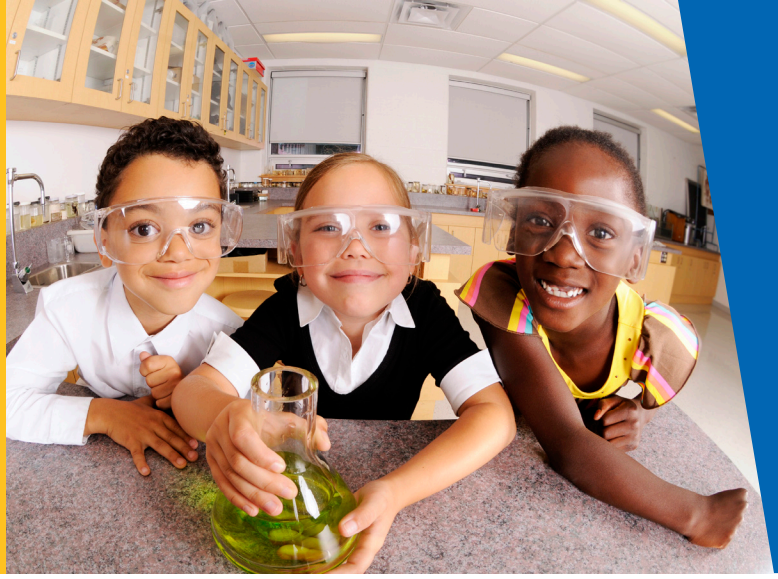

Foundation for the Future

Strengthening STEM Education in the Early Years

A Plan for Increasing the Number of Skilled PreK-6 STEM Educators in the Greater Boston Region

A Strategic Report Prepared by:

The Wheelock College Aspire Institute

May 5, 2010

Commissioned by:

The Massachusetts Technology Collaborative
John Adams Innovation Institute

About the Wheelock College Aspire Institute

Founded in 2007, the Aspire Institute has the mission to **advance knowledge and innovative solutions in response to social and education challenges**. Specifically, the Aspire Institute mobilizes the expertise of Wheelock College and community partners to promote effective social and education policy, practice and research in Massachusetts and across the country.

Aspire Institute's Director, **Jake Murray**, served as the principal author of the ***Foundation for the Future*** report. Aspire project consultant, **Isa Kaftal Zimmerman**, Ed. D., led the Higher Education Planning Project, overseeing recruitment and communication with participants, data collection and analysis and development of an initial strategic framework.

About the John Adams Innovation Institute / Massachusetts Technology Collaborative

The John Adams Innovation Institute is a division of the Massachusetts Technology Collaborative. The Innovation Institute is the Commonwealth's leading science, technology, and innovation policy agent which fosters the vitality and capacity for self-renewal of the Massachusetts Innovation Economy.

Working closely with academics, industry practitioners and government officials, region by region and sector by sector, the Innovation Institute's mission is to enhance the capacity of the Massachusetts economy to sustain an ongoing flow of innovation which is crucial to create, attract, and grow companies in emerging and established industries.

Acknowledgements

This strategic report is the result of contributions from numerous key collaborators. We begin by appreciating and acknowledging the participants in the **Higher Education STEM Planning Project**, who collectively identified the important issues and ideas reflected in this report. We thank and recognize Wheelock College Director of Government Relations and Civic Engagement, **Marta Rosa** and Wheelock Assistant Professor of Science, **Peter Holden** for calling attention to the need for this planning work**,** and Wheelock Instructors in Science**, Karen Worth** and **Jeff Winokur,** and Wheelock Assistant Professor of Science, **Ellen Faszewski** for serving as key advisors to this project. We also thank Wheelock College Vice President of Academic Affairs, **Julie Wollman**, for serving as an invaluable reviewer of this report; Aspire Graduate Assistant **Kathleen Ricci** for her research and administrative support; Director of Continuing Education, **Matt Pellish**, for the graphic design of the title page; and **Bart Wendell** for assisting with meeting facilitation.

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Letter from Wheelock College's President

Dear Friends,

We find ourselves at an exciting moment in education reform in this country. Massachusetts and several other states are seeking new ways to revitalize struggling schools, improve the quality of teaching, and strengthen teacher education. Cutting across all these efforts is the importance of Science, Technology, Engineering and Mathematics (STEM) education. In both the present and future, mastery of STEM knowledge and skills are essential for students to both succeed in the workplace and become informed, engaged citizens.

It is therefore my pleasure to present the report, ***Foundation for the Future: Strengthening STEM Education in the Early Years***. As its title suggests, this report offers an important new education agenda for the Boston region, outlining several high-impact strategies for strengthening the preparation of PreK-6 teachers in STEM education and, ultimately, ensuring that children receive a strong foundation in STEM areas. This foundation is critical to later school and college success.

A central strategy proposed in this report is for area teacher education programs, state agencies, school districts, early childhood education providers, out-of-school-time providers and business and community partners to collaborate closely through a Greater Boston STEM Education Consortium. On behalf of Wheelock College, I offer our full commitment to collaborate—or, in several cases, to continue to collaborate—with these key partners to form a consortium with the goal of greatly improving the STEM content knowledge and instructional skills of PreK-6 educators.

This report is the result of several months of planning facilitated by the Wheelock Aspire Institute and draws from the knowledge and perspective of advisors from over 12 higher education institutions and community organizations. I offer my thanks to those who participated in this project.

In closing, I encourage you to read this report and discuss it with us. I look forward to the conversation and the work ahead.

Best,

Jackie Jenkins-Scott
President

EXECUTIVE SUMMARY

The advances in science and technology over the past quarter century have been astounding, revolutionizing the way we live, learn and work. And while we pause to catch our breath, the pace of change over the next quarter century promises to be even more extraordinary.

Within this new and rapidly evolving landscape, STEM (science, technology, engineering and math) content knowledge and skills have become preeminent. No other set of content areas and skills is more vital to our near and long-term success. Both the nation's and the state's economic well-being depends on the development of a highly skilled STEM workforce. Moreover, it will be STEM professionals who drive key innovations in healthcare and medicine, environmental science, education and other fields that, among other benefits, will stimulate new economic growth, counter negative effects of climate change and pollution, and improve our overall quality of life. Further, a strong foundation in STEM knowledge and skills is critical for ensuring an educated citizenry—one equipped to gather and process information, assess the opportunities and risks that advances in science and technology present, and make informed, responsible decisions about policies and initiatives that will impact us personally and as a community.

For these reasons, there is an urgent need for wholesale improvement in STEM education. In recent years, most STEM education improvement efforts have focused on the middle school, secondary and post-secondary levels. There is now growing consensus among educators that quality STEM education must begin earlier, in grades PreK-6, both to ensure foundation knowledge and skills and to foster long-term interest and higher level study in these subject areas. However, to increase the quality of STEM teaching and learning in the early grades means confronting a significant human resource challenge: **many PreK-6 educators are not well prepared for this task, lacking both strong math and science content knowledge and instructional skills**.

In the spring of 2009, with funding from the Massachusetts Technology Collaborative John Adams Innovation Institute, the Wheelock College Aspire Institute convened the Higher Education STEM Planning Project ("Project"). Enlisting representatives from area teacher education programs and community STEM partners, this Project's purpose was to **identify strategies for improving the STEM training of PreK-6 pre-service and in-service educators.** Following several months of data collection and analysis, the Aspire Institute developed the ***Foundation for the Future*** report, which outlines a strategic goal, desired outcomes, recommendations, and action steps for improving the number of skilled PreK-6 STEM educators in the Greater Boston region.

While the geographic focus of this report is the Greater-Boston area, we hope it serves as resource to similar efforts across the state.

