Transforming Institutions: Accelerating Systemic Change in Higher Education

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Edited by Kate White, Andrea Beach, Noah Finkelstein, Charles Henderson, Scott Simkins, Linda Slakey, Marilyne Stains, Gabriela Weaver, and Lorne Whitehead.

About the Accelerating Systemic Change Network (ASCN)

The Accelerating Systemic Change Network (ASCN) is a network of individuals and institutions, formed with the goal of more quickly advancing STEM education programs. Our unique approach is to bring together those who are researching systemic change at higher education institutions, with those who are making systemic change happen at their individual institutions. By closing the loop between researchers and change agents, we aim to accelerate change at program and institution levels, and to improve STEM education nationally. ASCN hosted the 2019 Transforming Institutions conference. Find out more at www.ascnhighered.org.

About Transforming Institutions

The Transforming Institutions conferences and book series began with the first convening in 2011 at Purdue University, organized by the Discovery Learning Research Center (DLRC). The meeting sought then, as it still does, to bring together researchers, academic leaders, national organizations and funding agency representatives to discuss the practical aspects of changing institutional practices to align with the large body of evidence in the field. The second conference took place in 2014 in Indianapolis, still under the primary sponsorship of the DLRC at Purdue University. In the following year, the first volume of *Transforming Institutions* was published. Because the conversation about transformation of institutional practices in STEM education was quickly becoming a national one, and due to the contemporaneous establishment of the ASCN, the *TI* conference and its associated book series now exist under the umbrella of that organization.

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Suggested citation

White, K., Beach, A., Finkelstein, N., Henderson, C., Simkins, S., Slakey, L., Stains, M., Weaver, G., & Whitehead, L. (Eds.). (2020). *Transforming Institutions: Accelerating Systemic Change in Higher Education*. Pressbooks. http://openbooks.library.umass.edu/ascnti2020/

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Introduction

NOAH FINKELSTEIN

This volume of *Transforming Institutions* follows from and builds on its predecessor of five years ago (Weaver et al., 2015). The original volume specified a charge to our communities to create a “new normal” where expectations and behaviors in higher education courses would enact student-centered, inclusive, and evidence-based practices. Decades of scholarship from at least three diverse communities of research and practice—STEM/discipline-based education researchers, faculty development researchers, and higher education studies—have come to similar conclusions. Collectively, we know which practices support student success. We know how to support and develop faculty to enact these practices. We know about the complex structures that shape our practices within our colleges and universities and how these intersect within and beyond our campuses. And, instead of sitting in isolation, these communities have begun to engage in dialog, focusing on promoting this new normal by working at a systems level, linking the complex and often isolated elements of our educational enterprise.

The needs, promises and challenges of higher education are well outlined in the original volume and, if anything, have become more acute over the last five years. Higher education is among the most valuable forms of investment for individuals in their own lives and for societies in their collective welfare. A college degree is associated with a higher quality, healthier, more lucrative, and more civically engaged life. Institutions of higher education are mechanisms for a society to invest in its own future—building on inclusive democratic ideals, creating essential new forms of knowledge and associated technologies, enhancing capacities of communities, and seeding economic prosperity for states and countries.

In parallel with such promise, the documented pressures of finances, public will, technologies, and equity and inclusion for our institutions of higher education have grown in recent years in the United States. Finances remain a major shaper of the landscape. Continued state disinvestment in our public systems, operational challenges and costs across all sectors, and the pressures of the COVID-19 pandemic suggest that there will be a contraction and consolidation in the number of higher education providers. In parallel, the neoliberal framing of higher education as a private opportunity versus a public good continues to commodify and limit the goals of an undergraduate degree. This framing simultaneously shifts the burden and costs of education to the individual from its historic support by the state, and only captures a fraction of the value and purposes of higher education. As noted in the prior volume (Slakey & Gobstein, 2015), motivators for and financial impacts of transformations are largely decoupled; new models must attend to the shifting financial structures and political landscape of higher education. Technologies continue to serve as a double-edged sword—in many cases enhancing the quality and practices of higher education (supporting personalized learning, enabling more effective in-person meetings, and reaching students otherwise excluded from our educational system) while in other cases raising serious concerns (exacerbating inequities, reducing individualized support, depersonalizing the educational experience). For example, technologies have not always lived up to the touted promises of higher quality, lower cost, and more accessible forms of education. MOOCs have not replaced our classes (or in the instances where they have, they recapitulate the lower quality educational practices of stand-and-deliver lecture), and the early 2020 academic moves to online/remote education were met with dissatisfaction from students and teachers alike. These moves to online environments often disproportionally disadvantage first-generation, low-income, Black, Latinx, indigenous, and others from under-represented populations in STEM fields and higher education. As we sit in times of dramatic change and potential for a more socially just and equitable society, our classrooms remain key portals for change. In the last five years, there has been increased attention to building diversity, equity, and inclusion into our educational culture– leading with inclusive practices that then support student-engagement, rather than vice versa.

While many of the themes of challenge and opportunity from the original volume remain, it is important to acknowledge the significant strides we have made and the longer arc of history that we are a part of. The modern dramatic growth in higher education can be traced to post-World War II investments—including the GI Bill and the founding of the National Science Foundation. Decades later, the 1980s saw a shift to *science for all* from previous goals to support the best and brightest. In the early 2000s, we saw the emergence of STEM (following the short-lived SMET acronym) to emphasize economic and workforce needs, which remains dominant in today's public discourse around the value of higher education. As noted in the prior volume, the 2010s (and 2012 in particular) were a critical time in the STEM enterprise—2012 and surrounding years saw key initiatives and reports from the White House (President's Council of Advisors for Science and Technology, 2012), the National Academies (National Research Council, 2012) and professional organizations (the Association of American Universities [AAU]'s STEM Education Initiative [AAU, n.d.], and Association of Public & Land-Grant Universities [APLU]'s evolving efforts in STEM education and the Network of STEM Education Centers [APLU, n.d.]). Of course, it is worth noting the many antecedents to these initiatives including: AACU/PKAL (American Association of Colleges & Universities, n.d.), Project 2061 (American Association for the Advancement of Science, n.d.), and others.

Prior to the 2010s, higher educational change efforts focused largely on individual innovations and development of individuals' capacities. This essential work created a breadth of tools and approaches for building more effective and inclusive practices. It also came with the presupposition that disseminating the results from these educational innovations would lead to sustained, systemic change. But as we have discovered, they have not. Over the last decade or so, there has been a significant broadening of the landscape of higher educational innovation, particularly in STEM. In addition to continuing to develop models of quality practices and curricula, there is a greater emphasis on the human elements of change, institutional context and culture, bringing research into practice, and systems thinking. Such shifts can be observed in the evolution of funding lines, and nowhere is that clearer than within one of the leading drivers of STEM education transformation, the National Science Foundation (NSF). In the mid-1980s to 1990s, the NSF Instrumentation and Laboratory Improvement (ILI) program focused on new tools for educational practice (as microcomputers were developing promise educationally). It evolved into the broader Course Curriculum and Laboratory Improvement program (CCLI). Combined, these programs provided decades of work to ensure effective tools and practices. However, they focused on dissemination of good ideas as a theory of change and scaling. As such, scaling and sustaining of these innovations were limited. Subsequent initiatives, Transforming Undergraduate Education in STEM (TUES), the short-lived Widening Implementation & Demonstration of Evidence Based Reforms (WIDER), and the now-coalesced Improving Undergraduate STEM Education (IUSE) calls for proposed work have evolved to consider and require more robust models of change, sustainability, and scaling. Theories of change are now *expected* in order to obtain funding; those proposing innovations need to provide plausible models for change and how the particular efforts sit within their larger contexts.

While there is an observable narrative arc in approaches to improving undergraduate (STEM) education, such an arc is the product of intentional work and focus—of change leaders, disciplinary societies, professional organizations and funders. The NSF and many others (e.g., Howard Hughes Medical Institute, Sloan, and the Helmsley Trust) have been intentional about shaping the direction of research and programmatic efforts through the language of their calls. These have helped move from impacts at the individual course or department level to systems change, and have required that researchers and change agents make explicit their theories of change. Funders, as well as professional and disciplinary societies are also broadening our view of what the focus of change ought to be, for example to be more equitable and inclusive, and to consider new modalities of education. A great indication of this shift to a systems and holistic view is the National Academies of Science Engineering and Medicine's convening, the *Imagining the Future of Undergraduate STEM Education Symposium*, scheduled for Fall 2020.

