Change in Sustainability in Higher Education (CASHÉ):

National Science Foundation Math and Science Partnership Program

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Over the past decade, the federal government has established several incentive programs to help “prime the pump” and raise the stakes for colleges and universities to participate in P-20 STEM education reform, with a particular emphasis on engaging higher education faculty to lead these efforts. In 2002, Congress made an initial appropriation of around $160 million to the National Science Foundation (NSF), with additional funds to the U.S. Department of Education (ED) in 2003, to invest in Math and Science Partnerships (MSPs). By facilitating linkages between colleges and universities and K-12 school districts, MSP grants engage faculty in vital areas for improving science, technology, engineering, and mathematics (STEM) education, including K-12 teacher preparation, K-12 teacher professional development, and STEM curriculum reform at all levels. While such activities are not traditionally valued as “faculty work” in the academy—often regarded as outreach or service, but rarely as scholarship, particularly in the STEM disciplines—they are the foundation of these reform efforts nationwide.

NSF has funded 73 MSP projects, including “comprehensive” partnership projects that engage college and universities in broad-based reform efforts with K-12 school partners. The five key features of all MSP projects include: (1) challenging STEM courses and curricula; (2) enhancement of teacher quality, quantity and diversity; (3) partnerships among STEM teachers and faculty at all levels; (4) evidence-based course and curriculum design; and (5) institutional change and sustainability. The MSP initiatives recognize that to prepare the next generation of STEM professionals, we must have scientifically, technologically, and quantitatively literate K-12 teachers who are able to prepare college students in STEM fields.

**Purposes of the study**

Since 2002, the authors have been involved in these broader national efforts through two of their own NSF-funded MSP projects, and more recently, through a subsequent research supplement from NSF called Change and Sustainability in Higher Education (CASHÉ). CASHÉ studied the nature of change processes and outcomes among participating MSP colleges and universities across the nation, including the impact of the partnership activities on college and university faculty. This research suggests that faculty leadership is necessary for reform efforts of this scope and nature, but it is not sufficient to effect sustainable institutional change. On the other hand, institutional change cannot come about solely through administrative mandates or external calls for accountability. The evidence collected from this project suggests that faculty who lead these efforts often work outside of the established roles, norms, and boundaries of their institutions, at least initially. At the same time, there is evidence of real change in many institutions where faculty efforts have shifted from “marginal” to “mission-central” as a result of participation in MSP partnerships.

Recent alarms about America’s global standing and competitiveness have resulted in urgent national “calls to action” for developing a better trained workforce, a more scientifically literate citizenry, a stronger research and development infrastructure, and an expanded pipeline of students, educators, and other professionals in the STEM fields. Given this national and international context, increased attention has been paid to the role that colleges and universities—and their faculty—should play in strengthening the STEM education system and expanding the STEM pipeline, not just in higher education, but across the entire educational spectrum, including K-12. In many of these programs, higher education faculty have been called upon to play an active leadership role—by reforming courses and instruction at the college level, by getting involved in the preparation for future teachers, or by lending their expertise to the professional development of in-service K-12 educators. It is important to acknowledge that higher education faculty have a long history of grassroots involvement in educational reform. However, such activities are not traditionally valued as faculty “work” in the academy.

Research universities present one of the more challenging contexts for the emergence of this work, given the demands for research and scholarship that dominate institutional missions and cultures. Yet, the landscape is gradually shifting: faculty at many other types of four-year institutions are increasingly held accountable to similar incentive structures that reward faculty work in research universities. Additionally, community college faculty are frequently called upon to partner with K-12 schools through such activities as providing professional development workshops for teachers or offering content courses for teacher recertification. Even for community college faculty, however, K-12 involvement is not typically included in their academic workload.

Thus, faculty who participate in these initiatives—who are typically rewarded for research, scholarship, and teaching—are finding more of their time invested in activities that fall outside of the traditional boundaries for faculty work. While it is typically faculty members themselves—through the process of peer review for juried publications and tenure and promotion decisions—who determine the value and relative worth of the various strands of activity that define faculty work (Fairweather, 2002), it appears that for the most part, traditional faculty reward structures have not yet been recalibrated to incorporate these emerging roles and responsibilities (O’Meara, 2006). Without accepted standards for practice in the academy, it is difficult for deans, promotion and tenure committees, and faculty peers to actually evaluate the quality of faculty work with schools. By examining this phenomenon in the context of NSF’s MSP projects, our research seeks to build an emerging understanding of the role of faculty in such change efforts, as well as the complex interplay between faculty leadership, administrative leadership, and institutional culture and context.