STRATEGIC GOAL & DESIRED OUTCOMES

We propose collaborative action among teacher education programs (both higher education programs and alternative teacher education programs), school districts, early childhood education providers and community STEM partners to pursue one strategic goal:

To significantly increase the number of PreK-6 educators in the Greater Boston region who are skilled STEM teachers

We propose that success in meeting this strategic goal be measured by progress in reaching the following **desired outcomes**:

- Increase in the number of regional high performing math and science undergraduates electing to major in PreK-6 teacher education programs or enroll in Masters-level PreK-6 teacher education programs
- Increase in the number of regional pre-service PreK-6 educators who meet or exceed as a baseline requirement of two math content courses, two science content courses and two pedagogy courses (one in math and one in science) prior to completion of their teacher education program. (The "2-2-2" baseline).
- Increase in passing rate of regional PreK-6 teachers on the elementary mathematics MTEL test
- Increase in the number of regional in-service educators completing advanced professional math or science education courses (e.g. a four course, 12 credit math or science education "cluster")
- Increase the number of community-based early childhood education and out-of-school-time providers who receive preparation in STEM education

RECOMMENDATIONS

To achieve the strategic goal and desired outcomes, we propose the following core recommendations:

1. **Establish a Greater Boston STEM Educator Consortium to collaboratively pursue goals, practices and funding for preparing skilled PreK-6 STEM educators**

   Key strategies include developing a "Consortium Compact" that outlines common goals, commitments and benefits; engaging Higher Education STEM Planning Project participants and other strategic higher education, community and business partners, such a state agencies, museums, science centers and STEM firms; and aligning with existing collaborative structures (e.g. the state Readiness Centers).

2. **Elevate the focus on STEM education in PreK-6 teacher education programs**

   Key strategies include launching a focused PreK-6 STEM teacher recruitment campaign; assessing the math and science knowledge and skills of incoming pre-service educators to detect content area strengths and needs; upgrading the quality and relevance of math and science content and pedagogy coursework; facilitating course access and exchange across teacher education programs, and school and community partners; and establishing new baseline math and science content and pedagogy course requirements.

3. **Provide high quality in-service training to prepare 'skilled' PreK-6 STEM educators**

   Key strategies include developing new advanced professional math and science course "clusters"; facilitating access to and exchange of these advanced course across teacher education programs, and school and community partners; developing online or "hybrid" versions of these courses; recruiting a STEM teacher mentor corps comprised of experienced, retired educators and STEM professionals; and developing STEM professional development partnerships with school districts.

4. **Collaborate with state agencies, school districts and early childhood education providers to strengthen STEM education requirements for PreK-6 educators and to elevate the focus on math *and science* instruction in PreK-6 education settings**

   Key strategies include partnering with the Department of Elementary and Secondary

Education (DESE) to: (1) develop and endorse advanced professional PreK-6 math and science courses, (2) pilot an elementary math specialist and elementary science specialist certification program, and (3) review future math and science education and competency requirements for educator licensure for all MA elementary teachers. Other key strategies include partnering with the Department of Early Education and Care (DEEC) to adopt STEM education standards for early childhood education (ECE) programs, directors and teachers and collaborating with school districts and ECE providers to increase the instructional time and resources devoted to PreK-6 *science* education.

5. **Strengthen STEM education training for community-based early childhood education providers and out-of-school-time providers**

   Key strategies include developing STEM professional development institutes tailored to non-traditional adult learners; offering college-level math and science courses to ECE and OST providers; and recruiting STEM professional to teach and mentor staff in ECE and OST settings.

ACTION STEPS

To be successful, the proposed Consortium must have executive, financial, and program-level support. We suggest the following steps to ensure these levels of support:

1. **Engage top leaders**

   Specific steps include convening higher education, political, business, science center, museum and community leaders to review the *Foundation for the Future* report, establish formal Consortium agreements and appoint a Consortium steering committee, with diverse representation from across the region.

2. **Collaboratively pursue funding**

   Specific steps include developing collaborative proposals and pursuing public and private funding opportunities to support implementation of this report's recommendations and key strategies as well as to develop and support a Consortium management and assessment structure.

3. **Begin program-level coordination**

   Specific steps include establishing Consortium faculty and program staff planning teams to further develop, implement and manage this report's key recommendations and strategies.

Foundation for the Future: *Strategic Report At-A-Glance*

Strategic Goal: **To significantly increase the number of PreK-6 educators in the Greater Boston region who are skilled STEM teachers**

Recommendations	Key Strategies
Establish a Greater Boston STEM Educator Consortium	• Develop "Consortium Compact" outlining common goals, commitments & benefits • Engage strategic higher education, state, school & community partners • Align with existing regional higher education, K-12 & early childhood education collaborative structures.
Elevate the focus on STEM education in PreK-6 teacher education programs	• Launch a focused STEM educator recruitment campaign • Assess 'math & science readiness' of incoming pre-service educators & provide foundation skills training • Upgrade STEM content and pedagogy courses & offer access across Consortium partners • Establish baseline math & science course requirements
Provide high quality in-service education to prepare 'skilled' PreK-6 STEM educators	• Develop advanced STEM professional courses & offer these across Consortium partners • Develop online or "hybrid" versions of these advanced STEM courses • Establish STEM-focused professional development partnerships with districts • Recruit & support a high quality STEM teacher mentor corps
Collaborate with state agencies, districts and ECE providers to strengthen PreK-6 STEM education requirements	• Collaborate with DESE to approve advanced PreK-6 math & science courses & pilot certification for elementary math specialist & science specialists • Collaborate with the DEEC to include STEM education standards for ECE programs, directors & teachers • Collaborate with school district and ECE providers to increase the instructional time & resources devoted to Prek-6 science education
Strengthen STEM training for community-based ECE providers and OST providers	• Offer STEM professional development institutes to non-traditional adult learners in the ECE & OST fields • Provide access to advanced STEM training available to ECE & OST providers • Recruit STEM professional to mentor and teach in ECE & OST settings

Desired Outcomes

- Increase in the number of regional high performing math and science undergraduates who major in PreK-6 teacher education or enroll in Masters teacher education programs
- Increase in the number of regional pre-service PreK-6 educators who meet or exceed a *baseline* requirement of two math content courses, two science content courses and two pedagogy courses (one in math and one in science)
- Increase in passing rate of regional PreK-6 teachers on the elementary mathematics MTEL test
- Increase in the number of regional in-service educators completing advanced professional math or science education courses
- Increase in the number of community-based early childhood education and out-of-school-time providers who receive training in STEM education.

BACKGROUND

The advances in science and technology over the past quarter century have been astounding, revolutionizing the way we live, learn and work. And while we pause to catch our breath, the pace of change over the next quarter century promises to be even more extraordinary.

Within this new and rapidly evolving landscape, STEM (science, technology, engineering and math) content knowledge and skills have become preeminent. No other set of content areas and skills is more vital to our near and long-term success. Both the nation's and the state's economic well-being depends on the development of a highly skilled STEM workforce. In Massachusetts alone, of approximately 92,000 job vacancies in 2008, one-third were in STEM careers.[1] Despite the economic downturn, many Massachusetts companies still cannot find people with the necessary STEM skills to fill these job openings. Moreover, it will be STEM professionals who drive key innovations in healthcare and medicine, environmental science, education and other fields that, among other benefits, will stimulate new economic growth, counter negative effects of climate change and pollution, and improve our overall quality of life.

A strong foundation in STEM knowledge and skills is also critical for ensuring an educated citizenry. To address current and emerging community and political challenges, we all benefit from a population that is equipped to gather and process information, assess the opportunities and risks that advances in science and technology present, and make informed, responsible decisions about policies and initiatives that will impact us personally and as a community.

