VOLUME 6 ISSUE 4

The Journal of the

World Universities Forum

Secondary STEM Teacher Preparation as a Top Priority for the University of the Future

National UTeach Replication as a Strategic Initiative

MARTHA PÉREZ AND PAMELA ROMERO

COMMON GROUND

UNIVERSITIESFORUM.COM

THE JOURNAL OF THE WORLD UNIVERSITIES FORUM
www.ontheuniversity.com

First published in 2014 in Champaign, Illinois, USA
by Common Ground Publishing
University of Illinois Research Park
2001 South First St, Suite 202
Champaign, IL 61820 USA

www.CommonGroundPublishing.com

ISSN: 1835-2030

The Journal of the World Universities Forum is a peer-reviewed scholarly journal.

Secondary STEM Teacher Preparation as a Top Priority for the University of the Future: National UTeach Replication as a Strategic Initiative

Martha Pérez, University of Texas at Austin, USA
Pamela Romero, University of Texas at Austin, USA

Abstract: National calls, such as the National Academy of Science's Rising Above the Gathering Storm, and President Obama's Educate to Innovate and 100Kin10, caution against the detrimental effects that a lack of math and science literacy pose to the health of the nation's economy and call for immediate action to increase the nation's science, technology, engineering and mathematics (STEM) talent pool by increasing the number of K – 12 STEM teachers. A growing number of universities are responding to this challenge by adopting the UTeach program, making secondary STEM teacher production a university-wide priority through a unique cross-college collaboration. The University of Texas' UTeach program offers both a STEM degree and secondary certification to teach math, science, or computer science in just four years. UTeach combines rigorous content preparation, pedagogy, and early field teaching experiences into four-year STEM degree plans. The UTeach Institute[1] was established to support the implementation of the UTeach model at universities across the country and currently partners with 35 universities implementing UTeach-based programs in 17 states across the United States. As of Spring 2013, approximately 1,600 UTeach graduates have been produced and that number is expected to rise to 9,000 by 2020. Initial results indicate that UTeach implementation is creating institutional change and establishing programs that are making headway in bringing STEM teacher preparation to the forefront of each university's mission. This article examines this scale-up experience as an example of a successful model for strengthening university-based STEM teacher preparation. Specifically, we review the implications for the university of the future, and address the necessary institutional changes required for successful program implementation. Our experience shows that successful program implementation in a university setting requires a balanced approach. Clear articulation of operational and instructional program components, structured implementation support, explicit program benchmarks and continuous evaluation of progress must be paired with an awareness of the local context and opportunities for adaptations and innovations to the model.[2]

Keywords: Secondary STEM Teacher Preparation, UTeach Program, UTeach Institute, Change in Higher Education, Replication Model, Accountability, Education Preparation Programs

The National Narrative and Call to Action

For several decades now, the narrative has been clear—the United States has a science, technology, engineering, and mathematics (STEM) secondary teacher shortage that threatens to undermine its capacity to meet the demand for a 21st century skilled, well-educated competitive workforce. Beginning as far back as 1983, with the publication of *A Nation at Risk: The Imperative for Educational Reform* (Gardner et.al. 1983), to the 2010 National Academies' report, *Rising Above the Gathering Storm Revisited*, findings indicate that American students are lagging behind other industrialized nations in critical areas. In a 2009 study conducted by the Organization for Economic Co-operation and Development, American students ranked 17th of 24 developed and emerging countries in science literacy and 25th in math literacy (Ferber 2011, 20). On the National Assessment of Educational Progress, less than one-third of

[1] The UTeach Institute's work is funded through a variety of public/private partnerships that include state agencies, foundations, non-profits, and corporations. The UTeach Institute partners with the National Math and Science Initiative and the states of Arkansas, Texas, Florida, Tennessee, Georgia, Maryland, Massachusetts to implement UTeach at universities across the country. A complete list of our strategic partners is available at http://uteach-institute.org/about/detail/partners/.
[2] The opinions expressed in this article are those of the authors, and do not necessarily reflect the opinions of the UTeach Institute or the University of Texas at Austin.

The Journal of the World Universities Forum
Volume 6, 2014, www.ontheuniversity.com, ISSN 1835-2030

U.S. eighth graders demonstrate proficiency in mathematics and science (Executive Office of the President, 2010).

The shortage of highly qualified science and math teachers is also a continuing concern for schools around the nation. *The Gathering Storm* report draws attention to the shortage of STEM teachers graduating from colleges and universities, as have other reports. The National Center for Education Statistics (Table 1) reported that during the 2007-08 school year, approximately one third of high school math students, half of physical science and chemistry students, and two-thirds of those enrolled in physical science courses were taught by teachers teaching outside of their field. In addition to a lack of access to qualified teachers, Ferber points out the additional challenges presented by high attrition rates: of the 3.6 million teachers employed in the United States in 2011, 477,000 (13%) were STEM teachers. Approximate 25,000 (5%) STEM teachers leave the profession each year (Ferber 2011, 22). In an effort to recruit math and science teachers, and fill vacant positions, local school districts are offering signing bonuses and stipends, tuition reimbursements, and partnering with universities and certification programs to help increase the number of available STEM teachers (Ferber 2011, 20).

Table 1. High School Teachers Teaching Outside Their Major

Selected Field	Number of Teachers	Percent Not Teaching in Field
Mathematics	143,600	27.5%
Science	119,800	16.0%
Biology/Life Sciences	53,800	23.9%
Physical Science	99,900	51.5%
Chemistry	24,500	51.8%
Earth Sciences	8,500	66.8%
Physics	8,800	42.3%

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey (SASS), "Public School Teacher Data File," 2007–08. http://nces.ed.gov/surveys/sass/tables/sass0708_009_t1n.asp (retrieved 07/28/2013)

The *Gathering Storm* report suggested that increasing the United States' talent pool would require a vastly improved K-12 mathematics and science education system. To achieve this, at least in part, the nation must increase the number of qualified secondary STEM teachers. *The Gathering Storm* report proposed an agenda for science and technology, and delineated four overarching recommendations and twenty specific actions. (Rising Above the Gathering Storm Committee, et al. 2010) One of these recommendations specifically addressed the shortage of math and science teachers— it recommended that the country annually recruit 10,000 science and mathematics teachers. The report further recommended to "annually recruit 10,000 of America's brightest students to the teaching profession every year, each of whom can have an impact on 1,000 student over the course of their careers." (National Academy of Sciences 2007, 5). In this report, the University of Texas' UTeach secondary STEM teacher preparation program was noted as a model for this action.