**Theoretical frameworks**

This section reviews literature related to the researchers’ main assumptions about institutional change when developing our research study on the impact of the MSPs: 1) change in higher education requires more than top down leadership; 2) faculty leadership requires support from top down leaders; 3) institutional culture shapes change processes and leadership; and, 4) change processes may also require shifts in institutional culture to be sustainable.

**Difficulty of top down leadership efforts in higher education**

As Eckel and Kezar (2003) have observed, top down leadership efforts aimed at change are typically not successful in higher education due to the way that colleges and universities are structured. While traditional management theory and practice in the United States tend to be more top down and emphasize the role that individual leaders and organizational processes play in change, there are limitations to applying such frameworks that do not incorporate the unique cultural perspectives of higher education. Cohen and March (1974) characterized college and university environments as “organized anarchies” that are not receptive to top down leadership and hierarchy, and that operate similar to other professional bureaucracies with defining characteristics of a service mission, professionalism, goal ambiguity, problematic technology, and environmental vulnerability. Additionally, Weick (1976) likewise identified higher education institutions as “loosely coupled systems” with complex parts that are tied together frequently and informally rather than along tight linkages or hierarchical lines. Furthermore, Kezar (2001) identified a number of organizational characteristics of colleges and universities that make top down change processes difficult including their multiple power structures, distributed decision-making and authority, shared governance processes, professional and administrative values, and the presence of competing goals and outcomes. Such analyses all reinforce organizational complexities of colleges and universities and the need for distributed leadership to create change.

**The role of top down leaders**

Shared leadership models in higher education suggest that top down leaders may still be important to support bottom up leadership. This is particularly important in light of barriers related to faculty roles and reward structures that earlier research suggests may create barriers to faculty practicing grassroots leadership (Frank & Shapiro, 2007). Change processes in higher education can become protracted when grassroots leaders are distributed in various places across campus, and it often takes a positional leader with some level of authority to unify these efforts (Kezar, 2001). In addition, change efforts at the grassroots level often require top down support in order to be institutionalized, as they typically have broader administrative implications—including enhancements to infrastructure, development of new policies, and increased fiscal and human resources. This dilemma of blending top down and bottom up leadership is captured by Hearn (2006) in his research on leadership and change that identified one of the major challenges for institutional leaders as balancing external demands for accountability, which often call for executive style leadership, with more traditional processes of shared governance and distributed leadership on college and university campuses. Most academic leaders, including college presidents, have come up through the ranks of the faculty themselves, and therefore understand this unique cultural context of shared governance (Peck, 1983).

**The role of institutional culture and context**

One of the premises of this study is that organizational culture and the context for change in higher education play a significant role in shaping the extent to which faculty leadership in such areas as STEM educational partnerships is valued and rewarded. Kezar and Eckel’s (2002) study suggested that change processes in higher education are largely shaped by institutional culture. They found that while there are various general tactics or strategies that work to create change in organizations, change strategies in higher education seem to be most successful when they are contextualized for the specific institution. In examining 26 colleges and universities that were involved in varying types of institution-wide change initiatives, they found that institutional leaders are more successful when they choose strategies and tactics that are relevant and a fit with the culture. They observed that change strategies that consider institutional mission, history, and values are better positioned to facilitate change because they are more likely to resonate with members of the campus community and be met with less resistance.

