school STEM continuum in four schools that serve a majority of minority and impoverished students who are focused on careers in medicine. The first objective of this effort is "To promote diversity by reducing and preventing minority group isolation and increasing socioeconomic diversity." Initial, unpublished data indicate that the vast majority of students report increased learning engagement. Additionally, all four schools report increased parent and community engagement (STEAMM MedPro21, n.d.).

Grow your own teachers. Teaching remains a largely local profession. Those seeking to become teachers often intend to teach within or near their home communities. Recognizing this ongoing trend, states, rural regions, cities, and other localities have initiated programs to identify adults and, sometimes, secondary school students who have an interest in teaching, to recruit them to participate in intentional teaching apprenticeships.

The Greenville Alternative Teacher Education Program (GATE) is a district-based, job-embedded alternative certification program in Greenville, South Carolina, with a focus on recruiting adults (Greenville County Schools, n.d.). While not exclusively STEM-focused, it does aim to attract math and science teachers to its secondary schools.

Since 1985, the Center for Educator Recruitment, Retention and Advancement, based at Winthrop University in Rock Hill, South Carolina, has been encouraging high school students to consider teaching as a career through its Teacher Cadet program (Center for Educator Recruitment, Retention and Advancement, 2019). Again, this program does not specifically promote STEM teaching, but offers a well-tested structure for engaging students in an intentional teaching apprenticeship.

Elevate and honor STEM teaching. Research commissioned by 100Kin10, a national organization focused on recruiting STEM educators, identified more than 100 challenges to preparing and retaining STEM teachers. Among the themes that emerged from this research, "prestige" stands out as being relevant to gaining the interest of youth in STEM teaching as a career choice, in both unintended and intentional apprenticeships. 100Kin10 reminds us, "Many teachers do not actively promote PreK–12 teaching as a satisfying and attractive profession. As a result, students may be discouraged from aspiring to such careers themselves" (100Kin10, n.d., para. 2). It's also worth noting that many schools and districts do not promote STEM teaching, or teaching of any kind, at the career fairs they host.

To enhance STEM teaching as an aspirational career, organizations from the various niches of the STEM ecosystem are placing additional emphasis on specific recognition of STEM teachers. The states of Georgia, Massachusetts, and South Carolina, for example, all honor a STEM Teacher of the Year.

Additional Resources

https://aaas-arise.org/2021/02/16/reimagining-the-stem-education-pipeline-for-teachers-of-color/
This article identifies both the need for STEM educators of color and the lack of specific focus on encouraging students of color to become STEM educators. The author proposes strategies to inform students of color about the benefits of teaching as a career.

https://www.aps.org/policy/reports/popa-reports/stemteachers.cfm
This executive summary identifies key findings from a survey of current and recent U.S. undergraduate

students with STEM majors regarding their perceptions of teaching as a career choice. A link to the full report is included.

https://eprints.qut.edu.au/64419/
This Australian study identifies reasons why talented STEM university students do not consider STEM teaching as a career path. The authors present a framework for addressing this disinterest.

Diversifying the STEM Teaching Pathways in Colleges and Alternative K–12 STEM Teaching Pathways

Inequalities in STEM mirror the inequalities in larger society and therefore can undermine efforts to diversify the STEM teaching workforce. According to the National Science Foundation, the STEM workforce is 89 percent White and 72 percent male, while the overall workforce is 78 percent White and 53 percent male. In 2017, Black Americans made up 12 percent of the adult population in the United States, but only 7 percent of the STEM highest degree holders and 6 percent of STEM workers. In 2017, Hispanics and Latinos made up 16 percent of the adult population in the United States but only 9 percent of the STEM degree holders and 8 percent of STEM workers (Myers, 2021).

Embracing diversity is key to providing an inclusive environment for all students. Diversifying the STEM pathway increases the academic success of students of color by providing role models that ultimately benefit all students. Analysis of research data demonstrates that students who have teachers who look like and sound like them often do better academically. Identifying with STEM teachers of the same race and ethnicity serves as a catalyst for students to pursue that career pathway.

Challenges and Constraints

In every strategic plan, weaknesses must be identified and overcome. And in this process there are many. Below are some of the challenges that were shared by the Alumni Workshop participants.