As higher education shifts due to the pressures of finances, public will, technologies and diversity, inclusion and equity, a systems approach—one that recognizes the complex elements and wide range of actors (including our students)—is necessary. This volume presents theories, practices, and models to support such an approach. The volume is designed to be a practical guide for those engaging in change. It is a snapshot (though not exhaustive) of key initiatives at various stages of maturity in the current era. It provides an onramp for those seeking to engage in institutional transformation. It provides a wealth of data and case studies for those engaged in advancing our theories of change and institutional transformation in higher evaluation. As mature projects adapt to the changing landscape of higher education and grow into different stages of change, we provide resources and examples to consider. For funders and policy makers, this volume demonstrates what can happen, what might happen, and areas for influence—such as supporting systemic change and connecting practical interventions to theoretical bases for transformation.

This volume is composed of three parts: *Theories of Change*, *Change Across Scales,* and *Change Leaders/Leadership*. Across these three sections, the volume contains a mix of case-studies, models, and analysis of programs. While not exhaustive of the space of institutional change, these three lenses (theories, scales, and leaders), provide key perspectives for understanding and effecting any change initiative that seeks to advance undergraduate (STEM) education. In the last volume of this series (Weaver et al., 2015), there were explicit calls for more attention to theories of change; since then, and as noted, funders have been more explicit about requiring efforts to draw from theories of change. The first section provides seven chapters that explore a span of approaches to and utilities of theories of change. With descriptive studies and examples from both theory and practice, authors provide case studies for change, identify key themes that run across theories, and call for new and multiple theories of change.

In the second section, *Change Across Scales*, the chapters all have a foundation related to networks and networking as an essential approach. The studies vary in intentionality, scale, and drivers of these networks, suggesting the importance of attending to the wide and interacting facets of the enterprise of undergraduate education. Studies span scales from faculty development, to clusters of departments, to institutions, to national networks. In parallel, the intentionality of these networks varies from the implicit, to the opportunistic, to planned and constructed. Related to scale and form of intentionality, these chapters explore a span of drivers and motivators for change initiatives. Drivers range from centers and campus, to professional organizations, to funders. Each scale, form of intentionality and driver provides benefits and constraints in attending to institutional change, perhaps suggesting that a span of these approaches may be particularly helpful.

While this volume focuses on systems for change, change is engaged by people. The third section, *Change Leaders/Leadership*, explores the roles of individuals and institutions in leading change. The collection of chapters considers the wide array of actors who promote change—individual instructors, specialized embedded experts, department heads, deans, campus leaders and, importantly, students. The examples present collaborative relationships, grassroots development, and top-down approaches. Among these studies, we capture a picture of institutional change across scales from individual classrooms to campuses to consortia of organizations. Each example documents the key actors and associated models for change that promote a collective vision for sustainable, scalable, student-centered, evidence-based inclusive practices in higher education.

In reading these chapters, which review current theories, models, and case studies of transformational change, readers may consider the next steps and issues facing our higher education institutions. How might our institutions seek to employ more inclusive and equitable practices systemically, building on current work of Sloan Equity and Inclusion in STEM Introductory Courses (n.d.), SEA-Change (n.d.), NSF INCLUDES efforts such as Inclusive Graduate Education Network (n.d.) and the Aspire Alliance (n.d.), and many others who are studying and promoting more inclusive, equitable and diverse environments? How can we navigate the new models of online and remote educational practice that are being developed, promoted, and tested in the COVID era? Given the current emphases of national funding structures (e.g. that focus on convergence, quantum information, artificial intelligence, big data, and internationalization), how do our higher education institutions promote these capacities and at the same time ensure inclusive and ethical approaches?

References

American Association for the Advancement of Science. (n.d.). *Project 2061*. AAAS. https://www.aaas.org/programs/project-2061

American Association of Colleges & Universities. (n.d.). *Project Kaleidoscope (PKAL)*. American Association of Colleges & Universities. https://www.aacu.org/pkal

Association of American Universities. (n.d.). *Undergraduate STEM Education Initiative*. Association of American Universities. https://www.aau.edu/education-community-impact/undergraduate-education/undergraduate-stem-education-initiative

Association of Public & Land-Grant Universities. (n.d.). *Projects & initiatives: STEM education*. Association of Public & Land-Grant Universities. https://www.aplu.org/projects-and-initiatives/stem-education/

Aspire Alliance. (n.d.). *Aspire: The national alliance for inclusive & diverse STEM faculty*. Aspire Alliance. https://www.aspirealliance.org

Inclusive Graduate Education Network. (n.d.). *The Inclusive Graduate Education Network (IGEN)*. IGEN. http://igenetwork.org

National Research Council. (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. (S.R. Singer, N.R. Nielsen, & H.A. Schweingruber, Eds.). The National Academies Press.

President's Council of Advisors for Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. https://files.eric.ed.gov/fulltext/ED541511.pdf

Sloan Equity and Inclusion in STEM Introductory Courses. (2020). *SEISMIC overview*. SEISMICproject.org. https://www.seismicproject.org/about/overview/

Slakey, L., & Gobstein, H. (2015). *Toward a new normal*. In Weaver, G. C., Burgess, W. D., Childress, A. L., & Slakey, L. (Eds.), *Transforming institutions: Undergraduate STEM education for the 21st century* (pp. 485–496). Purdue University Press.

SEA Change. (n.d.). *See change with STEMM Equity Achievement*. American Association for the Advancement of Science. https://seachange.aaas.org

Weaver, G. C., Burgess, W. D., Childress, A. L., & Slakey, L. (Eds.). (2015). *Transforming institutions: Undergraduate STEM education for the 21st century*. Purdue University Press.

SECTION I

THEORIES OF CHANGE

Introduction: Theories of Change

CHARLES HENDERSON AND MARILYNE STAINS

As many authors have argued, efforts to transform undergraduate education are often undertaken using an implicit change theory or no change theory at all (Reinholz & Andrews, 2020; Kezar et al., 2015). This is a serious problem for educational improvement since lack of theory makes it hard to learn from or even talk about successes and failures of change efforts.

Theory is valuable for improvement in a variety of fields. Theory shapes how we frame the stories we tell about what happened, what we pay attention to, and the variables that we monitor and report on. For the purposes of this section, we have not tried to enforce any specific meaning of the term “change theory,” and authors frame their chapters using many related terms, such as change model, change framework, and theory of change. Although the differences between these terms may be valuable to investigate, for the purposes of this volume, we place them all under the broad heading of “change theory” and seek to learn what we can about change from each of the chapters.

1 Change Theory

The seven chapters in this section seek to highlight the role of theory in transforming undergraduate education. Each chapter identifies a specific change theory (or theories) that was used to plan for, assess, and/or understand their change initiative. The chapters suggest ways that change theories can be used and also represent some of the variety in the types of change theories that have been applied in undergraduate education.

Three of the chapters describe how change theory was used to design a change initiative.

These chapters all focus on the use of one specific change theory. They demonstrate how a specific theory can help shape the design and/or evaluation of a change effort.

Earl et al. describe the CACAO change theory. According to CACAO, individual instructors will change their teaching behavior when change agents engage in four important types of activities: Specify the (C)hange, Understand (A)dopters, Organize (C)hange (A)gents, and Attend to (O)rganizational structures and cultures. The chapter describes how the CACAO change theory was used to plan for successful implementation of evidence-based instructional practices at Boise State University.

Thompson and Marbach-Ad describe the Characteristics of Dissemination Success (CODS) change theory. According to CODS, the teaching behavior of individual instructors is a result of their intentions, which are influenced by 1) their attitudes about different teaching approaches, 2) the perceived departmental and disciplinary norms (subjective norms), and 3) the degree to which they believe they are able to successfully implement particular teaching approaches (self-efficacy). These three aspects of instructor beliefs are influenced by a larger set of individual and contextual factors.

The chapter describes how CODS was used to design and evaluate the implementation of active learning instruction in a series of four core biology courses at the University of Maryland.

Biscotte and Mouchrek describe Asset-Based Community Development (ABCD) change theory. According to ABCD, positive institutional change will emerge when change agents conduct the following five steps: 1) map individual assets, 2) build relationships between community members and stakeholders, 3) mobilize identified assets and share useful information among the constituencies, 4) bring the community together in ongoing discussion to develop a plan and mission for the future, and finally 5) leverage outside resources to support local initiatives. The chapter uses general education reform at Virginia Tech as an example to guide the reader through the process.

Two chapters describe emerging theories of change.