Building on Kezar and Eckel (2002), Merton, et al. (2004) noted that organizational culture was a critical variable in understanding curricular change processes in undergraduate engineering education. Without a clear understanding of institutional culture before launching these curricular change initiatives, they saw faculty leaders struggling with such issues as persuading fellow faculty to use the new teaching innovations, gaining the necessary departmental and college level approvals, needing to create new structures to coordinate and sustain the programs over time, and keeping up with collaborative relationships across disciplinary and college boundaries. They observed, “the point is that there was no one strategy, no ideal change model, or no universal process that could be applied to each situation that would guarantee successful adoption of these new curricula” (Merton, et. al, 2004, p. 2). Rather, faculty members had to understand their institutional context well enough to know what approaches would be most effective, and implement culturally relevant strategies for overcoming obstacles and barriers when they arose. Frost and Teodorescu (2001) went a step further in their views of faculty curricular reforms at research institutions. They asserted that changes involving the curriculum and the teaching and learning environment should be considered as forms of institutional culture change in and of themselves, as these investments of faculty time and effort serve to enhance and legitimize the value that institutions place on such activities. These studies collectively suggest that change efforts in higher education are heavily shaped by shared governance and institutional culture.

**Changing institutional culture**

At the same time, neither top down administrative leadership nor faculty grassroots leadership may yield sustainable change or result in widespread adoption of new ideas or methods unless a cultural shift takes place in tandem with such developments. Gaining support for culture change is a complex process. Lewin (1951) and Schein (1997) noted that organizational culture must change or shift in such a manner that the desired state replaces the existing state. Applying these change perspectives to higher education, Ewell (1997) described institutional change as requiring constant and consistent leadership, a fundamental shift in perspective, individuals and organizations to relearn their roles, and systematic ways to measure progress and guide improvements. Further, Burack and Saltmarsh (2007) posited that in order for institutional changes to transform into institutionalized practices, they must become routine, widespread, legitimized, expected, supported, permanent, and resilient, rather than those that are marginalized, occasional, isolated, unaccepted, uncertain, weak, temporary, or at-risk. Likewise, Levine (1980), in examining the innovation process at 14 colleges and universities, stressed that innovation efforts in higher education do not tend to become institutionalized unless such changes are congruent with underlying shifts in culture and therefore consistent with institutional values, norms, and goals.

Additionally, it is important to note that the culture within STEM disciplines has been cited as a roadblock to change in reform efforts. STEM faculty themselves have stated that while their institutions may publicly support faculty involvement with K-12 schools and teachers, there are few incentives for faculty to substantively participate in such activities (Frank & Shapiro, 2007). The premiere rewards structure in the STEM disciplines is shaped by external funding for scientific research, development, and discovery. Work that does not directly contribute to this end is often viewed as a deterrent, particularly for tenure-track faculty. Furthermore, K-12 outreach has traditionally been seen as something that faculty in colleges and schools of education should be responsible for, rather than drawing from a broader base of institutional support and responsibility. This disciplinary lens adds yet another layer of complexity to the process of changing institutional culture, yet it is important to recognize the role and potential impact of the academic disciplines, each of which offers its own forms of faculty rewards, and shapes the professional identity of faculty members.

**Modes of inquiry**

From the outset, one overarching goal of the CASHÉ project was to “catch colleges and universities when they were doing something right,” and to identify both intermediate and conclusive indicators that suggest or demonstrate how colleges and universities can successfully engage in change activities that strengthen their support of K-12 mathematics and science education and teacher preparation. Some of the global questions that guided this work are:

* How do we identify key indicators of institutional change across different types of institutions, and what documentation can we provide to demonstrate the presence of these factors and evaluate these factors in a given context?
* What tools and instruments already exist to evaluate and recognize institutional change in higher education? In what ways are the tools and instruments being used? What new tools or instruments should be developed?
* Where do we see examples of sustainable P-20 partnerships and cultures of organizational support, and what can we learn from them? Where are there good examples from other kinds of organizations that might offer some insight into change in P-20 education?
* What can we learn about the contexts that make sustainable and intentional change possible in higher education? Where do gaps exist across different contexts and higher education cultures?
* What changes that have been supported by MSPs have made a difference in creating institutional conditions and capacity in higher education to support the reform of science and mathematics education and the meaningful engagement of faculty in this enterprise? How can we evaluate these changes?
* How can institutions of higher education provide incentives and rewards to stimulate and motivate faculty so that creative teaching and pedagogical scholarship becomes part of faculty culture?