- Low number of minorities applying for teaching positions and/or low interest in STEM. Many believe that this is due to a lack of targeted recruitment of students to pursue STEM, a college degree, or the teaching field. To be effective, targeted recruitment needs to use a framework tool that provides a process. Targeted recruitment is a problem across the board, but having a framework can be a catalyst for increasing the percentage of minorities.
- STEM has for many years been an unfunded mandate and not a priority in education. The downward trend of academic excellence highlights this as compared to students in other countries. The first step in the framework needs to be a shared vision and message from advisors in STEM, STEM departments, and departments of education that is coherent and consistent and eliminates silos among K–12, higher education, and colleges. To be fair, it must be recognized that COVID has been a huge stumbling block for STEM progress in recent years. It has created a time imperative to keep this initiative as a priority.
- Another glaring challenge is that the current K–12 environment is viewed as “not a fun place to be or work, so why join?” Many workshop participants feel hiring practices are focused on cronyism, and critical race theory backlash discourages the process of recruiting minorities. In colleges, minorities feel a lack of support to pursue STEM.

Strategies and Recommendations

Discussion groups have shared strengths that currently exist in the educational field.

- There is a focus on preparing many more STEM teachers, with an eye to diversity. Statewide collaboration has priorities to sign student demographics with matching teachers who are high-quality STEM teachers who can lead the transition.

- Emphasis has been placed on building supportive relationships with school faculties and IHEs preparing future STEM teachers.
- john powel[3], Stephen Menendian, and Wendy Ake (2019) share in their report *Targeted Universalism* that Targeted Universalism is a way to design efforts to make transformative or transactional changes. The change they describe is aimed at increasing diversity and developing high-quality STEM teachers. One of these frameworks of change is designed by E3 Washington, an organization that organizes conferences to address the problems in STEM teacher preparation; it is aimed at catalyzing change through strategic collaborations.
- Enhancing equity, diversity, and inclusion in K–12 STEM teacher preparation can be addressed with financial incentives and early recruitment of underrepresented groups.
- Preparing and supporting all elementary school teachers to be teachers of STEM includes helping teaching students prepare for state licensure and providing a mentor who supports and encourages them.
- Creating interdisciplinary and culturally sustaining secondary STEM teacher preparation programs must include building a support group of colleagues who are diverse, and providing leadership training.

The key to effecting change is leveraging collaborations along the teaching pathway. While all teachers require intentional, culturally based preparation to reach an increasingly diverse student population, greater diversity in the teaching profession can also have positive effects on student educational experiences and outcomes.

Exemplary Case

Each stage in students' progression through K–12 poses obstacles to persisting in STEM learning. In an *Education Week* article by Madeline Will (2018), she describes how the Guilford County School system took a look at these barriers and came up with an innovative solution that has worked for them.

> *Nearly every school district across the United States has struggled finding enough science, technology, engineering, or math teachers. Could one solution be for districts to recruit content-area experts and both train and license them themselves?*
>
> *That avenue has been an answer to a persistent STEM teacher shortage in the Guilford County school system in Greensboro, N.C. The 72,000-student district became the first in the state to open an in-house licensure program in 2008—and it's still one of only a handful of districts across the country with such a program.*
>
> *That certification pathway has allowed the high-poverty district, which has schools in both urban and rural areas, to hire dozens of STEM teachers. While critics warn that such approaches risk lowering the bar for teacher preparation, officials in Guilford say the teachers they train are bringing real-world STEM experience to the classroom."*
>
> *While the district's overall teacher attrition rate was between 10 percent and 12 percent, it was 34 percent for alternatively certified teachers, Holcombe said.*
>
> *Now, she said, teachers who go through the program have a network of support. For the past three years, nearly all the STEM teachers who went through the program have stayed in the district for a second year of teaching.*

3 The author purposefully does not capitalize his name.

Attracting/Recruiting Teachers of Color

The global scientific competitiveness of the United States depends on the nation's ability to strengthen its STEM workforce. Diversifying the STEM teaching workforce is essential to the educational excellence of all students, as well.