Working with 12 departments at 24 institutions to implement undergraduate research, Malachowski et al. were able to identify six specific conditions that support the systemic institutionalization of undergraduate research that align with the Council of Undergraduate Research (CUR) recommendations. These six conditions comprise their emerging change theory and, as with other chapters in this section, can be used to plan for, assess, and improve change initiatives.

Ngai et al. describe a theory of change for the Departmental Action Team (DAT) model. Drawing on existing change theories, prior research, and their experiences developing the DAT model, they have constructed a theory of change that specifies how implementing the DAT model leads to departmental change. This underlying theory accounts for relationships among stakeholders, the expected outcomes from engaging in the DAT model, and separates the change process into stages. The authors emphasize that change is an iterative process involving many moving parts and that change theory helps to identify and understand different outcomes, stakeholders, and the relationships between them. Developing the theory of change was important for refining and implementing the change process in the DAT model.

One chapter identifies an important perspective for understanding change.

Bangera et al. do not focus on a specific change theory, but rather identify an important aspect of change that is not usually discussed. They introduce the concept of Idea Flow that they used to understand their change initiative after the fact. Idea Flow is a process of paying attention to the messiness of what actually happens in a change initiative (what they call the “squiggly line”) rather than the more simplified story that is often told afterwards (what they call the “straight line”). It is important to pay attention to the messiness in order to fully understand the change and what it will take to sustain it, as well as to better understand the current system and plan future changes. This way of thinking is not currently featured in common change theories, but is important for change agents to understand and may eventually lead to the development of more robust change theories.

One chapter emphasizes the value of using more than one change theory.

Pilgrim et al. describe the use of three different change theories—Diffusion of Innovations (Rogers, 2003), Theory of Planned Behavior (Ajzen, 1991), Four Frames (Reinholz & Apkarian, 2018)—to better understand aspects of their change initiative. They argue that the use of multiple change theories may be productive for enacting successful change: “No theory captures all the components of the complex system of higher education at once. However, using multiple theories provided a glimpse into different components of the system” (Pilgrim et al., Conclusion).

2 Common Themes across the Seven Chapters

Despite the apparent differences in the type of change targeted and the variety of change theories leveraged across the seven chapters, we noted several common themes. We describe these themes below.

2.1 Unit of Change

Two units of change are apparent across the six chapters that described an intervention: departments and curricula. Three of the change projects focused on enhancing practices in a subset of departments either within an institution (e.g., CACAO) or across institutions (e.g., DAT, CUR). Departments have been identified as a potentially effective target for instructional change (Austin, 2011; Corbo et al., 2016; Reinholz & Apkarian, 2018) since many of the factors influencing the teaching practices of faculty members revolve around departmental norms and practices (Lund & Stains, 2015; Reinholz & Apkarian, 2018). Studies have demonstrated that these norms and practices vary across departments (Lund & Stains, 2015; Shadle et al., 2017) implying that one uniform change approach is likely to be unproductive. Instead, change initiatives need to consider the unique culture and climate of each department. The three department-focused studies in this section provide examples of strategies that can be implemented to address and leverage departmental characteristics.

The other three chapters that described an intervention were aimed at transforming a set of courses spread across multiple departments (CODS, ABCD), a college (Idea flow, ABCD), or a program (ABCD). Interestingly, all three projects had broad goals such as enhancing coordination of biology introductory courses or infusing service learning into courses. The details of the actions to be implemented to achieve these goals were developed by participants (primarily faculty members) rather than being dictated by the change agents. This emergent approach to change recognizes the value and the importance of taking into account the knowledge, belief systems, and experiences of the instructors in order to attain the overarching goals of the change projects (Henderson et al., 2011).

2.2 Type of Change Efforts

We leverage the change strategies framework developed by Henderson et al. (2011) to identify commonalities in the type of change projects described in this section. This framework is based on an extensive review of the literature on instructional change in higher education and includes two criteria for classifying change strategies.

The first criterion focuses on whether the change aims at transforming individuals, such as faculty behaviors, or structures, such as policies or classroom layouts. All projects described in this section targeted both individuals and structures. For example, several of the projects engaged faculty in some sort of faculty learning communities (CACAO, Idea Flow, CODS, ABCD). Several of the projects also aimed to change departmental norms around teaching (CACAO, Idea Flow, CODS, CUR, DAT).

The second criterion aims to assess whether the outcomes of the change project will emerge during the project or are predefined prior to the implementation of the project. Four of the projects had an emergent approach as described in the previous section (ABCD, CUR, CODS, Idea Flow). Two projects (CACAO, DAT) used a mixed of prescribed and emergent outcomes. These two projects aligned emergent activities proposed by department members to the prescribed visions for their change projects.

The Henderson et al. (2011) literature review found that typical change strategies only focused on one aspect of each dimension, and that this was a weakness. Thus, the set of chapters in this section that focus on individuals and situations as well as having a mix of prescribed and emergent outcomes suggests that change theory is becoming stronger.

2.3 Inclusion of Context

The importance of considering and leveraging the context for change is highlighted in all seven chapters. Context is a part of most change theories, but is not usually prominent. The emphasis on context in these chapters suggests that attention to context has previously been underdeveloped within undergraduate instructional improvement. In particular, the projects commonly assessed needs and current states of affairs from the perspective of faculty members and/or students prior to the implementation of the change projects. This information was then leveraged to inform the design of activities and/or identify important stakeholders. For example, the CUR project, which aims to infuse research experiences throughout the undergraduate curriculum, required departments to collect, analyze, and reflect on students' assessment data throughout the change process. These data were leveraged to identify gaps in the curriculum where research experiences could be embedded. In the CACAO project, the leadership team requested feedback through conversations at faculty meetings and surveys about the constraints and affordances in implementing the vision for change. These data informed the selection of project activities and strategies to enhance faculty experience through the change project. These processes are essential to ensure that the projects are not based on misguided assumptions about the system and to enhance buy-in from the targeted population.

2.4 Role of Change Theories

Several of the chapters in this section commented on the messiness of change processes. The Idea Flow chapter highlights this messiness and argues for the importance of capturing and learning from instances of forward and backward progress. In most of the chapters, change theories were described as essential guides to change agents. Using a change theory helped them stay focused on critical features of the change process throughout the project even and especially when setbacks were experienced. For example, the CACAO project saw a decrease over time in the quality of proposals for curriculum transformation developed by faculty members. They reflected on the potential causes for this through the lens of the CACAO model. This led them to realize that the faculty submitting proposals early in the project were better informed and had more extensive experiences with evidence-based instructional practices than faculty who submitted proposals in the later stage of the project. This realization informed the development of new resources and support for faculty interested in submitting proposals.

3 Missed Opportunities

As discussed above, the seven chapters in this section suggest that change theory is being used more and in much more effective ways than was found in the past (Henderson et al., 2011). However, there still remain many opportunities to improve the use of change theory.

3.1 Lack of Diversity in Change Theories Leveraged

Several of the change theories leveraged in these seven chapters align with or directly build from Rogers' Diffusion of Innovation Theory (Figure 1). This stage-based change theory has been fruitful in discipline-based education research to guide and study instructional change processes (e.g., Andrews & Lemons, 2015; Henderson et al., 2012; Lund & Stains, 2015). However, this theory assumes a linear process of adoption and emphasizes individual decision-making as a key mechanism for change. Several of the chapters in this section recognized that change processes are cyclical and adapted their programmatic activities accordingly; however, none of the change theories are able to fully support cyclical change. In addition, for most chapters, there was only one change theory used to guide the change projects. Pilgrim et al. describe valuable insights about the change process that resulted from leveraging three different change theories. This approach has also been advocated elsewhere (Kezar & Holcombe, 2019). Moving forward, the implementation and study of instructional change processes ought to be pursued through the lens of multiple and diverse change theories.

Figure 1. Practice-Adoption Process, adapted from Rogers' Innovation-Decision Process

3.2 Uncertainty about Sustainability of Change

Many of the change theories were focused on individual-level change (e.g. change courses, or instructors within a department), with the exception of DAT, which was focused on systemic departmental change. Moreover, the change projects described in these chapters provided no information about whether or how the changes would be sustained. It is unclear in these chapters whether the progress achieved to date by these projects will eventually translate into systemic change or will regress to norms and practices experienced prior to the implementation of the project. Although the funding associated with instructional change projects is typically short lived (i.e., five years, at best), it is important to monitor long-term outcomes of these interventions and the role that the change theory played in sustaining (or not) the progress made during the implementation of the project.