**Data sources**

The data informing this study included a broad range of quantitative and qualitative sources collected in some cases by researchers, in some cases by external evaluators, and in other cases by MSP project participants themselves (i.e., faculty and administrators). The researchers also conducted site visits with six MSP projects (comprehensive, targeted, and institute) at various types of institutions and at various stages of progression and implementation. Data sources included site visitor reports, interview notes and transcripts, and various project artifacts (e.g., annual reports, project-related publications). The researchers formed descriptive categories for the data and tracked emerging themes across various data sources. They conducted a series of within-case analyses that examined unique patterns within each of the MSP project sites that were visited, as well as an overarching cross-case analysis that examined common themes as well as points of departure across the six MSP project sites. The findings were presented to the CASHÉ project’s external Advisory Board, which discussed and developed recommendations, implications, and next steps based on the research findings.

**Results**

CASHÉ staff attempted to synthesize the findings and observations it made during the grant. The findings and observations are drawn from the broad work undertaken by CASHÉ. Seven themes emerged:

**Theme 1: Backdrop of Institutional Culture/Context**

***MSP’s requirement for an increased role for higher education in K-12 STEM education surfaced conflicting beliefs regarding fundamental institutional priorities.*** By design, MSP grants have fostered strong linkages between colleges and universities and K-12 schools and school districts, and have engaged faculty in high-impact activities designed to strengthen K-12 STEM education. This increase in higher education’s participation in K-12-related activities, a requirement of the MSP program, has exposed campus conflicts regarding the institution’s definition and understanding of its fundamental priorities. On many MSP campuses there are tensions between the goals of increasing research standing and institutional prestige and the MSP-related priorities of STEM teacher recruitment, preparation, and professional development; partnerships with K-12 schools; and undergraduate education.

***On campus, MSPs catalyzed discussions that focused on shared responsibility for the recruitment, preparation, and professional development of K-12 STEM teachers.*** Some MSPs were successful in promoting cross-campus discussion, collaboration, and action related to core challenges associated with the recruitment, preparation, and professional development of STEM teachers. MSP projects expanded responsibility for addressing these challenges beyond the institution’s college/school of education to the broader academic community, specifically to the STEM disciplines on campus. Although cross-campus communication and collaboration on aspects of K-12 STEM teaching have increased, there are indicators that institutions have lagged in efforts to promote K-12 STEM teaching as a viable and honorable career to their undergraduate STEM majors.

***Higher education’s involvement in an MSP raised awareness of education as a “closed loop” system.*** As institutions of higher education worked more closely with school districts and schools within the framework of an MSP, they more clearly understood the notion of a “closed loop” education system. Many faculty moved beyond criticizing the quality of incoming students to a realization of their role in preparing the majority of K-12 teachers who teach these students. They recognized and accepted this role and were more open to collaborating with their K-12 partners to improve P-20 teaching and learning. The MSP provided higher education institutions the needed inroads into K-12 schools and K-12 schools the needed inroads into higher education institutions. In some cases, the acceptance of P-20 as a closed loop system resulted in activities that were not originally envisioned in the MSP’s scope of work. Most notably, some MSPs tackled the problem of P-20 curriculum alignment.

**Theme 2: Role of MSP Project Leaders**

***The emergence and sustainability of MSP projects depended on a few key faculty leaders.*** Key faculty leaders with a pre-MSP history of collaboration both within and across institutions, and in some cases with K-12 partners, were better able to guide the emerging MSP collaboration and to address the question of the project’s sustainability. Some MSP faculty leaders were seen as “academic entrepreneurs” capable of forging new relationships, creating revenue-generating programs, aggressively pursuing additional funding, and creating new organizations either inside or outside their home institution to house the work of the MSP. Many were described as “paving the way” for new faculty positions such as faculty appointments with a research focus on teaching and learning in the discipline.

***NSF’s decision to limit MSP principal investigator appointments to STEM faculty raised concerns about limiting MSP leadership capacity.*** While seeking to engage STEM faculty more fully in the work of the MSP program, NSF’s decision to require a STEM faculty member as principal investigator could eliminate the most experienced and qualified academic leader with the greatest potential for developing a successful MSP from assuming the leadership role. It also could prohibit future projects from residing in a campus structure, such as cross-functional administrative unit or at a university system level, which is best suited for engaging cross-campus collaboration on MSP work. Experience shows successful MSPs were guided by key leaders from across the academic spectrum and that some of the “academic entrepreneurs” mentioned above were not STEM faculty members.