Challenges and Constraints

Comments collected from focus groups during the Alumni Workshop suggest that barriers to attracting and recruiting teachers of color begin at the secondary school level. The challenges and constraints can be categorized into three general areas: the perception that administrators and school districts are not systematically and effectively recruiting teachers of color in STEM fields; school demographics and racial diversity; and the fact that the educational system does not encourage secondary students to see themselves as STEM teachers.

- **School districts do not consider the importance of recruiting STEM teachers of color**

  Some administrators don't see the lack of STEM teacher workforce diversity as a problem. In addition, there is a perception that administrators and school districts are not systematically and effectively recruiting teachers of color in STEM fields.

  Although more than 36 states and the federal government have established proposals for recruiting more people of color, the average rate of attrition is greater than the rate of entry. Although principals and administrators recognize the importance of recruiting teachers of color, they face many challenges. Unfortunately, some principals and administrators assume that diversification of teachers has little effect on their school's success, as few minorities majoring in STEM education graduate from college and the few that do are not entering the field of education.

  Research by the Learning Policy Institute (Carver-Thomas, 2018) suggests that deliberate preparation, hiring, and ongoing support is necessary to increase the number of teachers of color. This study also determined that increasing teacher diversity is a very important strategy for improving learning for students of color and for closing achievement gaps, because research shows that students of color do better when they are taught by teachers of color.

  Carver-Thomas (2018) suggests that school districts can implement programs designed to recruit teachers of color and that these programs can be supported through university-based partnerships and other financial and programmatic funding. Boston Public Schools is an example of a school district that implemented such a program. A district-wide Teacher Cadet Program was established that identifies and supports racially diverse high school students designated as future teachers. Students in this program receive academic support, gain leadership skills, and prepare for a career in teaching (BPS Office of Recruitment, Cultivation & Diversity Programs, n.d.).

- **School demographics and racial diversity**

  In secondary education, teachers and students have different demographics. For example, even in schools with a majority Hispanic student population, very few of the teachers are Hispanic (National Center for Education Statistics, 2020). Even as demographics shift in regions, the teaching workforce stays the same and does not follow the shifts in student populations.

  Systems must be put in place that ensure equitable STEM teaching and learning (Milgrom-Elcott, 2020). A significant barrier is the racial gap between students and teachers. According to the National Center for Education Statistics (2021), since 2000 the White student population has declined. However, according to an article in *Education Week* (Heubeck, 2020), in the 2015-16 school year 80 percent of the teachers were White, while 17 percent of the students were Black.

- **Secondary school students are not encouraged to see themselves as STEM teachers**

The current education system does not encourage secondary school students to see themselves as STEM teachers. Students' STEM experiences in elementary and secondary school are associated with their postsecondary field of study and career choices. Student reports of high self-efficacy in mathematics and science in high school are associated with the choice of STEM majors in college (Wang, 2013). Research also indicates that teachers and counselors can play a role in encouraging historically underrepresented minorities to pursue STEM majors and careers (Mau & Li, 2018; Reinhold et al., 2018; Shillingford et al., 2018).

Strategies and Recommendations

- **Effectively recruit teachers of color in STEM fields**
  - Promote programs such as Noyce Teaching Fellows (see below).
  - Listen to teachers of color. Conduct strategy sessions to better understand and improve their experiences and concerns and discuss ideas for what their school could do to attract more teachers of color.
- **School demographics and racial diversity**
  - If possible, establish relationships with colleges that have a high number of minority STEM students or with HBCUs. Use these relationships to recruit college seniors for STEM teaching positions.
- **Secondary school students should be encouraged to see themselves as STEM teachers**
  - Establish programs that nurture students' interest in teaching as a career. Provide opportunities for older students to mentor younger students. Establish partnerships with colleges to offer free summer programs through which students of color can explore careers in STEM education.

Exemplary Cases

The following are opportunities available for STEM majors interested in teaching careers (Marder et al., 2021).