It is preschools, schools and after school and summer programs—and most directly the teachers in these settings—that will have the greatest impact on whether we can participate and excel in the STEM-driven world of today and tomorrow.

For these reasons, there is an urgent need for wholesale improvement in STEM education. It is preschools, schools and after school and summer programs —and most directly the teachers in these settings—that will have the greatest impact on whether we can participate and excel in the STEM-driven world of today and tomorrow.

The STEM Education Gap—*It Starts Early*

Within the past year, national and local calls to strengthen STEM education have intensified. President Obama recently announced a $250 million initiative to train math and science teachers. The federal Race to the Top funding includes STEM as the only "content" area referred to as a "competitive preference priority." In Massachusetts, Governor Patrick recently created the STEM Advisory Council to advise on STEM education issues.

This mounting concern is warranted. US students consistently trail behind their peers in countries, such as China, Japan, Singapore, South Korea, Russia, England and the Netherlands in math and science academic performance.[2] And while Massachusetts as a whole performed well above the national average in math and science on the most recent National Assessment of Educational Progress

[1] **See** Department of Elementary and Secondary Education (DESE) Education Research Brief: *Supply and Demand of STEM Workers*. http://search.doe.mass.edu/search.aspx?q=STEM+brief

[2] **See** US Department of Education, Institute of Education Sciences, National Center for Education Statistics, Trends in International Math and Science Study (TIMSS) 2007 Math and Science Assessments.

(NAEP), it is among the states with largest achievement gap between different racial/ethnic and income-level student subgroups in these same areas.[3] Further, nearly 30% of Massachusetts high school graduates enrolling in state public colleges or universities as full-time, degree-seeking candidate were required to take at least one remedial mathematics course.[4]

Thus, the imperative to improve STEM education is clear. However, while there have been several STEM education improvement initiatives in recent years, most of these efforts have focused on the middle school, secondary and post-secondary levels. There is growing consensus among educators that quality STEM education must begin earlier, in grades PreK-6, both to ensure foundation knowledge and skills and to foster long-term interest and higher-level study in these subject areas in the later grades.[5]

To increase the quality of STEM teaching and learning in the early grades means confronting a significant human resources challenge: many PreK-6 teachers are not well prepared for this task, lacking both strong math and science content knowledge and instructional skill.

At the same time, educators argue that quality early STEM instruction can boost overall learning, by tapping into children's natural curiosity and interest in experimentation and engineering. Activating these learning impulses through integrated curricula and guided play can support children's cognitive and social skill development as well as foster their interest in multiple academic subjects.[6]

However, to increase the quality of STEM teaching and learning in the early grades means confronting a significant human resource challenge: **many PreK-6 teachers are not well prepared for this task, lacking both strong math and science content knowledge and instructional skill**.[7] The state received a stark indicator of this deficit last May (2009), when nearly three-quarters of prospective elementary school teachers completing the state's licensing exam (MTEL) failed the math test.[8]

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[3] **See** US Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP) 2009 Math and Science Assessments; & DESE Education Research Brief, Ibid.

[4] **See** DESE-DHE (2008) School-to-College Report. http://www.mass.edu/forinstitutions/prek16/documents/SchoolToCollegeReports/2005/2005_Southbridge_High_02770505.html

[5] **See**: The National Science Board: STEM Education Recommendations for the Obama Administration. http://www.nsf.gov/nsb/publications/2009/01_10_stem_rec_obama.pdf; Cross, Woods & Schweingruber, (*Editors*) (2009). Mathematics Learning in Early Childhood. National Research Council. http://www.nap.edu/catalog.php?record_id=12519; Viadero, D. (2010). "Experts Urge Earlier Start to Teaching Science," Education Week 29(18), 13 January. http://tinyurl.com/ylju8y6; Gelman, R., K. Brenneman, G., M.A. Gay Macdonald, & M. Roman. (2009) "Preschool Pathways to Science: Facilitating Scientific Ways of Thinking, Talking, Doing, and Understanding." Brookes. http://www.brookespublishing.com/store/books/gelman-70441/index.htm; Duschl, R.A. H.A. Schweingruber, & A.W. Shouse, eds. (2007) "Taking Science to School: Learning and Teaching Science in Grades K-8," National Academies Press. http://books.nap.edu/catalog.php?record_id=11625

[6] **See**: Carnegie Corporation Institute for Advanced Study. (2009). The Opportunity Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy. http://www.opportunityequation.org; Cross, Woods & Schweingruber. (2009). Ibid; Duschl, et al. (2007) Ibid.

[7] See National Research Council reports: *Taking Science to School,* 2007*; Rising Above the Gathering Storm,* 2007; Rich,D. (1998) "You Can't Teach What You Don't Know," *Education Week*, Sept. 16. http://www.edweek.org/ew/current/02rich.h18

[8] Vaznis, J. (2009) "Aspiring teachers fall short on math." Boston Globe. May 19.

Reversing this trend cannot fall to PreK-6 educators alone. Teacher education programs and current PreK-6 education policymakers bear significant responsibility. On the one hand, teacher education programs must re-examine how they prepare educators in STEM subjects, seeking new ways to introduce content and model effective, innovative teaching methods to students, many with limited prior knowledge and comfort in these areas.

On the other hand, education policymakers, school systems and early childhood education providers must place greater emphasis on STEM education in the earlier grades, especially science education. Currently, the majority of instructional time in elementary schools is devoted to literacy and math, often in the form of block scheduling or prescribed curriculum. Thus, science—as well as engineering and technology (or design technology)—is frequently pushed to the margins, taught once a week or for one semester. Preschool programs also do not provide significant instruction in STEM subjects, tending mostly to focus on early literacy development.

The importance of elevating science in PreK-6 settings cannot be understated. Up until this point, we have grouped math and science together in this background discussion on STEM education. Yet in the state education policy arena, these two content areas are, in fact, not equal. With the implementation of the math MCAS test and the elementary math MTEL test over the past decade and a half, school districts, ECE providers and PreK-6 teacher education programs have focused heavily on math instruction and comparatively little on science instruction—and even less on technology and engineering instruction. Thus, while this report

and several other recent, well-received reports (see Appendix II) outline promising strategies for preparing Prek-6 educators in science education, even the best efforts will have limited utility for teachers or impact on students unless they are accompanied by a

The importance of elevating science in PreK-6 settings cannot be understated. Up until this point, we have grouped math and science together in this background discussion on STEM education. Yet in the state education policy arena, these two content areas are, in fact, not equal.

clear mandates from state and local education leaders to increase the level of science instruction in the early grades. In other words, while teacher education programs can upgrade to more effectively prepare Prek-6 teachers in science education, once in classrooms these teachers will continue to have little instructional time and few resources to teach science well.

It is essential, then, for state agencies, school districts and ECE providers to revise current policies and practices, with a goal of ensuring that PreK-6 students receive adequate, high quality science instruction. And while science education should be the initial focus, these Prek-6 settings should next move to strengthen or introduce technology and engineering education. Without such steps, we will continue to 'short-change' our students as well as perpetuate the STEM education gap between different student sub-groups.