Overall, education experts and many policy makers agree that a new generation of math and science teachers is needed to prepare K-12 students for the 21st century (Ferber 2011), and many initiatives have prioritized this call for action. In his 2012 presidential inaugural address, President Obama referred to the need to continue to train math and science teachers (CNN Political Unit, 2013). The White House's 2009 Educate to Innovate campaign challenged public and private stakeholders to "find ways to recruit, train, reward, and retain teachers" (Office of the Press Secretary, White House 2010). Other organizations and initiatives have stepped up to the plate, including: 100Kin10, Change the Equation, The Science and Mathematics Teacher Imperative, The National Math and Science Initiative, and The Clinton Global Initiative, to name only a few. Through its Math and Science Education Initiative, Teach for America, a non-profit organization that places recent college graduates in high-needs schools for two years, is also committed to recruit, train, and support corps members to become effective STEM teachers.[3] Many universities are prioritizing STEM education and the production of math and science teachers.[4] Several have partnered with organizations committed to increasing the number of math and science teachers, like 100kin10, and have made commitments to recruit and train new teachers[5]. The Association of Public and Land-Grant Universities (APLU), an organization of 132 public research universities, launched the Science and Mathematics Teacher Imperative (SMTI) initiative and committed to prepare "a new generation of world-class science and mathematics teachers" (APLU 2013a). In response to a congressional request, the 2012 National Research Council published a report that delineates nine recommendations needed to help the United States compete, prosper, and achieve national goals for health, energy, the environment, and security in the global community of the 21st century. Two key recommendations specifically target colleges and universities. The report notes:

- Research universities should engage in efforts to improve education for all students at all levels in the United States by engaging in outreach to K–12 school districts and undertaking efforts to improve access and completion in their own institutions.
- Research universities should assist efforts to improve teacher education and preparation for K–12 STEM education and improve undergraduate education, including persistence and completion in STEM.

APLU's SMTI and the National Research Council's recommendations are moving more universities to respond to accountability efforts that prioritize national needs. Improving the participation and performance of America's students in STEM must begin with the preparation of qualified STEM teachers for K–12 schools. And universities have an essential role to play in this process. They are home to the world's top scientific minds and education researchers, and they also enroll approximately 350,000 undergraduate STEM majors--the single most significant pool from which to recruit the 100,000 future secondary STEM teachers that has been established as a national goal (Marder, 2012b). The national expansion of UTeach offers a model that can significantly contribute towards this national goal.

UTeach: A Contributing Solution

The UTeach Program at the University of Texas at Austin

UTeach[6] is an innovative teacher preparation program for science, mathematics, and computer science majors that started in 1997 at The University of Texas at Austin (UT Austin).[7] The program has at least doubled the number of secondary math and science teachers prepared by the university, and now graduates approximately 70 students per year. The program is a unique collaboration between the colleges of science, education and liberal arts that allows students to

---

[3] Several studies have been conducted regarding the overall efficacy of the Teach for America Model (see Vasquez Heilig et al, 2010).
[4] For a comparison of eight parallel initiatives (including UTeach replication), go to HHMI's graphic "*Sizing up preservice teacher training programs*" http://www.hhmi.org/node/19841.
[5] For more information visit the 100Kin10 organization's website at www.100kin10.org.
[6] More detailed information on the UTeach program at UT Austin is available at http://uteach.utexas.edu. A detailed discussion of the programs' elements is beyond the scope of this paper.
[7] http://uteach-institute.org/uteach

earn secondary teaching certification while simultaneously completing a rigorous degree in a science, technology, engineering, or mathematics (STEM) discipline. The program eliminates traditional barriers to teacher certification, ensuring that students can obtain a degree in a STEM discipline and teaching certification in just four years. It essentially offers one degree but two career possibilities with no additional time or cost required.

Students in STEM majors are actively recruited and are provided early and intensive field teaching experiences in diverse school settings. Students begin teaching in local classrooms as early as their freshman year. Instruction throughout the program is discipline specific, focusing on research-based best practices in STEM teaching and learning and the connections between math and science and among the sciences. Students carry out independent scientific inquiries and go on to design, implement, and evaluate a range of problem-based and project-based instructional approaches. UTeach retains students by offering extensive support services, including paid internships and scholarship opportunities, and personal attention and guidance from highly experienced master teachers, faculty, and successful public school teachers. The philosophy underlying the design of the UTeach instructional program is that students' knowledge and skills can be developed at an accelerated rate through a combination of extensive individualized coaching, intensive teaching opportunities, and relevant content.

1. Distinctive Program Identity
2. Cross-College and School District Collaboration
3. Long-Term Institutional and Community Support
4. Compact and Flexible Degree Plans
5. Active Student Recruitment and Support
6. Dedicated Master Teachers
7. Rigorous, Research-Based Instruction
8. Early and Intensive Field Experiences
9. Continuous Program Improvement

Figure 1: The UTeach Program Elements of Success
Source: The UTeach Elements of Success at http://uteach-institute.org/uteach

Between 2000 and 2013, the UTeach program at UT Austin graduated approximately 819 math and science teachers. Approximately 80% who begin teaching are still in schools five years later. The UTeach program estimates that these teacher graduates have taught more than 200,000 students in secondary STEM classrooms.

UTeach National Replication

The UTeach Institute was established in 2006 to respond to inquiries about UTeach, to support implementation of UTeach programs at universities across the United States, and to lead efforts toward continuous improvement of the model. From its inception, the UTeach Institute relied on one fundamental belief: that the innovative UTeach program at UT Austin could be successfully implemented and sustained at other universities. Underlying this belief is a theory of change that clearly articulates UTeach program components, goals and objectives, as these have explicit implications on implementation, project management, sustainability, monitoring, evaluation, and impact measurement. With a clear blueprint for change, the UTeach Institute is able to address the most appropriate interventions, know what to monitor, and what questions to ask to measure progress and impact. Just as UTeach changed long-standing practices and expectations for collaboration at UT Austin, UTeach implementation at other national universities can also create institutional changes.