- **Noyce Teaching Fellows** is a program in which STEM professionals are eligible to become teaching fellows and receive both support to complete a master's degree and a salary supplement of $10,000 a year for four years once they begin teaching.
- **Math for America** awards four-year fellowships to accomplished mathematics and science teachers, who join STEM communities of critical thinkers and collaborative learners, and receive a $60,000 stipend.
- **UTeach** enables universities to prepare STEM teachers. Elements of the UTeach model include early field experience led by master teachers, research-based coursework, compact degree plans for students leading to a major and teaching certificate at the same time, and collaboration among faculty specializing in content and pedagogy.
- **TEACH** grants from the U.S. Department of Education provide up to $4,000 per year for college to students who agree to teach in high-need fields in high-need elementary, middle, and high schools.
- **ACS-Hach Land-Grant Scholarships** give undergraduates pursuing careers as high school chemistry teachers $10,000 a year for full-time study at 72 partner institutions. Chemists who have already completed their undergraduate degree are eligible to apply for the post-baccalaureate and second-career teacher scholarships, which provide $6,000 per year for full-time study and $3,000 per year for part-time study.
- **ACS-Hach grants** to high school chemistry teachers already in the classroom offer up to $1,500 to support professional development, resources, activities, and laboratory equipment that enhance chemistry instruction.
- **QuarkNet** connects high school teachers and students with national labs. Activities are intense in the first year, with a one-week boot camp and seven-week research appointment, but the goal is to establish long-term relationships.

Retaining In-Service Teachers of Color

School districts should aim to have a racially and ethnically diverse teacher workforce to reflect the population of the students. As previously stated, this benefits the academic potential of students, who then have an opportunity to learn from role models who look like them. School districts must give as much attention, if not more attention, to retaining teachers of color as they do to recruiting teachers of color, if diversity in the teaching profession is to be sustained.

Challenges and Constraints

- Berry and Shields (2017) noted that the United States loses about twice as many teachers per year as top-performing countries. These losses can be attributed to teachers feeling undervalued and teachers experiencing a decreased amount of professional autonomy.
- Smith and Ingersoll (2004) noted that school staffing problems are essentially the result of too many teachers leaving their teaching jobs long before retirement, a phenomenon they refer to as a "revolving door."
- Concerning minority teacher recruitment, Ingersoll and May (2011) pointed out that although minorities entered teaching at higher rates than Whites during a two-decade period, minority teachers also left schools at higher rates and were more likely to migrate from one school to another or to leave teaching altogether. Organizational conditions in schools may have been a factor related to minority teacher departures.
- Compared to White teachers, teachers of color are two to three times more likely to be concentrated in hard-to-staff schools serving high-poverty, high-minority urban communities with the most challenging working conditions (Ingersoll et al., 2018).

Strategies and Recommendations

- Districts can offer comprehensive induction services to support beginning STEM teachers of color in their first years of teaching. Induction services often include being matched with a veteran STEM mentor teacher. They can also consist of seminars, classroom assistance, time to collaborate with other STEM teachers, coaching and feedback from experienced STEM teachers, and reduced workloads. Such a program could be further enhanced by local businesses and industries monetarily supporting initiatives to assist STEM educators.
- STEM educators can receive school and district-wide recognition through programs such as a STEM Teacher of the Year Award, Rising STEM Teacher Award, and/or Novice STEM Teacher of the Year Award.
- District and site-based administrators can provide differentiated support for teachers of color, including (but not limited to) addressing cultural awareness and eliminating implicit bias and its residual effects. The latter effort calls for administrators to balance the demands of individuals of color, build cultural awareness among the school and district community, and appreciate teachers of color for their cultural contributions.
- Researchers, states, districts, and site-based administrators, individually and/or collectively, should collect data. They can use surveys, focus groups, and other means to gather data on schools where teachers of color teach. These data could help identify the factors that contribute to retaining and/or losing teachers of color.

Exemplary Cases

Tennessee. Springer et al. (2016) reported findings from a quasi-experimental evaluation of a retention bonus program for effective teachers in Tennessee's Priority Schools. Priority Schools are those with low graduation rates or academic performance levels in the bottom 5 percent in Tennessee. Springer et al. (2016, p. 18) found, "Retention bonuses tied to estimates of teacher effectiveness could serve as a tool for policymakers to improve the quality of the teachers instructing disadvantaged students without

implementing layoffs or other punitive measures. . . . Bonuses that retain the teachers at the higher end of the effectiveness distribution can have substantial impacts on the quality of a school's faculty. Retention bonuses mitigate unwanted turnover and have the potential to strengthen leadership and institutional knowledge among the schools' faculty while avoiding financial burdens associated with turnover."