Finally, PreK-6 STEM education – and who is a "PreK-6 STEM educator"—must be viewed with a community-wide lens. Children learn within the context of whole communities—from the sum of their experiences before, in and outside of school. In fact, the more educational experiences children encounter prior to entering school and—once in school—in the larger community, the better it is for their overall intellectual growth. Research strongly suggests that children's learning is greatly facilitated when they have access to opportunities to explore academic content and practice academic skills in a variety of ways, with caring adults and across multiple

community settings.[9] In particular, numerous studies have demonstrated that quality early childhood education (ECE) and out-of school time (OST) programs (after school and summer programs) can both increase children's motivation to learn and improve academic performance in school.[10]

Perhaps the biggest argument for focusing on STEM education in ECE programs and OST programs is time. Young children spend the majority of their waking hours outside of formal school settings. In fact, the cumulative hours many young children in grades PreK-6 spend in community-based ECE settings (centers and family childcare settings) and after school and summer programs is equivalent to – and in many cases exceeds—the hours they spend in Prek-6 school settings.[11] Thus, it is essential for PreK-6 STEM education improvement efforts to also include specific strategies for strengthening the STEM content knowledge and instructional skills of community-based ECE and OST providers.

Taking Action: The Higher Education STEM Planning Project

In the spring of 2009, with funding from the Massachusetts Technology Collaborative, the Wheelock College Aspire Institute reached out to several Boston area higher education institutions and community partners to respond to the challenge of improving early STEM education. In all, 12 institutions responded and the Higher Education STEM Planning Project (the "Project") was launched –see appendix for the list of partner representatives. Led by STEM education consultant, member of the MA Governor's STEM Advisory Council, and former school superintendent, Isa Zimmerman, this Project's purpose was to **identify strategies for improving the STEM training of PreK-6 pre-service and in-service educators.** [12]

Because of the location of participating higher education institutions and community partners, the geographic focus of this Project is the Greater-Boston area. However, it is our hope that the ***Foundation for the Future*** report serves as a resource to similar efforts across the state.

[9] **See**: Broh, B.A. (2002). Linking extracurricular programming to academic achievement: Who benefits and why? *Sociology of Education* (Vol. 75, pp. 69-91); Russell & Reisner, 2006. *Supporting Social and Cognitive Growth Among Disadvantaged Middle-Grades Students in TASC After-School Projects. Journal of Youth Development.* Vol. 1 No. 2. http://www.nae4ha.org/directory/jyd/login.aspx

[10] **See:** Bowman, B., Donovan, M.S. &I Burns, M.S. (Eds.) (2000). Eager to Learn, Educating our preschoolers. Washington, DC: National Research Council; DC; Huang, D., Gibbons, B., Kim, K. S., Lee, C., and Baker, E. L. (2000). A Decade of Results: The Impact of the LA's Best After-school Enrichment Program on Subsequent Student Achievement and Performance. Los Angeles, CA: UCLA Center for the Study of Evaluation; Little, P., Wimer, C., & Weiss, H.B. (2008). After school programs in the 21st century: Their potential and what it takes to achieve it. Cambridge, MA: Harvard Family Research Project; Ganger, R.T., & William T. Grant Foundation (2008). After school programs and academics: Implications for policy practice and research. Social Policy Report XXII(2); Reynolds, A., Ou, S., Tapritzes, J. (2004). Paths of effects of early educational intervention on educational attainment and delinquency: a confirmative analysis of the Chicao Parent-child Centers. Chid Development 95 (5) 1288-1328; Shonkoff, J.P., I& Phillips, D.A. (Eds.) (2000). From neurons to neighborhoods. The science of early childhood development. National Research Council and Institute of Medicine; Wood, Y. & Reisner, E. (2009). Citizen Schools' Contribution to Improved Learning in Expanded Learning Time Schools: Research Brief. Washington DC: Policy Studies Associates, Inc

[11] **See** Hofferth, S.L. & Sandberg. (2001). How American children spend their time. *Journal of Marriage and the Family*. 63:295-308; Miller, B.M.(2003). *The Learning Season: The Untapped Power of summer to advance student achievement.* Quincy, MA: Nellie Mae Education Foundation.

[12] The initial focus of the Project was on strengthening ***PreK-3*** pre-service preparation and in-service education. However, several participants suggested an expanded focus on PreK-6 to meet the needs across all elementary grades and to align with state licensure categories.

Data-Collection and Analysis

In recent years, there have been numerous national and local commissions and reports focusing on STEM education. Thus, the goal of the Project was not to duplicate these efforts, but rather to synthesize this work and prioritize among various goals and strategic options to lift up **core, high-yield recommendations that higher education institutions, school districts, ECE providers and other key community partners could collaboratively implement to achieve results**.

To this end, the Lead Consultant engaged Project members in several targeted data collection and analysis activities from April 2009 until December 2009. These activities included the following:

- **Context and literature review** – review of state math and science education standards, early and elementary education teacher education program coursework and relevant publications, web resources and strategic reports (see Appendix)
- **Working meetings** – two face-to-face meetings with participants with follow up "homework assignments" to identify challenges, opportunities and strategies
- **Strategy Poll** – a survey of Project members asking them to rank/prioritize among possible strategies
- **Key informant interviews** – phone interviews with Project members to further prioritize and 'flesh out' selected strategies

The Aspire institute then synthesized the information gathered from these activities into the strategic goal, desired outcomes, recommendations, and actions steps presented in the ***Foundation or the Future*** report.

STRATEGIC GOAL AND DESIRED OUTCOMES

Strategic Goal

We propose collaborative action among teacher education programs (both higher education programs and alternative teacher education programs), school districts, early childhood education providers and community STEM partners to pursue one strategic goal:

To significantly increase the number of PreK-6 educators in the Greater Boston region who are skilled STEM teachers

Desired Outcomes

We propose that success in meeting this strategic goal be measured by progress in reaching the following desired outcomes:

- **Increase in the number of high performing math and science undergraduates electing to major in PreK-6 teacher education programs or enroll in Masters-level PreK-6 teacher education programs**

  "High performing math and science undergraduates"are defined here as one of the following:
  - Undergraduate students who have successfully completed six or more math and science content courses at the undergraduate level
  - Undergraduate students majoring in or who have majored in math and science at the undergraduate level.

  Benchmark
  Participating regional partners will research and establish a year one baseline number for this outcome. Regional partners will then seek to **increase this number by 25% to 50% within three years.**

- **Increase in the number of regional pre-service PreK-6 educators who meet or exceed as a baseline requirement of two math content courses, two science content courses and two pedagogy courses (one in math and one in science) prior to completion of their teacher education program.** (The "2-2-2" baseline).

  Pre-service PreK-6 educators can complete these courses during their undergraduate program or Masters program or across both programs. We suggest this as a baseline or 'bare minimum' requirement. While many teacher education programs currently meet this standard, other programs do not, especially in regards to requiring a full semester science pedagogy course.

  Benchmark
  Participating regional partners will research and establish a year one baseline number for this outcome. Regional partners will then seek to **increase this number by 25% to 50% within three years.**

- **Increase in passing rate of regional PreK-6 teachers on the elementary mathematics MTEL test**

  Currently there is no individual science subject matter MTEL exam requirement for PreK-6 educators. Science is a sub-section of the Early Childhood and General Curriculum MTEL tests for PreK-6 Educators. Thus, we propose an initial focus on performance on the mathematic MTEL test.

  Benchmark
  Participating regional partners will research and establish a year one baseline percentage for this outcome. Regional partners will then seek to **increase this rate by 20 percentage points within three years.**

- **Increase in the number of regional in-service PreK-6 educators completing advanced professional math or science education courses** (e.g. a four course, 12 credit math education or science education "cluster")

  Benchmark
  Participating regional partners will research and establish a year one baseline number for this outcome. Regional partners will then seek to **increase this number by 75% within three years.** This benchmark assumes a minimal number of current PreK-6 educators have taken these advanced math and science education courses.

- **Increase in the number of community-based early childhood education and out-of-school-time providers who receive training in STEM education.**

  Benchmark
  Participating regional partners will research and establish a year one baseline number for this outcome. Regional partners will then seek to **increase this number by 75% within three years.** Again, this benchmark assumes a minimal number of current community based ECE and OST providers have taken these types of courses.