***The MSP project has produced a community of faculty leaders from across the nation who are steeped in the knowledge and experience of MSP project work.*** There is a growing network of MSP faculty leaders who have specific expertise in doing MSP project work and who often turn to each other as peers for validation and support. One of the perceived benefits of the MSP community is that MSP leaders have frequent opportunities to convene, both face-to-face and online, in order to share evidence and best practices in a public forum. The MSP project has produced a cadre of leaders steeped in the knowledge and experience of MSP project work and accustomed to sharing that knowledge and experience with other undertaking similar projects across the nation. This cadre has the potential to support, inform, and promote MSP work at institutions of higher education not yet involved in the MSP enterprise.

**Theme 3: Impact of Institutional Leadership and Support**

***Both top-down and bottom-up leadership models emerged on MSP campuses.*** Some MSPs took a bottom-up approach to initiate change, with faculty leaders working at the grassroots level to move the MSP agenda and partnership forward. In other cases, campus administrative leaders served as the activators who led the MSP charge and developed specific strategies for engaging faculty at the grassroots level.

***Department chairs and school/college deans greatly influenced the acceptance of the MSP on campus.*** Department chairs and school/college deans were frequently mentioned as important agents – either positive or negative – in shaping the institutional climate for MSP work. Changes at this level of leadership (which occur frequently) can have a profound impact on how MSP work is viewed and valued both by the home department and by the broader campus community.

***Faculty recognition by the institution promoted MSP participation and program sustainability.*** There was widespread acknowledgement of the importance of faculty recognition by institutional leaders for participation in an MSP without specific commitments of whether or how this work would be looked upon in promotion and tenure decisions. The recognition suggested included financial incentives, special awards, and professional acknowledgement within and beyond the campus community.

***On campus, MSP work was more likely viewed as public service outreach rather than as a core educational mission of the institution.*** When asked, many institutional leaders drew the direct connection between the MSP work on campus and the institution’s public service outreach mission fulfilled through working with K-12 schools. MSP connections to the academic enterprise or to the core educational mission of the institution were not as explicitly seen or understood.

**Theme 4: Investment and Motivation of Participating Faculty**

***Many MSP faculty participants had a long-term history with K-12 outreach activities prior to the MSP project.*** Many participating faculty members already had long-term leadership and involvement in NSF-funded K-12 programs and projects similar to MSPs. Few faculty participants were encountered for whom the MSP was their first introduction to this type of work, which potentially raises questions about the challenges of bringing new faculty into MSPs and other types of P-20 activities. Many faculty members cited a personal interest or connection that originally got them involved in work related to K-12 education—children in the public schools, a spouse or parent who was a teacher, having some K-12 teaching experience in their background.

***Many STEM faculty come to appreciate and rely on work with K-12 as a way of being able to demonstrate “broader impact” (Criterion 2) in their NSF proposals.*** On some campuses, the MSP project was valued as a place for engaging STEM faculty in the demonstration of the “broader impact” of their NSF proposals and research. Rather than having to go out and forge new relationships and partnerships on their own, STEM faculty were able to link into a network of ongoing MSP activities, with colleagues who already had expertise and experience working with K-12 schools. The convergence of these activities suggests a unique opportunity for the institutionalization of MSP efforts.

***There was a notable absence of tenure-track faculty participation in MSP projects.*** The ranks of the faculty involved in MSP project were primarily filled by already tenured senior faculty members and non-tenure-track faculty members, while just a few junior faculty “stars” were carefully balancing their discipline research with MSP work. This suggests that MSP involvement continues to be viewed as a risky professional endeavor for pre-tenured faculty. Campuses were at various stages in determining if there was a “career trajectory” for tenure-track faculty in STEM whose focus was on teaching and learning in the discipline.