3.3 Unanswered Questions about How to Use Change Theory

The chapters in this section provide some insight about the role of theories in transforming undergraduate education. However, across all seven chapters, there are still questions left unanswered regarding the use of change theories to inform change projects. For example, it is unclear, except in the CACAO chapter, who the leaders of the change efforts were and to what extent the theories guided the selection of these leaders. Moreover, none of the chapters describe the timing, process, and criteria used to select the change theory, whether other theories were considered, and who the people involved in this decision were. It was also not always clear if the theories were leveraged for planning change activities (e.g., CACAO), for evaluation of the change project (e.g., CODS), or for both. While a description of the strengths and shortcomings of the theories was often lacking, Pilgrim et al. do discuss affordances and limitations of three change theories. The answers to these questions are extremely valuable for the creation of stronger change theory.

3.4 Lack of Student Input

It was noticeable that except for two chapters (CUR, DAT), students were seemingly not involved in the change projects and their assessments. Since students are a key stakeholder group impacted by these change efforts, it is reasonable to think that they should be consulted during the process. However, most of the change theories described in this section are silent about possible roles for students. Without guidance from these theories, it is unclear how and when students should be involved.

4 Suggestions for Change Researchers

The analysis of the chapters presented in this section led us to identify several lines of research that could advance our understanding of the role of change theories in change processes.

1. The Pilgrim et al. paper highlights the potential benefits of leveraging multiple change theories to guide and study change processes. Use of multiple theories is an emerging idea and little is yet known about how different theories are best leveraged. Future research should explore productive techniques for applying multiple change theories, what types of theories work best together, and whether projects based on multiple theories have better outcomes than those based on a single theory.
2. It was unclear whether or how the change theories resulted in the sustainability of project outcomes. Longitudinal studies monitoring these outcomes over a significant period of time (e.g., ten years) and exploring the role of the change theory in the maintenance or lack thereof of these outcomes overtime could help address this question.
3. As in this volume, most accounts of change are from successful change projects. However, the role of the change theory in achieving this success is unclear. Much could be learned from studies exploring unsuccessful change efforts or more carefully coordinating measurements with aspects of the theory (the CACAO paper is a good example of this type of work). Retrospective studies on the role of the change theory in navigating the change process and achieving positive and negative outcomes would also advance change research.

5 References

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes, 50*(2), 179–211.

Andrews, T. C., & Lemons, P. P. (2015). It's personal: Biology instructors prioritize personal evidence over empirical evidence in teaching decisions. *CBE—Life Sciences Education, 14*(1), ar7. https://doi.org/10.1187/cbe.14-05-0084

Austin, A. E. (2011). *Promoting evidence-based change in undergraduate science education*. National Academies National Research Council Board on Science Education.

https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072578.pdf

Bangera, G., Vermilyea, C., Reese, M., & Shaver, I. (this volume). "On the RISE: A case study of institutional transformation using idea flow as a change theory." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 6). Pressbooks.

Biscotte, S., & Mouchrek, N. (this volume). "Bringing an Asset-Based Community Development (ABCD) framework to university change work." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 3). Pressbooks.

Corbo, J. C., Reinholz, D. L., Dancy, M. H., Deetz, S., & Finkelstein, N. (2016). Framework for transforming departmental culture to support educational innovation. *Physical Review—Physics Education Research, 12*(1), 010113. https://doi.org/10.1103/PhysRevPhysEducRes.12.010113

Earl, B., Viskupic, K., Marker, A., Moll, A., Roark, T., Landrum, R. E., & Shadle, S. (this volume). "Driving change: Using the CACAO framework in an institutional change project." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 1). Pressbooks.

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952–984. https://doi.org/10.1002/tea.20439

Henderson, C., Dancy, M., & Niewiadomska-Bugaj, M. (2012). Use of research-based instructional strategies in introductory physics: Where do faculty leave the innovation-decision process? *Physical Review Special Topics—Physics Education Research, 8*(2), 020104. https://doi.org/10.1103/PhysRevSTPER.8.020104

Kezar, A., Gehrke, S., & Elrod, S. (2015). Implicit theories of change as a barrier to change on college campuses: An examination of STEM reform. *The Review of Higher Education, 38*(4), 479–506. https://doi.org/10.1353/rhe.2015.0026

Kezar, A. J., & Holcombe, E. M. (2019). Leveraging multiple theories of change to promote reform: An examination of the AAU STEM initiative. *Educational Policy*. https://doi.org/10.1177/0895904819843594

Lund, T. J., & Stains, M. (2015). The importance of context: An exploration of factors influencing the adoption of student-centered teaching among chemistry, biology, and physics faculty. *International Journal of STEM Education, 2*(1), 13. https://doi.org/10.1186/s40594-015-0026-8

Malachowski, M., Osborn, J. M., Karukstis, K. K., Kinzie, J., & Ambos, E. L. (this volume). "Scaffolding research into undergraduate STEM curricula and cultures: An emerging model for systemic change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G.

Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 4). Pressbooks.

Ngai, C., Corbo, J. C., Quan, G. M., Falkenberg, K., Geanious, C., Pawlak, A., Pilgrim, M. E., Reinholz, D. L., Smith, C., & Wise, S. (this volume). "Developing the Departmental Action Team theory of change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 5). Pressbooks.

Pilgrim, M. E., McDonald, K. K., Offerdahl, E. G., Ryker, K., Shadle, S. E., Stone-Johnstone, A., & Walter, E. M. (this volume). "An exploratory study of what different theories can tell us about change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 7). Pressbooks.

Reinholz, D. L., & Andrews, T. C. (2020). Change theory and theory of change: What's the difference anyway? *International Journal of STEM Education, 7*(1), 1–12. https://doi.org/10.1186/s40594-020-0202-3

Reinholz, D. L., & Apkarian, N. (2018). Four frames for systemic change in STEM departments. *International Journal of STEM Education, 5*(1), 1–10. https://doi.org/10.1186/s40594-018-0103-x

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). The Free Press.

Shadle, S. E., Marker, A., & Earl, B. (2017). Faculty drivers and barriers: Laying the groundwork for undergraduate STEM education reform in academic departments. *International Journal of STEM Education, 4*(1), 8. https://doi.org/10.1186/s40594-017-0062-7

Thompson, K. V., & Marbach-Ad., G. (this volume). "The Characteristics of Dissemination Success (CODS) model as a framework for changing the culture of teaching and learning." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 2). Pressbooks.

1. Driving Change: Using the CACAO Framework in an Institutional Change Project

BRITTNEE EARL, KAREN VISKUPIC, ANTHONY MARKER, AMY MOLL, TONY ROARK, R. ERIC LANDRUM, AND SUSAN SHADLE

1 Introduction

Reform of post-secondary STEM education has been the focus of efforts in many different institutions (Chasteen et al., 2015; Reinholz & Apkarian, 2018). A principal aim of these efforts is expanding the adoption of evidence-based instructional practices (EBIPs) by faculty teaching undergraduate STEM classes (Wieman, 2015). EBIPs are instructional strategies and methods that have been empirically demonstrated to improve student learning and success (Freeman et al., 2014; Wieman & Gilbert, 2015a). Despite decades of work documenting the effectiveness of EBIPs in STEM courses, high levels of adoption have been elusive (National Science Foundation, 2013; Reinholz & Apkarian, 2018; Wieman & Gilbert, 2015b; Thompson & Marbach-Ad, this volume). The lack of widespread adoption has resulted in increased calls for large-scale efforts to support both changes in individual teaching practice and institutional changes in teaching culture (Chasteen et al., 2015; McKenna et al., 2014; Reinholz & Apkarian, 2018).

Effecting meaningful change in teaching practice and culture requires action at the organization or systems level (Austin, 2011; Chasteen et al., 2015; Reinholz & Apkarian, 2018; Pilgrim et al, this volume). Higher education institutions are complex organizations characterized by multiple actors, layers, and other factors that must be considered (Austin, 2011; Thompson & Marbach-Ad, this volume). In addition, because the structure, systems, strategies, and human resources vary significantly among organizations (Al-Haddad & Kornour, 2015; Chasteen et al., 2016), strategies for catalyzing change must be tailored to the specific contexts in which they will be applied (Reinholz & Apkarian, 2018; Ngai-et al, this volume).

With few examples of wide-spread departmental or institutional adoption of EBIPs to draw upon, practical, operational models of change are needed to guide large-scale reform efforts (Austin, 2011; Owens et al., 2018; Reinholz & Apkarian, 2018) so that efforts are focused on factors most likely to yield success. In addition, “linking change efforts to existing theory ensures that new initiatives are informed by and built on prior efforts” (Borrego & Henderson, 2014, p. 222). Therefore, we share our experience with a theory-based model to support institutional changes to the teaching and learning environment on our campus. This work serves as an example of how a change model can guide large-scale changes.