An initial, ambitious, collaborative partnership with the National Math and Science Initiative, with funding from Exxon Mobil, allowed for UTeach implementation grants to be awarded in 2008 to a first cohort of 13 universities through a national competition. Since then, three additional cohorts have begun implementing programs based on UTeach, totaling 35 universities across 17 states. Up to 10 additional universities are expected to begin implement a program based on UTeach starting in 2014. These programs have been funded through either public or private funding, or a combination of both.[8]

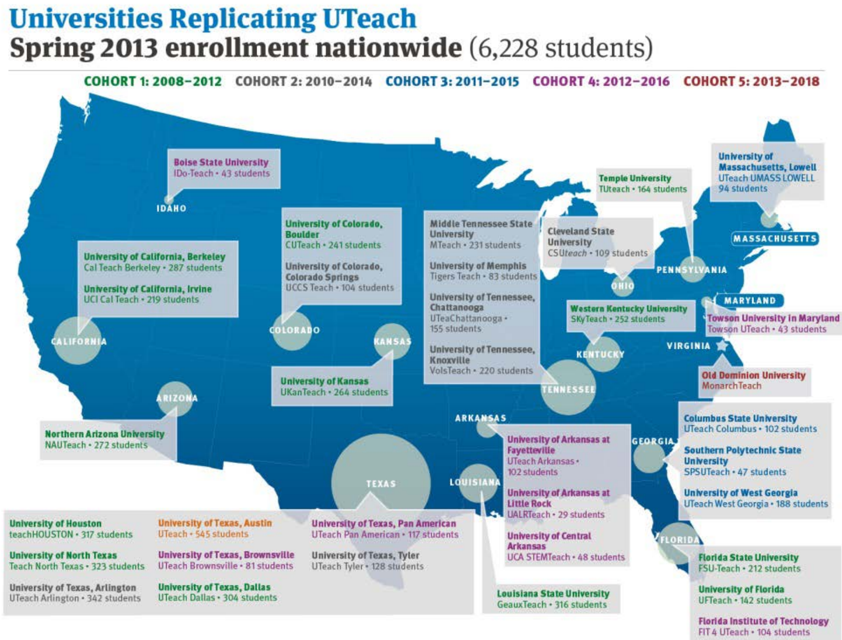

Figure 2: National Map of the UTeach Program

Each program is typically awarded a grant to implement UTeach over a four year period. Also typical, partner programs are competitively selected based on a demonstrated need to produce more secondary STEM teachers at the university level to, and a need at the state and/or local community level for more secondary STEM teachers. Applicants must also demonstrate knowledge of the UTeach program, a commitment and willingness to implement the UTeach model and sustain the program over time, top-level university support.

To promote the goals of fidelity to the UTeach model, long-term sustainability, and to ensure a that program implementation is adequately evaluated, the UTeach Institute has developed a comprehensive approach to program support and implementation aligned with recommendations from the research literature on fidelity of implementation, program replication and expansion, and program evaluation (e.g., Century, Rudnick, & Freeman, 2010; Glennan, Bodilly, Galegher, & Kerr, 2004; Hall & Hord, 2010; Hill, Maucione, & Hood, 2007, Patton, 2011, 2012).

[8] The UTeach Institute partners with the National Math and Science Initiative and the states of Texas, Tennessee, Georgia, Massachusetts, Florida, Maryland, and Arkansas to replicate UTeach at universities across the country. A complete list of strategic partners is available at http://uteach-institute.org/about/detail/partners/.

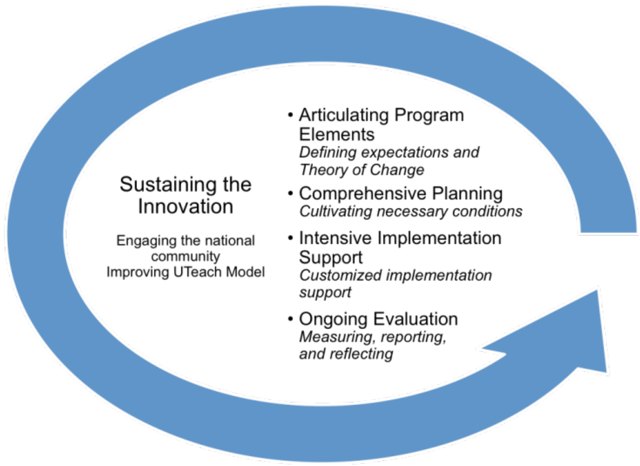

Figure 3: Approach to Implementation and Sustainability

This approach emphasizes (1) clear articulation of program elements and expectations for replication, (2) comprehensive planning with qualified sites, (3) intensive implementation support, and (4) ongoing evaluations of progress. A continuous and reciprocal relationship between implementation support and evaluation defines the UTeach Institute's dual role during program implementation and forms the basis for the bulk of the Institute's work. [9]

Program replication in a higher education setting is unique, and presents unique challenges. While literature exists with regard to fidelity of implementation, evaluation, technical support, etc., little is available regarding replication in higher education settings. The National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) developed one successful model. These two organizations initiated the Model Institutions of Excellence program (MIE) in 1994 and funded a group of minority-serving institutions (MSIs) to implement the MIE program to increase the number of underrepresented minorities in STEM. The NSF contracted with the American Institutes for Research (AIR) to "…determine whether the MIE model could guide national effort for achieving and sustaining diversity in the STEM workforce. (American Institute for Research 2005, iii). This initiative is similar to the UTeach replication model in that both require significant investments in time and resources. Both models clearly articulate program components and offer a multi-year implementation approach. Several MIE model components, like student and faculty support, physical infrastructure changes, and curriculum development, are also cornerstones to the foundations of the UTeach program implementation model. (The Institute for Higher Education Policy (IHEP) states that the MIE model is an effective pathway to success for replication initiatives. The IHEP report recommends further commitment to prioritize these types of initiatives calling for these to become *strategic national investments* rather than sporadic isolated efforts. (Cullinane, et.al. 2009, IHEP *fact sheet* 2009).