Also in Tennessee, Collins and Schaaf (2020, p. 11) hypothesized that "recruitment of teachers of color into schools with more favorable working conditions and lower turnover might also increase the number of teachers of color working in the state, provide a broader range of students with access to teachers of color, and bring parity to retention rates between teachers of color and their White peers."

Teach Plus/The Education Trust. Dixon et al. (2019) conducted research to examine the problems teachers of color tackle. The study included focus groups with several teachers of color across five states, along with a case study approach that included district offices, traditional public schools, and charter schools in several East Coast and Midwest locations. From the focus groups with the teachers of color, five challenges emerged, along with some solutions and recommendations. They are detailed in Table 5.1.

Table 5.1. Summary of challenges, solutions and recommendations (Dixon et al., 2019)

Focus Group with Teachers of Color (Challenges)	Case Study with Schools and Districts (Solutions)	School, District, and State Leaders (Recommendations)
They experience an antagonistic work culture that leaves them feeling unwelcome and/or invisible.	Schools should be places that culturally affirm teachers of color.	Value teachers of color by providing loan forgiveness, service scholarships, loan repayment incentives, and relocation incentives for teachers coming into the field.
They feel undervalued because they take on more of their fair share of responsibility but are not recognized or compensated for the work they do.	Schools should be places that affirm a teacher's humanity and racial identity, allowing teachers of color to feel free to be their authentic selves.	Collect and disaggregate data on teacher recruitment, hiring, and retention.
They feel they are deprived of agency and autonomy in their schools because of an inability to tailor their teaching to the population of students they serve.	Principals should create schools where they empower and invest in teachers, such as by providing pathways to leadership, informal and formal opportunities for mentorship, and the freedom to tailor teaching to the population of students in the classroom.	Invest in the recruitment, preparation, and development of strong, diverse leaders committed to positive working conditions for a diverse workforce.
They feel they are navigating unfavorable working conditions, and lack the support needed for them to grow as professionals.	School leaders should place a premium on building a schoolwide family where it's easy to build relationships, find a mentor, and hold one another accountable.	Empower teachers of color by ensuring that curriculum, learning environments, and work environments are inclusive and respectful of all racial and ethnic groups.
They bear the high cost of being a teacher of color, which takes a toll on them financially and psychologically.	District leaders need to make retaining teachers of color a priority by emphasizing methods of compensation for the extra work these teachers take on, and prioritizing hiring and placement of teachers of color to build cohorts and reduce isolation.	

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Chapter 6

Shared Vision and Innovative Partnerships

If we would like to maintain global leadership and competitiveness in science and technology as a nation, we must grow a strong and talented STEM workforce. Diversifying the K–12 STEM teaching workforce should be our priority. We must increase the involvement of absent and underrepresented minorities, including eliminating gender and racial bias in STEM education, to reach the goal of educating and producing a highly qualified STEM educator workforce for our community, statewide, and globally.

Shared Vision to Diversify the K–12 STEM Teaching Workforce

Participants who attended the Smithsonian Science Education Center's STEM Education Summit Alumni Workshop worked together on developing the shared vision of building networks and enhancing diversity in the K–12 STEM teaching workforce. Their vision is to influence sustainable, culturally responsive policies and systems at local and state levels that focus on creating new opportunities for all students in STEM, create a member-driven network to collaborate in achieving goals, and lead the advancement of STEM education with the aim of creating STEM global innovation and leadership by strengthening the increasingly underrepresented K-12 STEM teaching workforce.

Overall, there was a consensus among the workshop participants that diverse educators and leaders are crucial so that students from all backgrounds can envision themselves working in STEM and becoming educators. There was also agreement on the need to create engaging and inclusive learning environments to inspire students to pursue STEM education as a career. More diverse educators must be attracted to the profession via measures such as increasing the visibility and reputation of STEM education, lowering the barrier to entry into the career, and providing students and teachers with educator role models from similarly diverse backgrounds. Existing teachers from ethnically and racially diverse backgrounds must be retained by providing them with better support and resources, such as improved STEM training and financial incentives.

The group also came to consensus on the importance of collaborating with stakeholders across the education landscape to increase the diversity of the incoming K-12 STEM teaching workforce by supporting Minority Serving Institutions (MSIs), identifying barriers to diversity, and working together on sustainable solutions.