2 Overview of the CACAO Model

Dormant's CACAO model was developed for application in business, government, and non-profit environments and draws from research in organizational change and sociology, psychology, and education (Dormant, 2011). The model takes a systems-level approach and is built around four central elements that serve to guide the change process: 1) the Change, 2) the Adopters, 3) the Change Agents and 4) the Organization. The first letter(s) of each of the four elements creates the acronym CACAO.

The CACAO model was applied at Boise State University to guide a National Science Foundation (NSF)-funded change project, *Promoting Education Reform through Systemic Investments in STEM Transformation* (PERSIST). PERSIST was launched with the overarching goal of increasing the adoption of EBIPs to improve undergraduate student success. The following sections briefly describe the four elements of the model. Within the narrative for each CACAO element, we describe how the model guided our project, focusing on examples that were especially salient to us as change practitioners.

3 The Change

The first element of the CACAO model calls for "specifying the change." It requires that change agents thoroughly understand the change they seek in order to identify "adopters" and consider the change from the adopters' perspective. The model posits that change agents will have a difficult time enacting change if they are insufficiently clear or knowledgeable about the change they are going to implement and/or are not able to effectively communicate the change to adopters. Thus, how the change is communicated and the information provided to adopters about the change are important factors in the change process. When people lack good information, they tend to "horrible-ize," or fill in the missing information with worst-case speculation, and thus may resist change.

3.1 Developing A Vision Statement

Drawing from Lewin's (as cited in Dormant, 2011) proposed three stages of change, initiating a change starts with communicating an enticing vision. As such, we developed a vision statement to guide the change process and communicate the change to adopters. Because the actual change sought was a cultural shift—a new normal for how university community members think about and implement teaching practices in support of student learning—the vision was intentionally bold and broad.

PERSIST Vision Statement:

The culture of teaching and learning at Boise State will be characterized by

- *on-going exploration and adoption of evidence-based instructional practices*
- *faculty engaged in continuous improvement of teaching and learning*
- *dialogue around teaching supported through a community of practice*
- *teaching evidenced and informed by meaningful assessment*

The fulfillment of this vision will enhance our learning-centered culture and will result in increased studnet achievement of learning outcomes, retention, and degree attainment; especially among underrepresented populations.

Figure 1. PERSIST Vision Statement

Articulating the vision was essential to the change project. Besides being a mechanism to effectively communicate the change to faculty, articulating the vision for change forced us to consider how the project could be framed and activities implemented, so that faculty perceived the project and activities to be advantageous, simple, compatible, adaptable, and socially acceptable. Note the explicit attention to the adopters' perspective. Second, the vision statement helped keep project efforts grounded and focused by serving as a touchstone to which we could return again and again. Finally, because the vision statement was broadly written, it allowed project activities to emerge from the interests of the adopters. For example, as the project progressed and adopter needs and activity shifted, ideas for additional programming and resources were generated. These ideas were then vetted against the articulated vision to determine whether or not they were within the project's scope.

4 The Adopters

Once the change has been specified, the CACAO model focuses on the individuals whose behaviors must be altered for the change to manifest: The Adopters. The term *adopters* "emphasizes the dynamic relationship between the person and the change, as well as the choice aspect of the situation" (Dormant, 2011, p. 45). The assumption that adopters have a choice in deciding to adopt a change or not makes it critical to understand the reasons why they might resist. The CACAO model frames a prospective adopter's perspective along several characteristics: the relative advantage, the simplicity, the adaptability, the compatibility, and the social impact of the change. For example, an adopter might resist a change if it is complex (simplicity) and very different from their normal practice (compatibility). In contrast, if engaging in the proposed change will elevate the adopter's visibility in their department or on their campus (social impact), then they may be less resistant to the change. See Table 1 for example questions change agents might ask when considering the change from the adopters' perspective.

Table 1. Change Agent Questions Related to Change Characteristics

Change Characteristic from the Adopters Perspective	CACAO Questions Related to Change
Relative Advantage	Is the change better than alternatives?
Simplicity	Is the change simple to understand?
Adaptability	Can the change be adapted to meet individual needs/ preferences?
Compatibility	Is the change similar to what the adopter already does?
Social Impact	Will the change negatively impact the adopter's social relationships?

4.1 Understanding and Responding to Adopters at Boise State

Within typical organizational culture and structures in higher education settings, faculty adopters have a choice about whether or not to adopt a change. Thus, in order to support change effectively, it is important to have a strong understanding of the adopters. In the first few months of the project, we attended department meetings in each of the STEM departments to introduce the project and facilitate a discussion around the project's vision statement. The discussions were framed by first introducing the vision statement focused on new norms in the teaching and learning culture. Faculty were asked to respond to the vision using the five change characteristics (Table 1) to guide their responses. The data gathered in these meetings provided a rich understanding of the perceived constraints (i.e., barriers) and affordances (i.e., drivers) in each department (Marker et al., 2015; Shadle et al., 2017; Pilgrim et al, this volume) which allowed us to select strategies to leverage the drivers and minimize the barriers. For example, common barriers cited by Boise State faculty were a lack of time to engage in teaching-related activities and/or improvements, an unsupportive department culture, and a lack of understanding of EBIPs. In response, an important strategy involved providing resources (expertise and training, incentives, and time by means of course buyouts/summer salary) in order to address these barriers. These resources were provided by supporting teaching transformation sub-projects, or Partner Projects, proposed by faculty or departments. Most Partner Projects focused on redesigning a single course or a course sequence to incorporate EBIPs into the curriculum and/or creating supportive teaching structures within the department. Similarly, a common driver was the possibility that the change would foster more collaboration around teaching. In order to leverage this, we required Partner Projects to involve teams of faculty. The decision to use these strategies was a direct result of the change process and our efforts to understand and respond to adopters.

4.2 Attending to the Adoption Process

In elaborating her assertion regarding an adopter's choice in the change process, Dormant notes that adopters move through “evolving stages” as they begin to assimilate the change. Dormant’s description of the stages of adoption are largely based on Lewin’s (1951), Rogers’ (2003), and the Concerns-Based Adoption Model (Hall & Hord, 2010) research. The first stage of adoption is the *awareness* stage, marked by passivity and only basic information about the change. As the adopter builds a greater understanding of the change, they might move into the *curiosity* stage, where they are less passive but are mostly concerned about how the change will impact them personally. During the next two stages, *mental tryout* and *hands-on tryout*, the adopter becomes more active in thinking about and experimenting with how the change might work for them. The final stage is *adoption*, in which the adopter has implemented the change but may still need assistance sustaining the change in their context. It is important to note that an adopter may not move in a linear fashion through all stages of adoption, and adopters may digress back to an earlier stage (Henderson et al., 2012; Thompson & Marbach-Ad, this volume).

Throughout the project, we sought intentionally to engage and support faculty in all stages of adoption. Examples of strategies used throughout the project to target faculty in each stage of adoption can be found in Table 2. In addition to highlighting the need for different strategies based on an adopter’s stage of adoption, using the model also helped us better understand our short-term strengths and challenges associated with the project, enabling us to shift our implementation strategy in response. For example, about mid-way through the project, proposals for Partner Project funding appeared to decline in overall quality and strategic sophistication. We turned to the CACAO model for guidance and realized that this shift was likely related to the fact that early Partner Projects proposals had come from faculty who were already further along the adoption curve at the start of the project. Later projects were proposed by faculty in earlier stages of adoption so they did not have the same experience or knowledge of EBIPs. This understanding enabled us to engage faculty in a dialogue about how to strengthen their proposals and to provide additional support for these later adopters to be successful.

Table 2. Change Agent Strategies Related to Faculty Adoption Stages

Stage	Strategies suggested by CACAO Model	Examples of Application During PERSIST
Awareness	Advertise: introduce vision	*Early:* Vision statement shared at department meetings. *Later:* Department liaisons shared information with departments
Curiosity	Dialogue/Communication: listen and respond to adopters' needs, provide information and resources	*Early:* Compiled specific examples of EBIPs with discipline-specific references for implementation and efficacy; document served as a resource for faculty to ground their understanding of EBIPs. *Later:* Created "Teaching Visits" program so faculty could see what EBIPs looked like in action.
Mental Tryout	Demonstrate: show examples of the change, highlight others success	Highlighted work of faculty in the hands-on tryout and adoption stages; this included publishing monthly articles about Partner Projects, creating a mobile poster display with information about specific Partner Projects, and offering mini-workshops in department meetings
Hands-on Tryout	Train: provide training, information, and resources	Leveraged Center for Teaching and Learning programming to provide support, resources, and training on a variety of EBIPs and active learning strategies. Faculty were also supported to attend discipline-specific workshops off campus.
Adoption	Support: provide resources, rewards/incentives	Provided funding to support faculty in course redesign projects. Provided data and assessment support.