Implementing UTeach in higher education settings also presents unique challenges. UTeach replication involves the replication of a comprehensive academic teacher certification program. Perhaps the most significant challenge lies in engaging faculty members – experts in STEM and

---

[9] For more information about the Institute's approach to program implementation and replication support, see: *Replication as a Strategy for Expanding Educational Programs That Work: The UTeach Institute's Approach to Program Replication* (Beth et al. *2011)* http://www.uteach-institute.org/files/uploads/AACTE2011.pdf , also http://uteach-institute.org/replicating-uteach/detail/replicating-UTeach/.

STEM education themselves and peers of the developers of UTeach – in modifying or teaching new courses and becoming advocates for the new program, particularly when the new program is very different from the one(s) in place prior to replication, if there were program(s) in place. (Beth, Alicia D. et.al. 2012, 14). Our experience shows, however, that successful program implementation of UTeach in other university settings requires balanced approach. UTeach's clearly defined theory of change, with well-defined articulation of operational and instructional program components, coupled with a structured implementation support, explicit program benchmarks and continuous evaluation of progress allows the program to be implemented. This implementation framework, paired with university partners that are knowledgeable of their local community context and willing to adapt and innovate as necessary, have resulted in successful and sustainable programs. Bradach (2003) also notes "…replication is anything but a cookie-cutter process. The objective is to reproduce a successful program's *results*, not to slavishly recreate every one of its features." Our experience continues to highlight that a *meaningful* implementation leads to institutionalization and that such an undertaking requires time and resources. By *meaningful success*, we mean implementation that leads to long-term sustainability as well as a fulfillment of the original prescribed outcomes. Thus far, partner universities implementing UTeach continue to sustain their programs after the initial grant-funding phase. Programs continue to recruit STEM majors into the program and are on-track to increase secondary STEM teacher production.

Implementation Results to Date

After four years of program implementation, the first cohort of 13 universities completed its initial year funding period in Spring 2012. Initial end of grant analysis indicate that programs are experiencing similar successful results as UT Austin did when it first implemented UTeach, back in 1997. Early findings indicate that these programs are increasing the number of certified secondary STEM teachers at their universities. By the end of the initial UTeach program implementation period (Spring 2012), these 13 universities had produced 397 graduates. We estimate that, cumulatively, approximately 1,600 certified STEM teachers, including UT Austin, have graduated from all UTeach programs nationwide. In addition, partner programs are continuing to grow, enrolling new STEM majors and allowing them to try out teaching. Slightly over 6,000 students were enrolled in a UTeach program in Spring 2013. The number of UTeach graduates is expected to grow to more than 9,000 by 2020 and to impact more than four million secondary students.

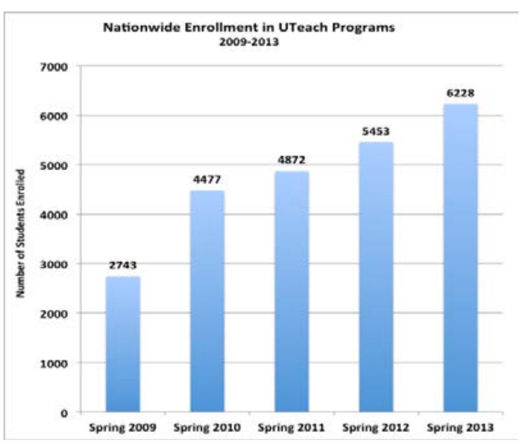

Figure 4: National Enrollment in UTeach Programs, Spring 2009 – 2013.
Source: The UTeach Institute at http://www.uteach-institute.org/ 2013

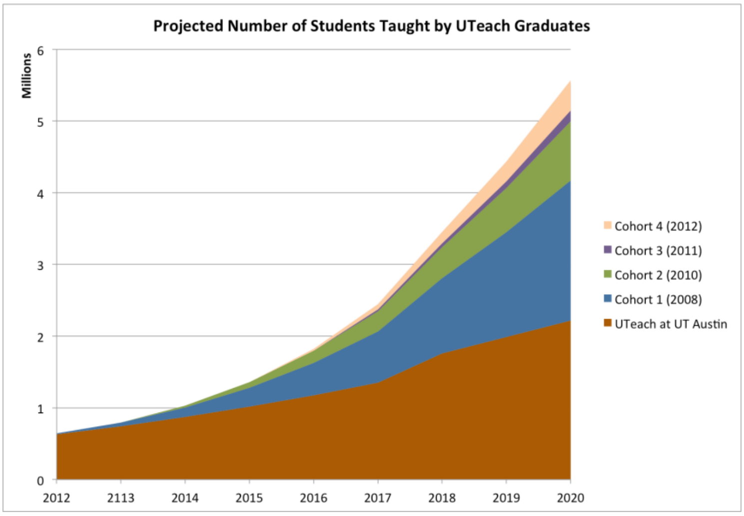

Figure 5: Projection of Students Taught by UTeach Educators 2013
Source: The UTeach Institute at http://www.uteach-institute.org/.

In addition to graduating teachers and enrolling students, these universities have, to various degrees, institutionalized the UTeach program model. Universities have implemented programs that bridge colleges of science and education, actively recruited STEM majors, promoted early and intensive field experiences, incorporated relevant and authentic STEM content in their professional development courses, established endowments to ensure sustainability, and supported students with a variety of benefits. (Beth, Alicia D. et.al. 2012, 14). By the end of the initial grant period, most programs had successfully secured space, and essential program costs had been absorbed by recurring institutional funds. We find across our partner programs, that despite some budget constraints, program and university leaders and key stakeholders continue to support this initiative.