Our shared visions to diversify the K–12 STEM teaching workforce are to:

- **Increase representation among K–12 teachers of color.** More educators are needed from underrepresented racial minorities to diversify the STEM education workforce. Additionally, current educators from diverse populations require more and better training in STEM subjects so they can better educate their students.
- **Include K-12 STEM educators of all backgrounds.** This includes characteristics such as gender, sexuality, religion, culture, language, and socioeconomic status, among others. Racial and ethnic diversity are also part of the larger whole of diversity in the education field. Educators from diverse backgrounds contribute their different experiences and perspectives to the profession, creating more inclusive learning opportunities for their students.
- **Support K-12 STEM educators to reflect the communities they serve.** This means diverse student populations should be taught by a teacher population that has similar levels of diversity. Teachers should come from many different backgrounds and be diverse in many different ways to best represent the students they teach. In locations where the student population is not diverse, their educators should still embody the diversity of the larger community.
- **Increase awareness of the K-12 STEM teaching profession among students.** Students should have chances to see themselves in a future role as a K-12 STEM teacher, such as including STEM education as

an option during career exploration events. Students who become teachers should also be able to come back to their communities to work in their chosen profession.

- **Support minorities and increase equity in the K-12 STEM profession.** This means taking action to lower barriers to entry and promoting inclusion by eliminating practices such as "weed out" courses and reducing the financial burden of becoming an educator. Collaboration with MSIs is also key to providing minority populations equal opportunities to enter the field.
- **Provide current K-12 STEM teachers with more funding and resources.** This includes educator grants and ensuring funds for STEM educators to teach in specific classrooms for a designated time period.
- **Provide K-12 STEM educators with more support and training.** Methods such as giving existing diverse educators stronger training in STEM subjects and creating teacher incentive programs run by people who reflect the diversity desired in the teaching workforce would be beneficial. Improving community knowledge of the profession and the reputation of STEM education as a rewarding career path, and supporting teacher wellness can also help bolster diversity.
- **Collaborate with all education stakeholders.** This includes public and private schools, businesses volunteering financial support, and educators. It is valuable to have people on board throughout the system, and each of their specific focuses contributes to the larger aim of enhancing diversity. It is also important to have designated people examining systemic barriers to diversity and working together to resolve them.

Below are some of the proposed approaches to diversifying the K–12 STEM teaching workforce to achieve these visions.

- Create and implement a logic model for attracting and retaining a diverse K-12 STEM teaching workforce.
- Empower K-12 STEM teacher leaders to be change agents in their schools and districts.
- Foster a community of professionals committed to improving K-12 STEM education for all students.
- Provide learner-centered experiences that prioritize K-12 STEM teaching and increase engagement with STEM professions.
- Develop, promote, and advocate for targeted solutions, including funding for people with STEM careers to teach in K-12 STEM classrooms.
- Increase community awareness (for future educators) and increase funding and resources for current K-12 STEM educators and STEM professionals.

The Important Role of Partnerships in Complex Activity Systems

What do teacher preparation programs that are effective at recruiting, preparing, mentoring, and retaining teachers of color have in common? Partnerships! Collaborative partnerships are an emerging trend in the diversification of the STEM teacher workforce. The IHE survey of 100 MSIs (discussed in Chapter 2) reported that they partner not only with K–12 schools, but also with other higher education institutions, nonprofit agencies, advocacy organizations, and intergovernmental organizations. From grow-your-own programs to future teacher academies, to grant-funded and alternative programs, to online programs, they all collaborate to some degree with partners.

Institutions of higher education, along with their K–12 school partners, have found value in developing mutually beneficial partnerships that advance their goals. At every stage of the teacher diversity pipeline partners can enhance the flow and interest of qualified candidates (Torres et al., 2004). Barriers to increasing STEM teacher diversity can create gaps that can clog the pipeline, creating shortages and chokeholds further down the line (Schmitz et al., 2012). Partnerships, with actionable strategies in complex systems, can have positive influences on teacher diversity.

Actionable strategies might include partnerships with institutions of higher education that offer professional development activities aimed at helping retain teachers through growth and development, which can expand into certifications in STEM fields. Another actionable strategy might be schools developing future teacher academies by partnering with other schools, local community groups, or intergovernmental agencies.