RECOMMENDATIONS

To achieve the identified strategic goal and desired outcomes, we propose the following core recommendations and related key strategies:

Recommendation 1: Establish a Greater Boston STEM Educator Consortium to collaboratively pursue common goals, practices and funding for preparing 'skilled' PreK-6 STEM educators.

Given the shortage of strong STEM educators in the early grades, coordination among several teacher training programs (both higher

education and alternative programs), school districts, ECE and OST providers and business and community partners is necessary to have a large and sustained impact on the quantity and quality of STEM ready Prek-6 educators in the region.

Through a consortium approach, key partners could exchange ideas and resources. For instance, teacher education programs with core strength and coursework in certain STEM areas and grade-levels could partner with other teacher education programs with expertise and quality coursework in other content areas and grade-levels. Both pre-service and in-service educators could choose from a wider range of educational options, not only in terms of subjects but also delivery – e.g. online, accessible times and locations. Further, through a Consortium, partner institutions could collaboratively pursue funding, coordinate teacher quality efforts with state agencies, school districts and ECE providers, advocate for increased instructional time in science, technology and engineering and measure impact on teaching quality and student learning.

Key Strategies

To launch this Consortium model, we propose the following strategies:

- **Draft a "Consortium Compact" outlining common goals, commitments and benefits**

- **Re-engage the institutions participating in the Higher Education STEM Planning Project and reach out to other strategic partners to determine interest and level of commitment and to capture current promising practice.** Other strategic partners include: the Executive Office of Education (EOE), the Department of Elementary and Secondary Education (DESE), the Department of Early Education and Care (DEEC), the Department of Higher Education (DHE), higher education institutions, school districts and education collaboratives, area museums, and science centers/STEM businesses.

- **Align with and enlist the support of existing regional higher education, K-12 education and early childhood education and out-of-school-time collaborative structures.** Among others, these include: the Colleges of the Fenway, the Greater Boston Readiness Center, the DESE District and School Assistance Centers, multi-district education collaboratives, Greater Boston DEEC regions, Thrive-in-Five, Head Start, the Massachusetts Afterschool Partnership, Boston Afterschool and Beyond and Citizen Schools.

Recommendation 2: Elevate the focus on STEM education in PreK-6 teacher education programs

Many PreK-6 pre-service educators enter and graduate from teacher education programs with limited knowledge, comfort and interest in STEM content areas. Traditionally, undergraduate students who excel in math and science continue on to pursue STEM related degree programs, rather than education programs. Those students who do pursue education careers predominantly enroll in secondary teacher education programs.

Thus, PreK-6 teacher education programs must address several key challenges if they are to improve the 'STEM readiness' of their students. First, they must fuel the STEM educator pipeline by attracting more students who enter with strong STEM content knowledge and/or strong academic secondary and undergraduate performance in these areas.

Second, they must reintroduce and reinvigorate STEM content and skills among students who do not come with this knowledge or these aptitudes. This level of support will require focused—and sometimes remedial—content coursework. It may also require enlisting math

and science faculty and STEM professionals to teach education courses or co-teach with education faculty to develop strong conceptual foundations in these areas and in new ways that model good instruction and engage and excite students about STEM subjects.

Third, regardless of their content knowledge, PreK-6 pre-service educators need effective preparation in high quality, appropriate and engaging STEM pedagogy for young children. This preparation should include developing knowledge and skills in evidence-based, developmentally appropriate and innovative teaching methods that excite young learners about STEM, challenge them to grasps key concepts and develop an understanding of the practice of STEM fields. This preparation should also include effective use of math and science assessments and differentiated instruction to support the range of student learning needs and styles they will encounter in classrooms.

Finally, high quality STEM content and pedagogy coursework must be paired with strong STEM-focused clinical training for pre-service teachers. All pre-service PreK-6 teachers should receive supervised classroom experience developing and delivering both math and science lessons prior to completing their student teaching. However, the level of required math-specific and science-specific clinical experience varies considerable across teacher education programs, with some programs requiring no specialized clinical training in these areas. At the same time, many supervising/cooperating Prek-6 teachers are themselves limited in their math and science content knowledge and instructional skill, and thus provide pre-service teachers with inadequate guidance in these areas.

Most, if not all teacher education programs, will be hard-pressed to provide this range of STEM content and pedagogical coursework or to ensure adequate STEM clinical training. In addition, not all programs will have expertise and coursework that spans early childhood education through grade six. The proposed Consortium model will allow teacher education programs to pool and make available a variety of coursework and supports.

Key Strategies

To improve the capacity of PreK-6 teacher education programs to prepare 'STEM-ready' educators we propose Consortium partners pursue the following strategies:

- **Develop a focused campaign and incentives to recruit high performing mathematics and science undergraduate students to major in PreK-6 teacher education or enroll in Masters-level PreK-6 teacher education programs.** Competing for these students will require incentives, such as scholarships, loan forgiveness, and teaching jobs upon completion. The Consortium should pursue state and federal funding currently targeting STEM teacher pipeline development and work closely with school districts and ECE providers in support of these incentives.

- **Develop a math and science pre-assessment process and aligned content-building (or "referesher") training program to identify and provide targeted support to students in need of additional content knowledge.** Pre-service students should be assessed prior to enrollment in education programs to determine their level of math and science content knowledge. Students needing additional preparation in these areas could then complete summer or mid-year content-building institutes offered by various Consortium partners and online. At the same time, students who perform well on an assessment could qualify as 'STEM-ready' students, while those who perform well in some but not all content areas could enroll in courses to address these specific needs. Consortium partners might initially focus on a math pre-assessment (as math screening tools currently exist or are in

development) and build towards a comparable science pre-assessment process.

- **Based on national and state standards, develop Consortium "guiding principles" for high quality undergraduate and graduate STEM content and pedagogy coursework.** In other words, Consortium partners—teacher education faculty and practitioners—should determine what content knowledge and instructional skills are needed for educators to effectively teach STEM subject areas in grades PreK-6. This process should initially focus on math and science and include review of current national standards (e.g. the Common Core Standards Initiative, the Association for Childhood Education International, the National Council of Teachers of Mathematics, the National Science Education and Teaching Standards and the American Association for the Advancement of Science Benchmarks), DESE licensure requirements and curriculum frameworks, (e.g. Quality Rating Improvement System (QRIS)) and other best practices in math and science teacher training (e.g. Mathematical Knowledge for Teaching).

- **Identify existing or develop new STEM content and pedagogy courses offered across Consortium institutions that meet these guiding principles. Then facilitate cross-institution enrollment in and awarding of credit for these courses to pre-service students from Consortium teacher education programs.** Again, the initial focus should be on math and science**.** See profile on the Wheelock College-Clark University elementary science course pilot project currently underway – page 16.

- **Establish a baseline '2-2-2' math and science coursework baseline requirement across Consortium partners for PreK-6 pre-service educators. The 2-2-2 baseline is equivalent to: two math content courses,**

New Science Course for Elementary Teachers

Through the Higher Education STEM Planning Project, faculty from Clark University and Wheelock College have convened a science curriculum group to brainstorm and develop guideline for "consortium" science education courses for MA elementary teaching candidates.

The group is working on trying out materials and ideas based on all of the group's experiences with pre-service science teaching "methods" –e.g. the most powerful set of texts, experiences, assignments, and multi-modal materials (videos, etc.) as a series of modules.

Faculty at both schools will apply these methods, document respective successes or failures, and find common tools to assess student learning.

As a result of this project, the group hopes to achieve the following:

- Development of a syllabus-driven course that others can adopt or adapt and which can be placed on-line, and made available to both pre-service and in-service teachers.