Implementing Change in Higher Education: Possible Strategies for Responding to National Needs

As stated earlier, the need to strengthen secondary STEM teaching and learning represents a significant challenge to universities of the future. This challenge must be tackled from multiple areas in the education system as there is no single solution to a problem of this scope and complexity. When it comes to preparing new teachers, however, the nation's more than 4000 four-year, degree-granting institutions of higher education probably represent the single best source for significant numbers of new, high quality STEM teachers. At the same time that colleges and universities have the potential for significant national impact, the culture of higher education does not have a reputation for swift reform (Kelderman 2011).

From the university of the future perspective, what does addressing this national need entail? How can a university prioritize this need? The UTeach Institute's experience working with 34 universities over the past six years to implement a unique approach to STEM teacher preparation has provided valuable insights into the challenges presented by the higher education context and potential approaches to overcome obstacles. Based on this experience, we now highlight important considerations for the university of the future and offer lessons learned from the national UTeach replication initiative as one example of a possible strategic approach to address the STEM teacher shortage.

Important considerations for strengthening and sustaining STEM teacher preparation as a university-wide priority include:

- Garnering departmental, college and university leadership support
- Establishing a cross-college team of key stakeholders
- Conducting a thorough internal assessment of existing programs
- Identifying high quality programs
- Insisting on fidelity of implementation and accountability for results, yet allowing for local adaptations and innovations
- Committing sufficient financial resources and time
- Leveraging the power of collaborative peer networks

Garnering departmental, college and university leadership support provides a vital foundation for any reform initiative, but especially at large academic institutions where teacher preparation is likely not among top institutional priorities. Initiatives like APLU's Science and Mathematics Teacher Imperative are changing that by working directly with university leaders to raise awareness about their critical role in addressing the STEM education teacher shortage. But while winning leadership support is necessary in order to launch a new STEM teacher preparation initiative, our experience has taught us that maintaining university top leadership support as well as that of individual departments must be an ongoing priority in order to ensure complete and sustained implementation. Competition for scarce university and college resources, turnover among administrators, and a resistance to change can challenge even the most successful new initiative on a university campus.

Establishing a cross-college team of key stakeholders to lead efforts can go a long way toward building a broad base of support for a new STEM education initiative. Involving content faculty from across STEM disciplines in what is often assumed to be solely the job of the education department is critical to preparing secondary teachers with deep content knowledge. Coordinating efforts across colleges also leads to increased interest among more STEM majors in pursuing teaching.

Conducting a thorough internal analysis of existing programs is an important early step. An initiative to significantly change or replace an existing program is unlikely to succeed unless you can establish a clear and compelling need for it early in the process. There are tools, such as the SMTI Analytic Framework (AF), that can systematically guide a cross-college team's analysis of existing programs in order to determine strengths and areas for improvement. Through the AF, SMTI began the process of "creating a classification, almost a taxonomy, of the critical components, goals, objectives and strategies that codify a shared language of concepts, strategies and assessments that are particular to science and mathematics teacher preparation (APLU, 2013). It allows program leaders to assess their policies and practices, and offers institutions the opportunity, in a systematic ways, areas that can be benchmarked to other programs.

Identifying an existing high quality program to implement offers a number of advantages over building a custom program. Probably the most significant advantage is in reducing the impact of trial and error. An existing, proven program will have successfully navigated obstacles and made improvements over time, allowing a university to build on a successful model rather than re-invent the wheel. It is important to acknowledge at this point that there are very few examples of higher education programs that have been thoroughly documented and codified to allow for easy adoption. And to do so requires a significant investment of resources. However, national UTeach replication provides a proof of concept in this area and has established that complex academic programs can successfully be developed to allow for replication at other institutions of higher education.

Insisting on fidelity of implementation and accountability for results when adopting an existing program model leads to reliable outcomes. It is tempting to select just a handful of program elements to implement, rather than the complete program model, in an attempt to preserve existing program strengths. But like all complex systems, the whole of an academic program is greater than just the sum of its parts. While all programs must be adapted to fit the local context, we have learned that adaptations are most effective once faculty and staff have developed a complete understanding of the program as a whole. That understanding develops as all program components are established over time.

Committing sufficient resources and time is absolutely necessary to attain a sustainable implementation of a new STEM teacher preparation initiative. External funding is a powerful driver and can provide program directors with additional leverage should university or college leadership fail to provide promised support. Matching institutional funding has proved to be key to long-term sustainability. An institutional investment from the beginning demonstrates buy-in. A combination of external funding that decreases over time as a percentage of total program costs along with increasing percentages of institutional funding has proven to be a successful formula for ensuring that all program components are implemented and sustained. Change takes time and university leadership should be prepared to commit to multiple years of program support to ensure a successful outcome.

Leveraging the power of collaborative peer networks is emerging as a significant contributor to successful program development in our work with universities across the country. The more than 400 research and clinical faculty affiliated with UTeach programs nationwide comprise a professional learning community that offers a significant advantage in that a collaborative infrastructure has been established that fosters sharing of best practices and community problem-solving with the explicit goal of continuous improvement of the UTeach secondary STEM teacher preparation model. In this way, all UTeach programs nationwide benefit from the insights gained by individual programs as they encounter new challenges. APLU's Science and Math Teacher Imperative and 100K in10 provide additional examples of similar collaborative peer networks organized specifically around strengthening STEM teacher preparation.

Dimensions of Organizational Change

Earlier we made brief mention of the UTeach program hallmarks, or elements of success. These elements of success represent components that are fundamental to the UTeach model. These elements form the basis for evaluating progress toward full program implementation at partner universities. While all 13 universities comprising the first UTeach cohort successfully implemented the majority of program components, there resulted a range in the degree to which any one element was fully established.

Now we turn to a discussion of documented structural and organizational changes we observed with the first 13 universities (Cohort 1) that completed the four-year grant period. UTeach program model's critical components are captured in the nine UTeach Elements of Success (EOS) and provide the framework for measuring and evaluating implementation progress. As a whole, these components represent what is required to establish program success and long-term sustainability. What follows is a brief discussion of changes that have been observed and documented among the first cohort of 13 universities. Table 2 reflects the gradual transformation process that takes place over a four-year implementation period. While many changes are noted, not all of these take place at the institutional level. Many elements are programmatic, not necessarily requiring top-level institutional and structural redefinitions. Taken as a whole, however, successful implementation of UTeach results in significant institutional changes that require top-level support, and commitment.[10]

[10]To learn more about costs associated with implementing a UTeach program, go to the "Budgeting for a UTeach program" at http://uteach-institute.org/publications.