Efforts to diversify the STEM teacher pipeline require coordinated efforts that are enhanced when partnerships are used in a strategic manner.

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Closing

This sourcebook outlines the collective learning from the Alumni Workshop that brought together participants of the Smithsonian Science Education Center's STEM Education Summits from the past five years. We hope the information within these pages can serve as a reference for schools, districts, and states that seek to recruit and retain a K–12 STEM teacher workforce that better represents the student population.

This Alumni Workshop and Sourcebook would not have been possible without funding from the NSF INCLUDES and DRK–12 programs. We are extraordinarily grateful for the dedication of educators at the state, district, and school levels who have been part of this effort. We recognize that they work tirelessly to ensure the best possible education for their students.

Individuals who would like to learn more about this work and other work from the Smithsonian Science Education Center can visit our website at *https://ScienceEducation.si.edu*.

Appendices

Appendix 1. Logic Model Template

Problem Statement:

Goal:

Inputs:	Tasks/Owners:	Outputs:	Outcome:

Program Evaluation:

Appendix 2. Logic Model Example

Problem Statement: We have difficulty attarcting a large diverse qualified pool of teaching candidates for STEM positions. In the past five years this pool of candidates has decreased, making our efforts to attract candidates to create a diverse STEM teaching staff much more challenging. This has resulted in a teaching staff which has left some groups underrespresented. STEM positions are defined as any all 5-12 Science, K-12 computer/related arts, and 5-12 Math positions.

Goal: By September of 2022, we will show a 30% growth in our qualified candidate pool and 20% more qualified candidates from groups that are traditionally underreperesented as measured over time against our baseline of the 2018-2019 school year.