5 The Change Agents

The third element of the CACAO model focuses on the Change Agents, or those who are responsible for facilitating the change. This element encompasses both forming a change implementation team and engaging organizational leadership and other critical actors who can influence the change process. The CACAO model emphasizes that the team of change agents driving the change should represent a range of expertise related to training, organizational understanding, technical skills, and the like. Larger change projects require more robust change teams with effective expertise and representation from relevant stakeholders (i.e., adopters). Longer change projects require mechanisms for bringing new members onto the team to cover critical team roles and functions when former members depart.

5.1 Leadership Team at Boise State

Our leadership team was comprised of the Director of the Center for Teaching and Learning (CTL); the Deans of the College of Arts and Sciences and the College of Engineering; and faculty/staff from the Departments of Geoscience, Psychological Science, Mathematics, and Organizational Performance and Workplace Learning. Many of us on the team had collaborated on previous institutional projects around teaching or curriculum. We all viewed the work of the project as critical to the university's success and, therefore, it was naturally part of our role at the institution to contribute to the project. These factors contributed to sustained engagement, including weekly meetings attended by all team members throughout the five-year project. Finally, many of the leadership team members are well respected across campus, which helped to create buy-in from the start of the project and to sustain momentum throughout the project.

5.2 Other Actors at Boise State

Other actors can influence the change process, including sponsors or project champions, and other individuals (or groups) with the power and influence to legitimize and provide ongoing support for the intended change (Dormant, 2011). We fostered the creation of local project champions by engaging at least one faculty member from each STEM department to serve as a liaison to the project. These liaisons (a.k.a. "The FAST Team"—Faculty Advocates for STEM Transformation) provided an extra window into the mindset of adopters in each department. Additionally, we supported each liaison to craft departmental action plans based on the barrier and driver data collected during the department meetings that introduced the project (described above). Each action plan included both short- and long-term strategies to foster dialogue and prompt exploration of EBIPs among faculty in the department and was tailored to the department's specific context. The ongoing engagement of the departmental liaisons helped inform us of additional support needed to help faculty move toward the vision; after implementing their action plans, many liaisons came back to us with both general questions or concerns and specific insights into challenges in their department. For example, some liaisons felt their colleagues were unwilling to adopt EBIPs because they did not understand how the EBIP "looks in action." As a result, a new program was created so faculty could observe colleagues using EBIPs in the classroom setting in real time.

6 The Organization

The fourth element in the CACAO model requires that change agents understand and attend to features of the organization within which the desired change will occur. The CACAO model underscores the significance of the organizational culture's impact on the change process. Larger organizations may be characterized by multiple cultures that differ across units or areas within the organization. In addition, as previously stated, the structure, systems, and human resources vary significantly among organizations (Al-Haddad & Kornour, 2015; Chasteen et al., 2016), therefore we will focus on the two most salient organizational features that contributed to the leadership team's approach to the change process: focusing on the department as the unit of change and leveraging existing resources.

6.1 Concentrating Activity at the Department Level

In the higher-education context, decision making relevant to teaching is highly distributed and is largely driven by faculty and administrators at the college and department levels. In particular, because studies have shown that faculty teaching choices are highly influenced by their departmental context (Bager-Elsborg, 2017; Lund & Stains, 2015; Reinholz & Apkarian, 2018; Wieman & Gilbert, 2015b; Ngai et al., this volume) our project was designed to emphasize project activity at the department level. However, strategies aimed at the individual and institutional levels were also being implemented, but similar to others (Ngai et al., this volume) the department was seen as the locus of change.

A total of twelve STEM departments at the institution were involved in the project (five departments in the College of Engineering and seven departments in the College of Arts and Sciences). Each department has its own set of cultural norms and practices impacting the various change strategies that might be implemented. Departmental differences were evident from the beginning of the project. For example, support and engagement from department chairs varied, with some being highly engaged in Partner Projects and supporting FAST Team members, while others were passive or even resistant to the idea of EBIPs. In addition, while some of the barriers and drivers referenced above were similar across departments, we found many differences among departments (Shadle et al., 2017). Finally, in a few departments there were a number of faculty who were already aware of, interested in, or actively using EBIPs, while awareness of EBIPs in other departments was low. By focusing many of our efforts at the department level and utilizing project sponsors (FAST Team members), we were more aware of departmental nuances and were able to respond to and leverage the culture of each department, leading to more significant progress towards our vision. Approximately 147 (66%) full-time faculty participated in activities during the project's five-year duration.

6.2 Center for Teaching and Learning (CTL) as the Project Hub

Throughout the project, existing and new CTL programming was leveraged to support project goals. The CTL and its director are seen as important resources for faculty and are well respected across campus. Prior to launching this change initiative, the CTL had well-established communication strategies and a variety of programs to support faculty (e.g., a workshop series which regularly supported faculty exploration of EBIPs, a week-long summer course design institute, and a strong consultation program for faculty). Over the course of the project, more than 100 workshops focused on EBIPs were offered through the CTL, and an increase in STEM faculty engagement with CTL activities was observed. In the five years prior to PERSIST (2009–2013), 99 full-time STEM faculty participated in CTL programming (511 instances). During the five-year project period (2014–2018), 173 full-time STEM faculty participated in CTL programming (949 instances). The project also supported over 69 STEM faculty in attending external, discipline-specific workshops and trainings related to active learning, an approach which leveraged an existing CTL travel grant program.

7 Progress toward a Shared Vision

While the CACAO model focuses on the process of supporting change, it does not explicitly address strategies for assessing change. Nonetheless, we used a variety of data sources and assessment methods to monitor changes in the campus climate and faculty practice. A more comprehensive description of the impact of our project is planned for a forthcoming publication; selected examples of indicators of change are highlighted below.

7.1 Campus Climate

The Current Instructional Climate Survey (CICS; Landrum et al., 2017) was administered annually during the project period. The mean responses for many survey items over the 5-year project period show changes in faculty perceptions of the campus climate and shifts in faculty practice that align with the vision statement created at the outset of the project (Table 3). For example, toward the end of the project faculty were more likely to report that their teaching was informed by discussion with colleagues or research about best practices. In addition, faculty were more likely to report that the campus culture encouraged the use of EBIPs, bred collaboration in teaching discussions, and connected faculty with other teachers. These results indicate a shift toward the achievement of two components of our vision statement: *ongoing exploration and adoption of EBIPs* and *dialogue around teaching supported through a community of practice*.

Table 3. Means (M) and Standard Deviations (SD) for STEM Faculty Responses to Select CICS Items for Years 2014 and 2018

CICS Item	2014 Survey Results *M* (*SD*)	2018 Survey Results *M* (*SD*)
1 = I believe that my teaching is not informed by discussions with colleagues. 7 = I believe that my teaching is informed by discussions with colleagues.	5.14 (1.32)	5.65 (1.31)
1 = I believe that my teaching is not informed by research about best practices. 7 = I believe that my teaching is informed by research about best practices.	5.08 (1.32)	5.62 (1.18)
1 = I believe that the campus culture encourages use of evidence based instructional practices. 7 = I believe that the campus culture discourages use of evidence based instructional practices.	2.96 (1.28)	2.35 (1.36)
1 = I believe that the campus culture breeds divisiveness in teaching. 7 = I believe that the campus culture breeds collaboration in teaching discussions.	4.92 (1.36)	5.27 (1.13)
1 = I believe that the campus culture connects me with other teachers. 7 = I believe that the campus culture isolates me from other teachers.	3.61 (1.48)	3.25 (1.55)

Note. Survey items used a 7-point semantic differential scale; low anchors = 1 and high anchors = 7 on the scale.

7.2 Faculty Practice

In the final year of the project, STEM faculty were asked to reflect on their current and past teaching practices with respect to their knowledge and use of EBIPs. During this reflection process, faculty completed the Evidence-based Instructional Practices Adoption Scale (Landrum et al., 2017) twice; once for their current teaching practices and a second time for their teaching practices four years prior (retrospectively). Although not all faculty were directly involved in project activities, 75.6% (112) of faculty reported moving through one or more of the adoption stages during the project period with approximately 57% (84) of those faculty moving into the adoption stage. This also indicates faculty were engaged in *ongoing exploration and adoption of EBIPs*, a key component of the project's vision.