Table 2: Elements of Institutional Change in Higher Education before and after UTeach Implementation

Element	Before Implementation	After Implementation
Cross-College Collaboration	STEM teacher preparation was the responsibility of the college of education.	STEM Teacher preparation is the responsibility of multiple colleges.
Long-Term Institutional and Community Support	Teacher preparation units did not necessarily have an identifiable structure (department). As such, it was more difficult to garner university, cross-college, and departmental support.	As an identifiable unit programs have garnered departmental, college and university leadership support necessary to promote cross-college collaboration, develop and approve new degree plans, provide adequate space and resources, and hire appropriate staff.
	Teacher preparation programs did not have access to a national learning community of similar programs to exchange knowledge.	Programs leverage the power of collaborative national network across 35 universities. More than 300 faculty and 100 master teachers[11] are affiliated with UTeach programs nationally.
Compact and Flexible Degree Plans	Degrees were awarded in science or mathematics education not in STEM disciplines. Students entered as post-baccalaureates or completed an additional year of coursework and field experience for licensure.	Degree plans allow students to earn both a degree in the STEM major and teaching licensure in the same amount of time required to earn an equivalent STEM degree alone, without the time and cost of additional semesters.
Active Student Recruitment and Support	STEM majors were not systematically recruited.	Programs actively recruit STEM majors and offer financial incentives and advising support to students to help them determine if teaching is something they might pursue.
Dedicated Master Teachers	Education faculty typically taught all professional development courses and supervised field experiences for student teaching.	Programs employ master teachers with expertise in science or mathematics to teach alongside education faculty to teach courses and student field teaching experiences.
Continuous Program Improvement	Programs did not systematically collect programmatic operational and instructional evaluation data.	Programs collect and regularly review operational and instructional evaluation data.
Rigorous, Research-Based Instruction	Deep content knowledge (DCK) was not systematically documented.	Program courses emphasize the development of DCK. Students take courses specifically created for future STEM teachers. Research-based professional development courses address instructional strategies used to support curricular choices that best fit STEM student needs. Courses are developed and taught by faculty who are actively engaged in research in STEM or STEM education.
Early and Intensive Field Experiences	Students' first teaching experience typically occurred towards the end of their course sequence. In many programs, No systematic effort was made to match apprentice teachers with cooperating teachers who address individual needs.	Field experiences occur beginning in the first course. Teaching opportunities continue regularly throughout the program. Field experiences are individualized, carefully scaffolded, and intensively coached.

Opportunities and Possibilities for the University of the Future

As stated earlier, when STEM teacher production becomes a matter of public policy, as well as a strategic national priority, universities should make concerted efforts to prioritize this need. The university of the future will need to respond to calls for increased accountability in higher education and prioritize this need. For decades now, the K-12 educational environment has been under pressure to achieve reform and accountability objectives. Pressures to align the higher

[11] Master Teachers are non-tenured faculty members. Master Teachers have successful teaching experience and are widely recognized for their educational leadership.

education system and integrate P-16 pathways for student initiatives are already underway at national and state levels. Critical to these initiatives, is higher education's contribution to increase production of qualified math and science teachers.

Among many strategies, some highlighted earlier, UTeach is one possible avenue toward more comprehensive teacher preparation programs. It brings with it the value of a program that can be replicated with successful results, and allows institutions to adopt a recognizable model with clearly articulated outcomes. Typically, Colleges of Education have operated in silos, lacking a cross-college collaborative environment. UTeach is the opposite, recommending a strong foundation for cross-college collaboration that helps re-define the responsibility of for teacher production from an isolated college, to a cross-college and university, top-level priority. In addition, implementing UTeach allows universities to become affiliated with a national network of programs with research and clinical faculty in colleges of mathematics, science, and education universities that are collectively implementing UTeach. This national learning community offers a significant advantage in that a collaborative infrastructure has been established that fosters sharing of best practices and community problem-solving with the explicit goal of continuous improvement of the UTeach secondary STEM teacher preparation model.

This article describes programmatic and structural changes and efforts undertaken by committed universities in order to respond to this call to action. The UTeach program and its structured approach to replication, as evidenced by the first cohort, have been successfully implemented. As programs complete the grant period, the Institute continues to collect data and engage with all programs. With established UTeach programs implementing past the grant period, our evaluation has shifted from an approach that focuses on program fidelity, program implementation support to an approach that addresses the sustainability, networking, and long-tem impact of the universities' secondary STEM teacher preparation programs and their graduates in the K-12 community (Romero, Pérez 2012). This new phase of study provides the UTeach Institute with a reflective opportunity to understand and refine our theory of change and our overall approach to program implementation support. It is our intent that this refinement will inform the implementation parameters and adjustments for subsequent cohorts and the next phase of planning and evaluation.

Acknowledgements

The authors wish to thank Kim Hughes, Alicia Beth, and Martin Evans for their contributions and feedback.

REFERENCES

Association of Public and Land-Grant Universities (APLU). 2012. *APLU 125th Annual Meeting Convocation*. http://www.aplu. org/sslpage.aspx?pid=2551

Association of Public and Land-Grant Universities (APLU). 2012a. *SMTI Science and Mathematics Teacher Imperative: The Analytic Framework.* http://www.aplu.org /page.aspx?pid=584

Association of Public and Land-Grant Universities (APLU) 2013. *SMTI Science and Mathematics Teacher Imperative*. http://www.aplu.org/page.aspx?pid=2182.

American Institute for Research. 2005. *Creating and Maintaining Excellence: The Model Institutions for Excellence Program*. www.air.org/reportsproducts/index.cfm?fa= viewContent&content_id=161.