- Development of a course that can be one "requirement" for all Massachusetts elementary teachers, ensuring a baseline of science teaching and learning understanding and experience.

Through a Consortium model, similar cross-institutional course development groups would be formed for math, engineering and technology.

two science content courses and two pedagogy courses (one full semester math pedagogy course and one full semester science pedagogy course). Pre-service educators can complete these courses during their undergraduate program, masters program or across both undergraduate and graduate programs. However, while recommending this policy, **we feel strongly that this number of courses is a 'floor-level' or 'bare minimum' standard that should serve only as a baseline for all teacher education programs.** Many PreK-6 teacher education programs –particularly undergraduate education programs—currently do meet this coursework standard. We would encourage these programs to explore opportunities to expand math and science coursework beyond this level to further strengthen STEM background knowledge and instructional skill. For those programs that fall short of this standard, we urge implementing the 2-2-2 requirement as a starting point.

- **Collaborate with Consortium school districts to establish shared clinical placement goals for elementary teachers that include minimal requirements for supervised math and science lessons.** While all teacher education programs require clinical placements, the extent to which pre-service educators are required to complete supervised classroom lessons in STEM areas is minimal or non-existent, especially in respect to science, technology and engineering. The Consortium should work with partner districts to ensure that both math *and* science lessons are included as part of clinical placements and that supervising teachers meet minimum requirements in terms of their own math and science instructional knowledge and skill.

Recommendation 3: Provide high quality in-service training to prepare *skilled* PreK-6 STEM educators

Similar to pre-service educators, many current PreK-6 educators have limited knowledge, comfort and interest in STEM content areas. Thus, they also would benefit from high quality training in STEM content and pedagogy, similar to that outlined above for pre-service educators. At the same time, many mid-career educators are seeking opportunities to expand their knowledge and skills and assume new leadership roles within their school settings. Completing specialized graduate-level training in STEM education thus would provide these educators with a unique professional growth opportunity.

Yet there are particular challenges to delivering professional development to in-service educators. First, as predominantly full-time working professionals, in-service PreK-6 educators have limited time to complete graduate coursework. Thus, they need courses that are delivered at accessible times and in accessible formats (e.g. field and seminar courses and online).

Second, and perhaps most important, in-service educators must see a positive cost-benefit relationship for their participation in in-service education programs – i.e. the rewards must be worth the investment of both their money and time. Thus, teacher education programs must provide in-service STEM education training that is high quality, offers diverse course topics, awards graduate credit, and leads to in-demand credentials and/or career advancement, such as math or science curriculum leadership roles within schools and early education settings. Moreover, they must receive clear messages from school leaders that STEM education is valued through, for example, the creation of math and science teacher leadership positions, investment in STEM professional development/course tuition and increased

instructional time for science, technology and engineering.

Third, training must be paired with effective onsite support. PreK-6 Teachers, especially teachers in their first few years in the profession, would benefit from in-classroom mentoring and coaching that models high quality STEM instruction.

Key Strategies

To develop accessible, high-value in-service STEM education training for Prek-6 educators, we propose the following strategies:

- **Based on national and state standards, define the content knowledge and instructional skills needed to be a "skilled PreK-6 STEM educator" as determined and conferred by the STEM Education Consortium.** This process should initially focus on math and science and include review of current national standards (e.g. the Common Core Standards Initiative, the Association for Childhood Education International, the National Council of Teachers of Mathematics, the National Science Education and Teaching Standards and the American Association for the Advancement of Science Benchmarks), DESE licensure requirements and curriculum frameworks, (e.g. Quality Rating Improvement System (QRIS)) and other best practices in math and science teacher training (e.g. Mathematical Knowledge for Teaching).

- **Develop aligned advanced math and science professional courses and course "clusters" (12 credits) that provide the necessary content and pedagogical training to become a skilled Prek-6 STEM educator.** This coursework could then support Prek-6 teachers with initial licensure who are seeking professional licensure or lead to recognized status or certification as an elementary math specialist or elementary science 'specialist', pending DESE approval.

- **Identify existing or develop new quality and innovative graduate-level STEM content and pedagogy courses across Consortium institutions that qualify as advanced professional courses and are offered at accessible times and locations. Then facilitate cross-institution enrollment and awarding of credit to in-service educators.**

- **Develop and pilot online or "hybrid"** (combined online and seminar) **courses that make high quality, advanced STEM courses widely accessible to in-service teachers.** The Consortium should enlist the support of area technology firms to support high-end product development.

- **Recruit, train and support a corps of STEM teacher mentors.** The Consortium should recruit both experienced, retired educators and current and retired STEM professionals, who with proper training and support, could serve as mentors. These mentors would then work with new teachers over their first few years in the classroom, specifically to strengthen math and science instruction. The Consortium should provide these mentors with access to free STEM education courses to strengthen or 'refresh' their content knowledge and instructional skills.

- **Establish STEM-focused professional development partnerships with districts and ECE providers.** These partnerships would train cohorts of PreK-6 teachers as skilled STEM educators and math specialists and science specialist, who could then assume roles, such as elementary or preschool math or science grade-level team leaders, coaches or coordinators (or department leaders for those schools moving in this direction).

- **Collaborate across institutions to monitor and assess the effectiveness of STEM coursework and in-service education both in fostering quality STEM instruction and improving student learning.**

Recommendation 4: Collaborate with state agencies, school districts and ECE providers to strengthen math and science education requirements for PreK-6 educators and to elevate the focus on math *and science* instruction in PreK-6 education settings.

Currently, most states, including Massachusetts, only require that middle school and secondary-level educators complete specialized training and obtain licensure as math and science teachers. To be sure, this traditional division of content between lower and upper grades has pedagogical and practical origins. Yet as the environment in which children learn undergoes rapid change, so too must their learning context.

Given the vital importance of STEM content and skills to students' future success, we recommend Consortium partners work closely with the Department of Elementary and Secondary Education (DESE) to review licensure requirements for PreK-6 teachers and explore new state-endorsed advanced elementary math and science coursework and specialist certification programs. We also recommend Consortium partners work with the Department of Early Education and Care (DEEC) to adopt new STEM education standards for ECE programs and staff. It is our intent that this work would support and complement state educator licensure revisions and ECE program improvement efforts currently under consideration or planned.[13]

At the same time, the Consortium should work with partner school districts and ECE providers to prioritize hiring of PreK-6 teacher candidates with specialized math or science training and to develop key teacher and curriculum leadership roles in preschool and school settings for these educators.

Further, along with revised PreK-6 teacher licensure and certification initiatives, we also call on state agencies, school districts, and ECE providers to increase the amount of science instruction in the early grades. Policymakers should review policies and practices to ensure schools and ECE programs provide comprehensive PreK-6 science education that includes high quality curriculum, adequate instructional time and resources, and ongoing, data-driven planning and professional development.

Key Strategies

To support development of new state, district and ECE program STEM policies and practices, we propose the Consortium pursue the following strategies:

- **Seek DESE approval of the Consortium's advanced professional math and advanced professional science course clusters as a 12 credit program that meets qualifications for teachers to move from initial to professional licensure.**

- **Partner with the DESE to explore development of an elementary math specialist and a science specialist certification, upon completion of advanced professional coursework.**

- **Review state professional licensure to explore whether advanced STEM education coursework and demonstrated**

[13] At both the February 4, 2010 meeting of the WGEE (Working Group for Educator Excellence) and the March 3, 2010 meeting of the State Readiness Centers Network, David Haselkorn, Associate Commissioner who leads the Center for Educator Policy, Preparation, Licensure, and Leadership Development, indicated that the Department is going to overhaul the licensure process which has not been thoroughly reviewed since 1995.

competence should become a future licensure requirement for all PreK-6 teachers.