The high level of participation by STEM faculty in project activities and CTL programming coupled with positive trends in the instructional campus climate and the movement of faculty through the adoption stages suggests shifts in both individual faculty practice and the STEM teaching culture.

8 Conclusion

Effecting meaningful change in teaching practice and culture requires a systems-level approach that is tailored to the specific institutional context in which the change will be applied (Al-Haddad & Kornour, 2015; Austin, 2011; Chasteen et al., 2015; Chasteen et al., 2016; Reinholz & Apkarian, 2018). Knowing this, the use of a framework like the CACAO model is particularly important, as it grounds work in a local context and provides guidance (rather than a prescription) for change agents. In addition, because these types of projects do not unfold in a linear fashion (Bangera et al., this volume; Thompson & Marbach-Ad, this volume), the broad focus of the CACAO model allowed for an emergent approach in project activities. At Boise State, the CACAO model provided a common language for communicating and understanding the change process. It helped to frame our thinking around critical aspects for effecting change, rather than simply offering programs through the project. The theoretical underpinnings of the model increased our ability to move faculty toward the stated vision. Our experience demonstrates that the use of a theory-based change model is valuable for enacting changes in the complex environment of higher education; our use of the CACAO model was critical to the success of the PERSIST project.

9 Acknowledgements

This material is based upon work supported by the National Science Foundation under grant # DUE-1347830. In addition, the co-authors of this chapter we would like to acknowledge Doug Bullock as a member of the PERSIST project leadership team and contributor to the efforts described in this chapter.

10 About the Authors

Brittnee Earl is a project manager in the Center for Teaching and Learning at Boise State University.

Karen Viskupic is an Assistant Professor in the Department of Geosciences at Boise State University.

Anthony Marker is a Professor in the Department of Organizational Performance and Workplace Learning at Boise State University.

Amy Moll is a Professor in the Micron School of Materials Science and Engineering at Boise State University

Tony Roark is the Interim Provost and a Professor of Philosophy at Boise State University.

R. Eric Landrum is the Department Chair and Professor in the Department of Psychological Science at Boise State University.

Susan E. Shadle is the Vice Provost for Undergraduate Studies and a Professor of Chemistry at Boise State University.

11 References

Al-Haddad, S., & Kotnour, T. (2015). Integrating the organizational change literature: A model for successful change. *Journal of Organizational Change Management*, *28*(2), 234–262. https://doi.org/10.1108/JOCM-11-2013-0215

Austin, A. E. (2011). *Promoting evidence-based change in undergraduate science education*. National Academies National Research Council Board on Science Education. http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072578.pdf

Bager-Elsborg, A. (2017). Discipline context shapes meaningful teaching: A case study of academic law. *Journal of Further and Higher Education, 41*(4), 508–520. https://doi.org/10.1080/0309877X.2017.1377162

Bangera, G., Vermilyea, C., Reese, M., & Shaver, I. (this volume). "On the RISE: A case study of institutional transformation using idea flow as a change theory." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 6). Pressbooks.

Borrego, M., & Henderson, C. (2014). Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. *Journal of Engineering Education, 103*(2), 220–252. https://doi.org/10.1002/jee.20040

Chasteen, S. V., Perkins, K. K., Code, W. J., & Wieman, C. E. (2016). The Science Education Initiative: An experiment in scaling up educational improvements in a research university. In G. C. Weaver, W. D. Burgess, A. L. Childress, & L. Slakey (Eds.), *Transforming institutions: Undergraduate STEM education for the 21st century* (pp. 125–139). Purdue University Press.

Chasteen, S. V., Wilcox, B., Caballero, M. D., Perkins, K. K., Pollock, S. J., & Wieman, C. E. (2015). Educational transformation in upper-division physics: The Science Education Initiative model, outcomes, and lessons learned. *Physical Review Special Topics—Physics Education Research, 11*, 020110-1–020110-21. https://doi.org/10.1103/PhysRevSTPER.11.020110

Dormant, D. (2011). *The chocolate model of change*. lulu.com.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H. & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics.

Proceedings of the National Academy of Sciences, 111(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Hall, G. E., & Hord, S. M. (2010). *Implementing change: Patterns, principles, and potholes* (3rd ed.). Prentice Hall.

Henderson, C., Dancy, M., & Niewiadomska-Bugaj, M. (2012). Use of research-based instructional strategies in introductory physics: Where do faculty leave the innovation-decision process? *Physical Review Special Topics—Physics Education Research, 8*(2), 020104. https://doi.org/10.1103/PhysRevSTPER.8.020104

Landrum, R. E., Viskupic, K., Shadle, S., & Bullock, D. (2017). Assessing the STEM landscape: The current instructional climate survey and the evidence-based instructional practices adoption scale. *International Journal of STEM Education, 4*, 25. https://doi.org/10.1186/s40594-017-0092-1

Lewin, K. (1951). *Field theory in social science: Selected theoretical papers* (D. Cartwright, Ed.). Harper and Row.

Lund, T. J., & Stains, M. (2015). The importance of context: An exploration of factors influencing the adoption of student-centered teaching among chemistry, biology, and physics faculty. *International Journal of STEM Education, 2*(1), 13. https://doi.org/10.1186/s40594-015-0026-8

Marker, A., Pyke, P., Ritter, S., Viskupic, K., Moll, A., Landrum, R. E., Roark, T. & Shadle, S. (2015). Applying the CACAO change model to promote systemic transformation. In G. C. Weaver, W. D. Burgess, A. L. Childress, & L. Slakey (Eds.), *Transforming institutions: Undergraduate STEM education for the 21st century* (pp. 176–188). Purdue University Press.

McKenna, A.F., Froyd, J., & Litzinger, T. (2014). The complexities of transforming engineering higher education. *Journal of Engineering Education, 103*(2), 188–192.

National Science Foundation. (2013). *Widening implementation and demonstration of evidence-based reforms (WIDER)* (Solicitation 13-552). https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504889

Ngai, C., Corbo, J. C., Quan, G. M., Falkenberg, K., Geanious, C., Pawlak, A., Pilgrim, M. E., Reinholz, D. L., Smith, C., & Wise, S. (this volume). “Developing the Departmental Action Team theory of change.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 5). Pressbooks.

Owens, M. T., Trujillo, G., Seidel, S. B., Harrison, C. D., Farrar, K. M., Benton, H.P., Blair, J.R., Boyer, K.E., Breckler, J.L. Burrus, L.W., Byrd, D.T., Caporale, N., Carpenter, E.J., Chang, Y.-H., Chen, J.C., Chen, L., Chen, L.H., Chu, D.S., Cochlan, W.P., … Tanner, K. D. (2018). Collectively improving our teaching: Attempting biology department-wide professional development in scientific teaching. *CBE—Life Sciences Education, 17*(1). https://doi.org/10.1187/cbe.17-06-0106

Pilgrim, M. E., McDonald, K. K., Offerdahl, E. G., Ryker, K., Shadle, S. E., Stone-Johnstone, A., & Walter,

E. M. (this volume). “An exploratory study of what different theories can tell us about change.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 7). Pressbooks.

Reinholz, D. L., & Apkarian, N. (2018). Four frames for systemic change in STEM departments. *International Journal of STEM Education, 5*(1), 1–10. https://doi.org/10.1186/s40594-018-0103-x

Rogers, E. (2003). *Diffusion of innovations* (5th ed.). The Free Press.

Shadle, S., Marker, A., & Earl, B. (2017). Faculty drivers and barriers: Laying the groundwork for undergraduate STEM education reform in academic departments. *International Journal of STEM Education, 4*(1), 8. https://doi.org/10.1186/s40594-017-0062-7

Thompson, K. V., & Marbach-Ad., G. (this volume). “The Characteristics of Dissemination Success (CODS) model as a framework for changing the culture of teaching and learning.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 2). Pressbooks.

Wieman, C. (2015). A better way to evaluate undergraduate teaching. *Change: The Magazine of Higher Learning, 47*(1), 6–15. https://doi.org/10.1080/00091383.2015.996077

Wieman, C., & Gilbert, S. (2015a). Taking a scientific approach to science education, Part I– Research. *Microbe, 10*(4), 152–156. https://10.1128/microbe.10.152.1

Wieman, C. & Gilbert, S. (2015b). Taking a scientific approach to science education, Part II–Changing Teaching. *Microbe, 10*(5), 203–207. https://10.1128/microbe.10.203.1

2. The Characteristics of Dissemination Success (CODS) Model as a Framework for Changing the Culture of Teaching and Learning

KATERINA V. THOMPSON AND GILI MARBACH-AD

1 Introduction

Theories of change based on existing change models are indispensable tools for planning, implementing, and evaluating the success of change efforts. This chapter describes how a theory of change based on the Characteristics of Dissemination Success (CODS) framework (Bourrie et al., 2014) is being used to guide a multi-departmental effort to create a more collaborative, student-centered culture of teaching and learning within the biological sciences.