Beth, Alicia D., Pamela Romero, Mary Lummus-Robinson, and Martha P. Perez. 2012. "Implementing a Secondary STEM Teacher Preparation Program at Multiple Universities: The UTeach Institute's Evaluation Approach and Pilot Summative Data" *Paper presented at the annual meeting of the American Educational Research Association, Vancouver, B.C., Canada.*

Beth, Alicia D., Kimberly K. Hughes, Pamela Romero, Mary H. Walker, and Melissa M. Dodson. 2011. "Replication as a strategy for expanding educational programs that work: The UTeach Institute's approach to program replication." *Paper presented at the annual meeting of the American Association of Colleges for Teacher Education, San Diego, CA.* UTeach Institute, http://uteach-institute.org/ publications.

Bradach, Jeffrey L. 2004. *Going to Scale: The Challenge of Replicating social Programs*. Stanford Social Innovation: Non-Profit Management Institute. Stanford graduate School of Business: Stanford Social Innovation Review. http://www.ssireview.org/ articles/entry/ going_to_scale.

Century, Jeannie, Mollie Rudnick, and Cassie Freeman. 2010. "A framework for measuring fidelity of implementation: A foundation for shared language and accumulation of knowledge." *American Journal of Evaluation*. 31:199-218. Association of Public and Land-Grant Universities.

Coble, Charles. 2012. Developing the Analytic Framework White Paper. Assessing Innovation and Quality Design in Science and Mathematics Teacher Preparation. Association of Public and Land-Grant Universities. http://www.aplu.org/page.aspx?pid=2182.

Coble, Charles R., Presley, Jennifer B. 2012a. *Seeking Consensus on the Essential Attributes of Quality Science and Mathematics Teacher Preparation Programs*. Association of Public and Land-Grant Universities (APLU): SMTI conference Paper 2, http://www.aplu.org/document.doc?id=4098

Committee on Prospering in the Global Economy of the 21st Century (U.S.), and Committee on Science, Engineering, and Public Policy (U.S.), 2007. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, D.C: National Academies Press.

CNN Political Unit. 2013. Obama: 'It is now our generation's task to carry on what ... pioneers began'. http://politicalticker.blogs.cnn.com/2013/01/21/obama-it-is-now-our-generations-task-to-carry-on-what-pioneers-began/?hpt=hp_t2

Cullinane, Jenna, Lacey H. Leegwater. 2009. *Diversifying the STEM Pipeline: The Model Replication Institutions Program*. Institute for Higher Education Policy, http://www.ihep.org/Publications/ publications-detail.cfm?id=132.

Executive Office of the President, President's Council of Advisors on Science and Technology. 2010. *Report to the President. Prepare and Inspire: K-12 Educations in Science,* *Technology, Engineering, and Math (STEM) for America's Future.* http://www.whitehouse.gov/ sites/default/files/microsites/ostp/pcast-stemed-report.pdf

Ferber, Dan. 2011. "Calling all teachers. Everyone agrees that the U.S. needs to train a new generation of inspiring science teachers. But how?" *HHMI Bulletin V. 24 (4),*http://www.hhmi.org/bulletin/ november-2011/calling-all-teachers. (info-graphic embedded in this article "*Sizing up preservice teacher training programs"* http://www.hhmi.org/node/19841)

Gamble, Jamie. 2008. *A Developmental Evaluation Primer*. Quebec: The J.W. Connel Family Foundation. http://www.mcconnellfoundation.ca/assets/Media%20Library/Publications/ A%20Developmental %20Evaluation%20Primer%20-%20EN.pdf.

Gardner, David, et.al. National Commission on Excellence in Education. 1983. A Nation *At Risk: The Imperative For Educational Reform. An Open Letter to the American People. A Report to the Nation and the Secretary of Education*. Washington, D.C.: Department of Education. http://files.eric.ed.gov/fulltext/ED226006.pdf

Glennan, Thomas K., Susan J. Bodilly, Jolene Galegher, and Kerri A. Kerr. 2004. *Expanding the reach of education reforms: Collected essays by leaders in the scale-up of educational interventions*. Santa Monica, CA: RAND.

Hall, Gene E., Shirley M. Hord. 2010. *Implementing Change: Patterns, Principles, and Potholes.* Upper Saddle River, NJ: Prentice.

Heilig, Julian V. and Jez, Su Jin., 2010. *Teach For America: A Review of the Evidence.* Boulder and Tempe: Education and the Public Interest Center & Education Policy Research Unit. http://epicpolicy.org/publication/teach-for-america

Hill, Laura G., Katherine Maucione, and Brian K. Hood. 2007. "A focused approach to assessing program fidelity." *Prevention Science* 8, 25-34.

Institute for Higher Education Policy. 2009. A Model of Success: The Model Institutions for Excellence Program's Successful Leadership in STEM Education. http://www.ihep.org/Publications/ publications-detail.cfm?id=53.

Institute for Higher Education Policy. 2009. *Diversifying The STEM Pipeline: Recommendations from the Model Replications Institutions Program*. http://www.ihep.org/ assets/files/publications/a-f/(Fact_Sheet)_Diversifying_the_STEM_Pipeline.pdf.

Kellog Foundation 2004. *Logic Model Development Guide*. Michigan: http://www.wkkf.org/ knowledge-center/resources/2006/02/wk-kellogg-foundation-logic-model-development-guide.aspx

Marder, Michael. 2009. *A Path to 10,000 Teachers for 10,000 Minds*. Austin, Texas: Unpublished paper.

Marder, Michael. 2012. *Failure of the U.S. Public Secondary Schools in Mathematics*. AASA Journal of Scholarship and Practice V 9 (Spring No.1, p. 8-24).

Marder, Michael. 2012. *STEM Landscape*. University of Texas at Austin: Unpublished Paper. Presentation is available at http://prezi.com/dqxnxul33hti/texas-stem-landscape/.

Marder, Michael. 2012b. *100,000 STEM Teachers in Ten Years: The UTeach Advantage*. University of Texas at Austin: Unpublished Presentation. http://bit.ly?MarderTTarg

National Academy of Sciences. Committee on Science, Engineering and Public Policy. 2007. *Rising above the gathering storm: Energizing and employing America for a brighter economic future. Committee on Prospering in the Global Economy of the 21st Century.* Washington, D.C.: National Academies Press. http://www.nap.edu.