***Some MSPs produced outcomes related to teaching and learning on college and university campuses that were rarely addressed in the MSPs original scope of work.*** Providing support for faculty to work on undergraduate course redesign, student learning assessments, or targeted improvement of their teaching was an important “hook” for engaging faculty in MSP work, yet was rarely a part of the original design of any of the MSPs. Examples of unintended, yet welcomed outcomes included the initiation of faculty fellows programs, faculty learning communities, and professional development workshops for faculty. In more than one case, MSP-supported redesign of teacher preparation courses influenced redesign efforts in content courses in the STEM discipline. The MSP-related work undertaken on college campuses suggests the importance of differentiated faculty roles in MSP projects. Not every MSP faculty participant will be directly involved with K-12 teachers or students, some MSP faculty will labor to initiate and promote changes on campus that directly influence STEM teaching and learning in K-12 education. This suggests that K-12 STEM education reform can provide fertile soil for higher education STEM education reform.

**Theme 5: Structural Changes that Supported and/or Resulted from MSP Work**

***On many campuses, MSPs created or expanded an infrastructure for targeted and sustained collaboration on STEM education between higher education, including STEM faculty, and K-12 teachers, schools, and districts.*** There was a realization that no formal mechanism existed that allowed for free and equitable communication and collaboration between STEM faculty and K-12 teachers, schools and school districts on matters related to K-12 STEM education. Without dedicated supports and structures, collaboration between these two education entities rarely happened naturally or spontaneously. Prior to the MSP program, many P-20 collaborations were forged and maintained almost exclusively by college/schools of education with little or no participation by STEM content faculty. As an outgrowth of MSP, some institutions created (or built upon existing) multi-disciplinary STEM centers or partnership outreach offices to facilitate and sustain the work of the MSP. The MSP program represents a shift in thinking about a campus’s scope of responsibility in working with K-12 on matters related to STEM teaching and learning.

***Some MSP institutions of higher education established new faculty positions to facilitate and sustain the work of their MSP.*** Institutions created “boundary spanning” faculty positions including joint faculty appointments, education appointments in STEM departments, and the reverse, STEM appointments in education departments. Some institutions intended to increase these types of appointments as institutional funding became available, as these appointments were seen as pivotal to sustaining MSP work in the long term. Such positions also served as an important entre into interdisciplinary work at the institution. MSPs have the potential to serve as a national model for learning about the support and management of interdisciplinary faculty teams, as well as for evaluating, rewarding, and advancing interdisciplinary work in higher education.

***MSPs gave rise to a variety of learning networks that linked all P-20 MSP STEM practitioners.*** MSPs fostered the establishment and growth of formal and informal professional networks and learning communities focused on the work of MSPs. In addition to linking participants within the K-12 teaching community or connecting MSP faculty on a campus, these networks/communities reached across not only the K-12/higher education divide, but successfully connected participants in different disciplines and on different campuses.

***Cross-campus collaboration on MSP work varied across sites and was directly related to the support of key administrative leaders.*** There was variation across MSP sites in terms of the degree of formal collaboration related to MSP work (or to the topic of teacher preparation in general) between faculty in colleges/schools of arts and sciences and faculty in colleges/schools of education. This was often attributed to the influence and buy-in of individuals in key positions – deans and departments chairs—and to the degree of collegiality of their working relationships.

**Theme 6: Course and Curricular Changes that Supported and/or Resulted from MSPs**

***MSP work drove the review of and, in some instances, significant changes in campus offerings related to the preparation and support of STEM teachers.*** New programs, new courses, and new pathways for initial teacher certification, as well as new professional develop programs for teachers are now in place on some campuses as a direct result of MSP support.

***STEM curriculum alignment was an outgrowth of the work of some MSPs.*** In response to identified gaps in STEM achievement at key transition points, some MSPs attended to curricular alignment in STEM to combat these gaps as students transition from elementary school to middle school to high school and into higher education.

***MSP work generated unexpected changes in STEM undergraduate courses and curricula.*** Increased numbers of STEM faculty involved in MSP work generated unexpected interest in the relationship of teaching and learning in K-12 to teaching and learning in higher education. As a result, several MSP projects initiated significant content and pedagogical changes in undergraduate STEM courses and curricula, changes not planned for in the MSPs original scope of work. Specific examples include the infusion of inquiry-based methods of instruction, collaborative learning/group-based work, more frequent classroom assessments, and undergraduate learning assistants.

**Theme 7: Question of Sustainability**

***It was recognized that MSPs require a long-term investment and commitment by higher education institutions; sustainability plans of most MSPs depended on securing additional external funds.*** There was a collective realization that MSPs are not designed as “quick fixes” and that higher education involvement in K-12 requires a long-term investment that is built upon a history of collaboration and trust. The predominant institutional sustainability plan for MSP work was to secure additional external funding from NSF or an alternative funding source.