- **Collaborate with the DEEC to include math *and science* content knowledge and instruction skill as part of the Quality Rating and Improvement System (QRIS), specifically related to Director and Teacher Qualifications and Professional Development.**

- **Collaborate with school districts to promote comprehensive, system-level PreK-6 science instruction.** To demonstrate the importance of and possibilities for PreK-6 science education, the Consortium should partner with school districts who have developed –or have a strong commitment to developing—innovative, system-wide PreK-6 science models that include not only strong curriculum, but also substantial, weekly instructional time and resources, professional development, and school-level science curriculum coordination.

Recommendation 5: Strengthen STEM education training for community-based early childhood education and out-of-school-time providers

Given the substantial amount of time children spend outside of formal education settings, we recommend the Consortium make concerted efforts to support and maximize the potential of "informal" STEM education provided in community-based ECE settings (center and family childcare settings) and OST programs (after school and summer programs). In addition to the significant time they care for children, these programs also enjoy wide latitude to implement innovative learning activities, such as project-based and experiential learning projects, that can excite children about STEM subjects, deepen their understanding, extend learning over time, and enhance the awareness of the relevance of knowledge and skills in STEM areas. When these activities are aligned with school curriculum or early education settings, they provide foundation knowledge and skills for later school curriculum and can powerfully promote student's overall learning and school success.

However, many educators in community-based ECE settings and OST programs are 'non-traditional adult learners.' These learners include low-entry, low skill adults and recent immigrants with no or limited postsecondary educational experience. In terms of college-level coursework and training, they often contend with barriers to entry and success, such as limited English language proficiency, poor academic skills and familiarity with college environments, family/work obligations and tuition costs. Thus, training for these providers must address these factors.

Key Strategies

To provide STEM education training to community-based ECE and OST providers, we propose the Consortium pursue the following strategies:

- **Modify STEM undergraduate courses and in-service education to develop transitional (or "bridge") STEM education professional development institutes tailored to non-traditional adult learners** These institutes should include both STEM content and pedagogy training *and* support with academic study skills and reading and writing. Further, they could be offered in collaboration with community-based adult education programs and award college credit that can be applied towards degree programs.

- **Provide advanced STEM courses and in-service training accessible to community-based ECE and OST providers who are ready for college-level coursework.** ECE and OST providers capable of and

interested in this level of coursework/training should have access to it. However, this training should be both less time intensive and costly than college coursework to accommodate the fields part-time professionals and modest salaries.

- **Recruit STEM professionals to mentor staff and teach STEM activities in ECE and OST settings.** The Consortium should recruit current and retired STEM professionals to introduce high quality and engaging STEM learning activities in ECE and OST settings, by serving as staff mentors as activity leaders. The Consortium should review current promising efforts to integrate STEM professional into these settings (e.g. Citizen Schools and Science Club for Girls).

ACTION STEPS

Sharing knowledge and resources and linking services through a Greater Boston STEM Education Consortium and in the specific ways outlined in this report holds real promise for substantially improving both the quality and quantity of skilled PreK-6 STEM educators in the region. However, broad partnerships involving multiple institutions are especially difficult to launch and sustain and thus often fall short of expectations and achieve minimal results.

To be successful, the proposed Consortium will need executive, financial, and program-level support. The following action steps address these key levels of supports.

Action Step 1: Engage top leaders

In collaboration with the Massachusetts Technology Collaborative, Wheelock and the Aspire Institute will reach out to leaders in higher education, school districts and collaboratives, state agencies, science centers/STEM business, community organizations and museums to enlist their participation in a diverse Consortium. Specific steps include:

- **Meeting individually and collectively with leaders from partner institutions to review the *Foundation for the Future* report and the STEM Educator Consortium Compact**
- **Formalizing agreements with an initial group of partner institutions and school districts to pilot a Consortium model**
- **Establishing a Consortium Steering Committee with representation from partner institutions, STEM businesses, and community organizations.**
- **Engaging/ sharing this report with policymakers** (e.g. the Governor's STEM Advisory Council, the Secretary of Education, the three Commissioners (DESE, DEEC and DHE), and legislative leaders).
- **Engaging/ sharing this report with key STEM education and STEM business partners and associations** (e.g. Science centers, Commonwealth Corporation, the Museum of Science, the Museum Institute for Teaching Science, the Massachusetts High Technology Council, the Massachusetts Biotechnology Council, and the Massachusetts Business Roundtable).

Action Step 2: Collaboratively pursue funding

The recent rise of STEM education as a national and state priority has resulted in several STEM-focused public funding initiatives. Wheelock and the Aspire Institute will coordinate with Consortium partners to explore and, if appropriate, pursue this funding. Through a collaborative approach, the Consortium will

offer greater opportunities to impact STEM education within the region and thus increase the competitiveness of proposals. Specific steps include:

- **Convening Consortium partners to identify and respond to public and private funding opportunities** –e.g. National Science Foundation, US Department of Education, state funding initiatives, STEM-focused foundations and business associations, etc.

- **Developing collaborative proposals that are aligned with and support implementation of this report's recommendations and key strategies.** These proposals should also seek funding to build adequate capacity to manage and assess a Consortium model.

Action Step 3: Begin program-level coordination

The real work of this Consortium—and thus its real success—will rest on the involvement of key staff from teacher education program, school-district and ECE programs. For example, faculty and community practitioners must have adequate time and resources to plan and develop new STEM education coursework. Thus, following agreements among a core group of institutions to secure funding for and participate in a Consortium, these key staff must be engaged in focused ways. Specific steps include:

- **Establishing a Consortium administrative team.** Comprised of program managers from partner institutions, this team would plan and implement key operational strategies, such as a regional recruitment campaign, cross- institution course enrollment and tuition agreements, and professional development partnerships with school districts and education collaboratives.

- **Establishing Consortium content team.** Comprised of teacher education faculty, school district curriculum leaders and teachers, ECE and OST providers and DESE and DEEC content area specialists, this team would to develop 'skilled PreK-6 STEM educator' standards and related coursework and advanced professional courses/clusters, as well as online versions of these courses. This team would also research and develop a pilot elementary math specialists and science specialists program.

- **Establish a Consortium practice team.** Comprised of teacher education faculty and school, early childhood education and out-of-school-time staff, this team would develop common goals and strategies for implementing STEM-focused clinical experiences and mentoring supports, in-service education programs and comprehensive science education models across PreK-6 settings.

Closing Thoughts

Preparing children for success in today's competitive, STEM-driven world is among the most important responsibilities of current and future educators. As we have highlighted, there is growing consensus among education researchers and practitioners that quality STEM teaching and learning must begin in the early grades, and thus PreK-6 educators play a pivotal role in meeting this responsibility.

However, greatly increasing the numbers of PreK-6 educators with the ability to teach STEM subjects well will require sustained collaboration between teacher education programs, schools and other partners. No one teacher education program or community partner has the capacity to either provide the range of effective, innovative STEM coursework

and professional development required across all grades and subjects, or to enroll, prepare and place the number of PreK-6 educators needed across the region over the next several years.

Collaboration, of course, is not a new idea. Higher education and community partners have a long tradition of developing partnerships to improve educational outcomes. Yet, with the size of the STEM education gap and the accelerated pace at which our society is becoming dependent on STEM knowledge and skills, it is essential that teacher education programs and community partners reach out anew, identifying innovative, in-depth ways to prepare skilled STEM PreK-6 educators .

This report proposes one such collaborative path. Its strategic goal, desired outcomes, recommendations and action steps all provide a clear direction for addressing this important challenge locally and, with proven success, a model for similar efforts across the state and country.