National Center for Education Statistics. 2011. *Trends in International Mathematics and Science Study* http://nces.ed.gov/timss/results11.asp

National Center for Education Statistics. No date. *Fast Facts: What are the current trends in the teaching profession?* nces.ed.gov/fastfacts/display.asp?id=28

National Research Council (U.S.), Committee on Research Universities, and Board on Higher Education and Workforce, Policy and Global Affairs. 2012. *Research Universities and* *the Future of America: Ten Breakthrough Actions Vital to Our Nation's Prosperity and Security*. Washington, D.C: National Academies Press.

National Science Foundation. 2012. *Model Institutions for Excellence - PHASE III (MIE-III) (RFP)*. http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5739.

OECD. 2011. *Education: Sixteen countries and regions convened for first-ever international summit on the teaching profession to promote building, developing and sustaining world class teaching force.* New York: Organization for Economic Cooperation and Development.http://www.oecd.org/unitedstates/educationsixteencountriesandregionsconvenedforfirsteverinternationalsummitontheteachingprofessiontopromotebuilding developingandsustainingworldclassteachingforce.htm

Office of the Press Secretary, The White House. 2010. *President Obama Expands "Educate to Innovate" Campaign for Excellence in Science, Technology, Engineering, and Mathematics (STEM) Education.* http://www.whitehouse.gov/the-press-office/president-obama-expands-educate-innovate-campaign-excellence-science-technology-eng.

Patton, Michael Quinn. 2011. *Developmental Evaluation: Applying Complexity Concepts to Enhance Innovation and Use*. New York: Guilford Press.

Patton, Michael Quinn. 2012. *The Complex Ecology of Developmental Evaluation*. Expert lecture series held at the annual meeting of the American Evaluation Association, Minneapolis, MN. October 25.

Patton, Michael Quinn. 2012b. *Essentials of Utilization-Focused Evaluation*. Thousand Oaks: Sage Publications.

Poirier, Jeffrey M., Courtney Tanenbaum, Charles Storey, Rita Kirshstein, and Carlos Rodriguez. 2009. *The Road to the STEM Professoriate for Underrepresented Minorities: A Review of the Literature.* Washington D.C.: http://www.air.org/files/AGEP_Lit_Review_10-26-09.pdf.

Porter, Wayne, Mark Mykleby. 2011. *A National Strategic Narrative*. Washington, D.C.: Woodrow Wilson International Center for Scholars. http://www.wilsoncenter.org/sites /default/files/A%20National%20Strategic%20Narrative.pdf

Rising Above the Gathering Storm Committee (U.S.), National Academy of Sciences (U.S.), National Academy of Engineering, and Institute of Medicine (U.S.). 2010. *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*. Washington, DC: National Academies Press. http://download.nap.edu/cart/deliver.cgi?record_id=12999

Romero, Pamela, Martha P. Perez. 2012. "UTeach: Evaluating Adaptations in a STEM Educator Preparation Program–Next Steps: Incorporating a Developmental Evaluation Model to Assess Innovations, Fidelity and Sustainable Change." *Unpublished manuscript presented at the annual meeting of the American Evaluation Association, Minneapolis, MN*.

Rodriguez, Carlos, Rita Kirshtein, and Margaret Hale. 2005. "Creating and Maintaining Excellence: The Model Institutions for Excellence Program." http://www.air.org/files/MIE_Report _final.pdf.

Schwab, Klaus. 2010. *The Global Competitiveness Report 2010-2011*. World Economic Forum http://bit.ly/mGewli

UTeach Institute. 2013. *UTeach and UTeach Replication: Data Through Fall 2012*. Updated February 5, 2013. Austin: www.uteach-institute.org/files/uploads/uteach-replication-stats-2013feb5.pdf.

UTeach Program. 2012. *UTeach: A New Kind of Teacher Preparation Program.* UTeach Report (Academic Year 2012-2013). University of Texas at Austin.

U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey. 2013. "Public School Teacher Data File." *Number and Percent of public high* *school-level teachers teaching in and out of the field in which they majored in: 2007–08.* http://nces.ed.gov/surveys/sass/tables/sass0708_009_t1n.asp

Walker, Mary 2012. "UTeach, UTeach Replication and the UTOP (UTeach Observation Protocol) – Strategies to increase the quantity, long-term retention and diversity of science and mathematics teachers and tools to measure the effectiveness of high quality science and mathematics teaching." Washington D.C.: Presented at The Science and Mathematics Teacher Imperative (SMTI) conference on the *New Standards and STEM Education Reforms: Implications for Teacher Preparation*.

ABOUT THE AUTHORS

Martha Pérez: Martha, Evaluation Coordinator at the UTeach Institute, has dedicated over two decades to educational program evaluation and research. She has worked for educational agencies in the State of Texas and has also been a teacher in higher education environments. She currently works for the UTeach Institute, an Institute dedicated to the replication of a secondary STEM educator preparation programs, at the University of Texas at Austin.

Pamela Romero: Pamela, Associate Director of the UTeach Institute, earned an M.S. degree in community and regional planning from UT Austin. She brings more than 15 years of experience in planning and managing evaluation projects to the Institute where she oversees the development and implementation of comprehensive program evaluation services. Pamela has worked with state agencies, nonprofit and for-profit organizations, universities, and school districts, and she has a strong understanding of various educational and political settings.

The Journal of the World Universities Forum seeks to explore the meaning and purpose of the academy in a time of striking social transformation. The journal brings together university administrators, teachers and researchers to discuss the prospects of the academy and to exemplify or imagine ways in which the university can take a leading and constructive role in the transformations of our times.

Today, universities face significant challenges to their traditional position in society. Contemporary knowledge systems are becoming more distributed and learning ubiquitous. Where does this leave the university—as a historically specialized and privileged place for certain kinds of knowledge and learning, as an institutionally bounded space? What do these changes mean for the mission and structures of the renewed university? What are emerging as principal areas of the academic interest? These are some of the key questions addressed by the journal.

The Journal of the World Universities Forum is a peer-reviewed scholarly journal.

ISSN 1835-2030

ISBN 000-0-00000-000-0
00000
0 000000 000000