***Higher education partners identified several categories of MSP initiatives with a high potential for sustainability beyond the initial funding period.*** There were several categories of MSP investments that MSP higher education faculty considered to be the most sustainable: reformed courses for STEM undergraduates, new academic programs for teacher preparation, new professional development courses focused on content and pedagogy, creation of STEM centers or similar campus structures to house cross-disciplinary collaboration and partnership work, joint appointments, and policy and regulatory changes such as new pathways to certification and changes in K-12 curriculum standards or assessments.

***The key to MSP sustainability was often couched in terms of relationship- building while recognizing the challenges imposed by decreased funding over the long term.*** The person-to-person networks and relationships that had been built through the MSP were seen as the cornerstones supporting the continued commitment to the MSP work beyond the initial funding period. The investments that were made in individual participants were seen as investments in intellectual/human capital that would continue to pay out, while the new courses and programs what were initiated would increase the capacity of higher education to be responsive to the needs of K-12. At the same time, the most frequently cited challenge to sustainability was maintaining the viability of these new courses and programs without access to the same level of funding to involve teachers and faculty, especially during difficult economic times.

**Significance of the study’s findings and implications**

MSPs have been parlayed into initiatives with a broader scope and higher visibility, often operating at regional or state levels. As this study unfolded, we came to appreciate an evolving dialectic between our two key areas of inquiry, change and sustainability. The factors in the MSP projects that fostered changes in courses and curricula, partnerships with public schools and innovative pathways to teacher preparation and certification came into conflict with the forces that exist on university campuses to preserve proven structures of knowledge management and dissemination such as tenure and promotion policies, college, departmental and disciplinary course policies, and academic calendar-driven programs. Under these conditions, change is predictably deliberate at best. When, however, changes become institutionalized—and sustainable—they can have a profound impact.

Where, for example, an MSP provided the initial funding for a partnership to establish a new Master’s level program for teacher certification, we recognize how one-time funding can lead to a self-sustaining partnership with a school system that generates revenue for the institution while providing high quality STEM teachers for K-12 classrooms. The “jump start” from NSF through MSP catalyzed sustainable change.

The “broader impact” criterion in NSF proposals—linking research funding with education, outreach, and benefits to society—is one such means to encourage and support STEM faculty engagement. As this study unfolded, we looked for sustainable changes in tenure and promotion policies, but with the exception of the Georgia Board of Regents policy on “Faculty Work in the Schools,” we did not encounter specific examples of newly created institutional or system-level policy changes that were designed to support, reward, or sustain faculty engagement in MSPs (or in MSP-related P-20 work). We attribute this major policy change to multiple factors, including the general education context in Georgia that has supported P-20 work over the past 20 years. MSP came along at the right time to institutionalize work that had a long track record at the University System.

Establishing the expectation and a track record for faculty who engage in the scholarship of teaching and learning and in work with K-12 schools is a pathway to sustainable changes, and needs to be supported and encouraged. The “broader impact” criterion in NSF proposals—linking research funding with education, outreach, and benefits to society—is one such means to encourage and support STEM faculty engagement. Through our MSP research, we found other examples of dedicated tenured faculty and non-tenure track faculty who were serving in a variety of unique positions, including outreach professors, discipline-based education researchers, joint appointments, and clinical faculty who worked directly with school partners. We also encountered uniquely positioned university leaders, such as Freeman Hrabowski (UMBC) and Diana Natalicio (UTAustin) who prompted us to ask the question—is long service or stability in office a necessary condition for fostering a culture of change on a campus?

Thus, while higher education institutions are structured to preserve/sustain what exists, we found many examples of a receptivity to change, given the right motivation, institutional context, and leadership. We have arrived at a set of recommendations based on our research, that we believe can be game-changers. The recommendations that follow are directed to three different audiences: The National Science Foundation: college and university leaders, and college and university faculty.