At the same time, this report is only a start. The real, in-depth and challenging work of coordinating efforts and resources across institutions and developing high quality, accessible coursework and professional development must now begin.

APPENDICES

Appendix I: Higher Education STEM Planning Project

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Appendix II: Suggested and Reviewed Resources

Bowman, B. T., Donovan, S. D., & Burns, M. S. (Ed.). (2000). Eager to Learn: Educating Our Preschoolers. Washington, D. C.: National Academy Press.

Bransford, J. D., Brown, A. L., & Cocking, R. R., (Ed.). (2000). How People Learn: Brain, Mind, Experience, and School. Expanded Edition. Washington, D. C.: National Academy Press.

Donovan, M. S., Bransford, J. D., & Pellegrino, J. W. (Ed.). (1999). How People Learn: Bridging Research and Practice. Washington, D. C.: National Academy Press.

Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (Ed.). (2007). Taking Science to School: Learning and Teaching Science in Grades K-8. Washington, D. C.: National Academy Press.

On STEM Curriculum and Instruction Guidelines:

Criteria used by AACTE in its 2007 report entitled: Preparing STEM Teachers:
The Key to Global Competitiveness: Selected Profiles of Teacher Preparation Programs
http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/2b/60/d4.pdf

UTeach (Univ of TX/Austin) What can we learn from middle and high school programs?
http://www.uteach-institute.org/files/Uteach_Institute_eos.pdf

Educational Development Corporation report for the Robert H. Goddard Council.
http://media.umassp.edu/massedu/stem/MASTEMEDCLandscape_051908.pdf

Learning and Teaching in PreSchool http://www.pbs.org/teachers/earlychildhood/articles/learning.html

Educating Preschool Teachers: Mapping Teacher Preparation and Professional Development.
http://www.fcd-us.org/usr_doc/EducatingPreschoolTeachers.pdf

Quality Teacher Preparation Pre K-12 www.teacherpartner.com/_PDF's/QualityTeacher.pdf

Opportunity to Learn Audit: Elementary School Science
http://www.renniecenter.org/research_docs/0806_ElemScience.html

Ready, Set, Science: Putting Research to Work in K-8 Classrooms
http://www7.nationalacademies.org/bose/Science_Learning_Practitioner_Volume.html

Appendix III: Summary of Strategy Poll Results

Higher Education Planning Project
Poll of Strategy Options

Total Respondents: 14

Question 1: Please rate the importance of the proposed elements of Content Knowledge:

A. Pre-service educators complete a minimum of 6 credits each in science and math to learn the content.

Essential	**69.2%**
Very Important	15.4%
Desirable	15.4%
Somewhat Important	0.0%
Not Important	0.0%

B. Experts in science and math team teach content courses with education faculty.

Essential	15.4%
Very Important	**38.5%**
Desirable	30.8%
Somewhat Important	0.0%
Not Important	15.4%

C. Pre and in-service educators gain insight about the math and science through internships in higher education labs and businesses in order to reflect real life perspectives and problems in their teaching.

Essential	7.7%
Very Important	15.4%
Desirable	**38.5%**
Somewhat Important	23.1%
Not Important	15.4%

Question 2: Please rate the importance of the proposed Pedagogy elements:

A. Students learn through play and experience so pre and in-service educators should learn the same way, e.g. hands-on, project-based, using technology, doing experiments.

Essential	**76.9%**
Very Important	7.7%
Desirable	0.0%
Somewhat Important	7.7%
Not Important	7.7%

B. Pre-service educators complete a minimum of 6 credits each in science and math pedagogy.

Essential	**38.5%**
Very Important	23.1%
Desirable	30.8%
Somewhat Important	7.7%
Not Important	0.0%

C. *Pre- and in-service educators devise opportunities to extend the learning of science and math beyond the school day and in/with community.*

Essential	**30.8%**
Very Important	23.1%
Desirable	**30.8%**
Somewhat Important	7.7%
Not Important	7.7%

D. *Pre- and in-service educators learn to encourage students to be creative and find alternative, conceptually sound solutions and approaches.*

Essential	**53.8%**
Very Important	38.5%
Desirable	0.0%
Somewhat Important	7.7%
Not Important	0.0%

E. *Mentoring of in-service teachers in science and math is essential for quality instruction and retention.*

Essential	**61.5%**
Very Important	38.5%
Desirable	0.0%
Somewhat Important	0.0%
Not Important	0.0%

F. Pre- and in-service educators team teach and collaborate.

Essential	15.4%
Very Important	**61.5%**
Desirable	15.4%
Somewhat Important	7.7%
Not Important	0.0%

Question 3: Please rate your institution's capacity for the following:

A. *Pre-service educators complete a minimum of 6 credits each in science and math to learn the content.*

Currently Doing	**57.1%**
Working Toward Doing	0.0%
Would Like to Do, but Currently Cannot	42.9%
Not Doing/No Immediate Interest	0.0%

B. Experts in science and math team teach content courses with education faculty.

Currently Doing	14.3%
Working Toward Doing	14.3%
Would Like to Do, but Currently Cannot	**42.9%**
Not Doing/No Immediate Interest	28.7%

C. *Pre and in-service educators gain insight about the math and science through internships in higher education labs and businesses in order to reflect real life perspectives and problems in their teaching.*

Currently Doing	0.0%
Working Toward Doing	0.0%
Would Like to Do, but Currently Cannot	42.9%
Not Doing/No Immediate Interest	**57.1%**

D. *Students learn through play and experience so pre and in-service educators should learn the same way, e.g. hands-on, project-based, using technology, doing experiments.*

Currently Doing	**75.0%**
Working Toward Doing	25.0%
Would Like to Do, but Currently Cannot	0.0%
Not Doing/No Immediate Interest	0.0%

E. *Pre-service educators complete a minimum of 6 credits each in science and math pedagogy.*

Currently Doing	14.3%
Working Toward Doing	28.6%
Would Like to Do, but Currently Cannot	**42.9%**
Not Doing/No Immediate Interest	14.3%

F. *Pre- and in-service educators devise opportunities to extend the learning of science and math beyond the school day and in/with community.*

Currently Doing	0.0%
Working Toward Doing	28.6%
Would Like to Do, but Currently Cannot	**57.1%**
Not Doing/No Immediate Interest	14.3%

G. *Pre- and in-service educators learn to encourage students to be creative and find alternative, conceptually sound solutions and approaches.*

Currently Doing	**62.5%**
Working Toward Doing	37.5%
Would Like to Do, but Currently Cannot	0.0%
Not Doing/No Immediate Interest	0.0%

H. *Mentoring of in-service teachers in science and math is essential for quality instruction and retention.*

Currently Doing	14.3%
Working Toward Doing	14.3%
Would Like to Do, but Currently Cannot	**71.4%**
Not Doing/No Immediate Interest	0.0%

Appendix IV: Protocol for phone interviews

Higher Education STEM Planning Project

Specific Strategies

1. Have you taken the poll? Did we leave out any key or essential element?
2. Which of the potential strategies in the poll do you think are most necessary?
3. What actions need to be taken in order to implement these strategies?
4. What potential challenges do you see? Opportunities?

Cross-Institutional Partnership

5. How can we fulfill the "mission" of a partnership among our institutions to improve STEM teaching and learning?
6. Do you think this type of partnership can have any impact? Where and how?
7. We have some starts and stops to this initiative – some loss of momentum. Do you have any theories about why this is the case? How to strengthen partnerships like this?
8. One outcome has been that people have met and had conversations. Do you think this might continue? Under what conditions?
9. What should our next steps be? What are you willing to do?

Eight key informants were interviewed

For More Information About This Report…

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