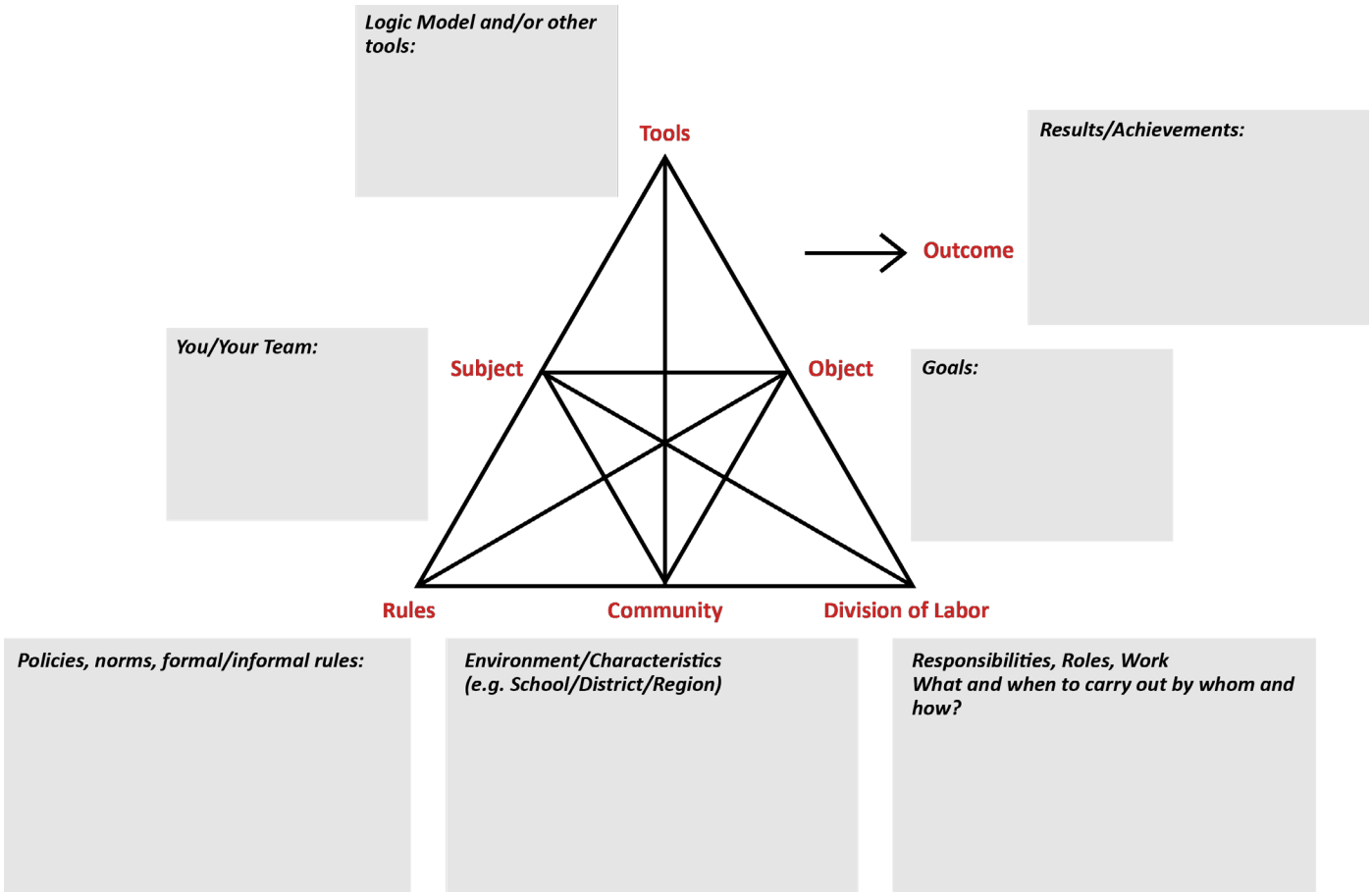
Inputs:	Tasks/Owners:	Outputs:	Outcome:
People/Resources/Programs • New partnership with XXX. • Director of Special Projects (TBD) • Strong STEM program in existence with many awards recognitions • New hiring practices that may support additional changes • Social Media/PR position for the district that could be leveraged • Administrative Team • Community Connections through existing Committees and Organizations • Teacher Leaders • District Strategic Plan **Data** • Population Breakdown data showing the last 7 years • Baseline application data from last 3 years (emphasis of 2018-2019) • Evaluate starting and median salaries for dashboard school, local, and whole state	**Market and Celebrate ABC Public Schools** • Create a Linkedin/Twitter Organization Page for ABC School District • Meeting with the Social Media Coordinator: develop KPI's, strategy, positive engagement **Develop Pipeline and Connections with Qualified Candidates** • Continue active collaborations • Conduct a "Sub Cert. and Praxis" information session with seniors in the spring • Connect with three different colleges in Math, Science, Engineering and discuss the what's involved in becoming a feeder program **Develop/Promote culture of diversity and inclusiveness and then improve hiring process to reflect values** • Develop administrator and staff capacity for inclusive practices to promote a positive and safe school culture • Application, screening, and interview process/questions » Review process/items with administrative team » Identify solutions to roadblocks » Implementation of solutions	• Increase network growth over 18-month period, # of postings, # of repostings • Social media reports with recommendations to measure all engagement around social media related to district diversity and hiring. • Add at least 3 interview questions related to understanding the culture needs and cultural climate of the district; how can the individual contribute to this • Connect with XX other organizations (including XXX) focused on increasing diversity in the teaching programs • # of board approved substitutes • # of student teaching assignment	**Short Term: Primary** • # of applications per job posting for STEM-related positions • # of applications for STEM-related position from candidates of traditionally underrepresented group in our district (African-American, Latinx, Asian, Native American) **This will be tracked quarterly to align with the reporting periods** **Short Term: Secondary** • # of candidates were screened, interviewed, demoed, recommended, hired **Long Term** • Increase the percent of underrepresented groups in STEM teaching positions at ABC School District to mirror current population breakdown

Program Evaluation:

- # of applications per job posting for STEM-related positions
- # of applications for STEM-related position from candidates of traditionally underrepresented group in our district (African-American, Latinx, Asian, Native American)
- Increase the percent of underrepresented groups in STEM teaching positions at ABC to mirror current population breakdown
- Secondary Data: # of candidates that were screened, interviewed, demoed, recommended, hired and their breakdown by representation group

Appendix 3. CHAT Template

1. Identify the elements of your activity system.



2. What are potential tensions you may experience in implementing a logic model in the system?

Building Networks and Enhancing Diversity in the K–12 STEM Teaching Workforce

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