**Recommendations for policy and practice for targeted stakeholders**

**For the National Science Foundation**

1. Continue to fund a variety of types of two-year and four-year colleges and universities within the NSF MSP portfolio. This will maximize the dissemination of evidence-based best practices from MSP across higher education, and demonstrates the value of the diversity of institutional types and missions. (Theme Area #1: Institutional Culture and Context)
2. Reconsider the requirement that MSP principal investigator eligibility be limited to faculty members in the STEM disciplines. Our work suggests that there are a number of different leadership models for implementing successful MSP projects on college and university campuses. (Theme Area #2: MSP Project Leaders)
3. Help MSP projects more intentionally plan for institutional commitment and sustainability on the front end of the award, by including criteria for such in the initial grant proposal and requiring a progress report to be filed with the annual project report. (Theme Area #7: Sustainability)
4. Explicitly establish expectations in future RFPs for higher education faculty to utilize the knowledge and experience gained in working in K-12 through MSP as a catalyst for curricular and pedagogical changes in undergraduate STEM courses. (Theme Area #4: Participating Faculty; Theme Area #6: Curricular Changes)
5. Strengthen NSF’s commitment to the advancement of undergraduate STEM education by providing benchmarks and models for faculty research proposals to NSF that specifically address undergraduate STEM education through the “broader impact” criterion. (Theme Area #4: Participating Faculty)
6. Building on experience from MSP, develop a policy on STEM teacher preparation at NSF that positions it as a cross-campus activity involving collaboration between STEM faculty, education faculty, and K-12 educators. This will create the rational and framework for institutions that want to engage in transformative work, but need a justification and rationale. (Theme Area #7: Sustainability)
7. Promote the scholarship of teaching and learning in the STEM disciplines as an important contribution to the faculty tenure and promotion portfolio. (Theme Area #4: Participating Faculty)
8. Continue to invest in the MSP KMD infrastructure—knowledge management and dissemination—as part of NSF’s mission around STEM teaching and learning. In particular, partner with other federal agencies, discipline societies, and accrediting organizations to move the conversation to the highest levels of leadership and to the broader community, including higher education institutions and K-12 school systems not participating in the MSP program. (Theme Area #7: Sustainability)

**For College and University Leaders**

1. It is important for colleges and universities to examine their core strengths before committing to an MSP project. MSPs should align with institutions that envision themselves first and foremost as leaders in undergraduate education with a strong commitment to K-12 education. If an institution seeks to be something else, then an MSP may not be best situated there. (Theme Area #1: Institutional Culture/Context)
2. Because the visibility and recognition that they give to their MSP and participating faculty make a difference, presidents, provosts, and deans should make a concerted effort to know more about this work and to publicly recognize those faculty involved in it. They should publicize faculty work with K-12 schools as valuable in its own right, as well as being important in increasing the success of other NSF funding proposals by demonstrating broader impact. (Theme Area #3: Institutional Leadership and Support)
3. Institutional leaders should ensure that STEM teaching and learning is a priority in the institutional strategic plan in order to value and prioritize such initiatives as MSP, as well as to expand the campus’s responsibility for preparing K-12 teachers and supporting K-12 education beyond colleges/schools of education. (Theme Area #3: Institutional Leadership and Support; Theme Area #5: Structural Changes)
4. Institutional leaders should know that their leadership in facilitating cross-disciplinary collaboration (e.g., between education and arts & sciences) around MSP and related STEM teaching and learning priorities is important. This may involve elevation to a campus-level group or structure (e.g., committee, center, etc.) in order for such collaboration to be sustained over time. (Theme Area #3: Institutional Leadership and Support; Theme Area #5: Structural Changes)

**For Higher Education Faculty**

1. With well-respected, well-established STEM leaders taking the lead and serving as role models, faculty and professional societies should establish mechanisms to support P-20 education that are comparable to practices and policies inherent in the research enterprise. (Theme Area #4: Participating Faculty)
2. Create opportunities for career advancement and expanded leadership capacity among non tenure-track faculty, adjunct faculty, and non-faculty academic administrators who are proactively working with MSP and related areas of STEM teaching and learning. (Theme Area #4: Participating Faculty)
3. In departmental and institutional self-studies, document how work with K-12 teachers and schools through MSP has implications for pedagogical improvements in undergraduate education. (Theme Area #4: Participating Faculty; Theme Area #6: Curricular Changes)

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