There is convincing evidence that students who are actively engaged in constructing knowledge achieve deeper and more durable learning. STEM courses that utilize active learning have higher pass rates (Freeman et al., 2014), which could ultimately lead to greater persistence of students on STEM career trajectories. Thus, wider adoption of these active learning approaches is key to maintaining our scientific research enterprise and cultivating a diverse, scientifically literate workforce (President's Council of Advisors for Science and Technology [PCAST], 2012).

Despite the wide variety of active learning approaches that have been described in peer reviewed journals, shown to be effective, and championed by esteemed scientists, these approaches are far from widespread in undergraduate STEM classrooms (Dancy & Henderson, 2010; Hazen et al., 2012; Wieman et al., 2010). Attempts to change the culture of teaching to integrate more active learning have largely relied on a somewhat naïve model for the diffusion of innovation, in which increasing faculty awareness of effective teaching practices was thought to be a sufficient impetus to catalyze widespread adoption (Foote, 2014; Henderson et al., 2011; Kezar et al., 2015). Recent research has revealed that faculty are generally familiar with active learning approaches and believe in their superiority over passive approaches, but their behavior in the classroom often does not reflect this belief (Henderson et al., 2012; Marbach-Ad et al., 2012; Marbach-Ad et al., 2014). This may be due in part to the tendency of faculty to overestimate the extent to which their teaching incorporates active learning (Ebert-May et al., 2011), but it is also common for faculty to try out new teaching methods and then abandon them (Henderson et al., 2012) or adapt them in ways that undermine their effectiveness (Henderson & Dancy, 2008). Others never broaden their approaches beyond the traditional lecture.

Many administrative and institutional barriers to the widespread implementation of empirically supported, active learning approaches have been identified, including class size, physical constraints of large lecture halls, lack of support for faculty professional development, institutional pressure for high research productivity, and lack of institutional rewards for effective teaching (Brownell & Tanner, 2012; Kober, 2015; Labov et al., 2009; PCAST, 2012; Seidel & Tanner, 2013; Wieman et al., 2010). STEM faculty members consistently identify student resistance as another major barrier (Bourrie et al., 2014; Henderson & Dancy, 2007; Seidel & Tanner, 2013). Undergraduate students often favor traditional lecturing over active learning (Fagen et al., 2002; Henderson & Dancy, 2007; Weimer, 2002), possibly because active learning methods often require students to exert greater effort in class, meet higher standards, and cope with the uncertainties and risks that come with novel learning environments compared with traditional learning environments (Doyle, 2008; Weimer, 2002). Negative instructor and student attitudes towards active learning can be mutually reinforcing. The risk of negative student evaluations can intensify instructors' resistance to change, especially when these evaluations influence tenure and promotion (Austin, 2011; Henderson & Dancy, 2007). It is now clear that overcoming the complex barriers to widespread implementation of active learning approaches will require a systems-level approach that engages students, instructors, and the administrative structure in which they operate.

Agencies that fund undergraduate STEM education reform have recognized this need and increasingly expect that proposals for instructional reform be guided by an explicit theory of change. For example, the National Science Foundation's Improving Undergraduate STEM Education program guidance states

> Institutional and Community Transformation projects are expected to include one or more theories of change to guide the proposed work. A theory of change functions to identify and organize the dimensions of the proposed work and is a critical component of ICT projects (National Science Foundation, 2019).

While it is expected that each proposed undergraduate STEM education reform project be tied to a theory of change, there are few models for how theories of change should drive specific project activities. We describe how a theory of change developed specifically for the university context, the Characteristics of Dissemination Success (CODS; Bourrie et al., 2014), provided the framework for improving undergraduate biological sciences education at the University of Maryland.

1.1 Theories of Change

Theories of change are intended to guide the planning, management, and evaluation of interventions (Mayne, 2015). They are particularly useful when promoting change in a complex system, because they require a detailed accounting of 1) the relationships among specific activities, 2) the outcomes that can result from those activities, and 3) the conditions under which the activities produce the desired outcomes. They are similar to other frameworks for project planning, such as causal pathways and logic models, but recognize that the linkage between activity and outcome may only be realized when key assumptions are met. Theories of change strengthen project evaluation by providing a process for identifying critical unmet assumptions in the event that a particular intervention is less effective than expected.

Having a well-reasoned and articulated theory of change is important for the success of STEM education reform efforts. Indeed, in the absence of an explicit theory of change, change agents (who are typically STEM faculty unfamiliar with the scholarly literature on change) are likely to rely on implicit theories of change that are faulty, which undercuts their efforts to catalyze change (Kezar et al., 2015). Kezar et al. (2015) identified several examples of implicit theories of change that are widespread and likely to undermine STEM education reform efforts, including the belief that change efforts must be centered at the level of the department, data alone can motivate change, and change cannot be accomplished without an infusion of funding.

1.2 The CODS Model

CODS is particularly well suited to instructional reform efforts because it explicitly acknowledges the multifactorial nature of decision-making in higher education (Bourrie et al., 2014). The framework emerged from an NSF-funded Delphi study to identify the characteristics that might influence the spread of teaching innovations. It provides a promising theoretical model of institutional change because it explicitly acknowledges the multiple individual and contextual factors that influence an individual's decision of which teaching methods to employ. The multifactorial nature of this framework implies that change efforts that encompass multiple components of the university educational system are more likely to succeed than more narrowly tailored efforts.

The CODS framework is built on a robust theoretical literature on decision-making (e.g., Ajzen's [1991] Theory of Planned Behavior). It takes as its starting point Rogers' (2003) Innovation-diffusion model, which describes how changes can spread across people and organizations. Within the context of teaching, an individual gains knowledge of a new teaching approach and forms an attitude towards it. If that attitude is favorable, the individual may decide to try out the teaching approach. This initial decision can be reinforced following successful implementation, which leads to long-term change in teaching practices (Bourrie et al., 2014).

To this basic model, CODS adds layers of contextual factors that might influence a faculty member's decision-making process. Under the CODS framework (Figure 1), a faculty member's use of evidence-based approaches (behavior) is a result of a change in their intentions, which in turn is influenced by their attitudes toward evidence-based teaching approaches, the perceived departmental and disciplinary norms, and the degree to which they believe they are able to successfully implement those approaches. These faculty beliefs are themselves determined by a combination of individual and contextual factors that include characteristics of the students, faculty members, institution, and the teaching approaches under consideration.

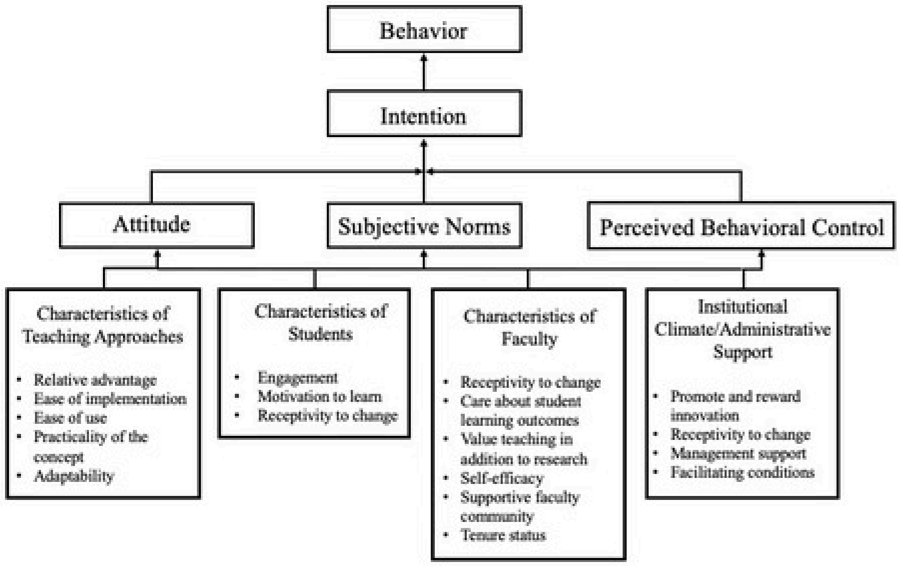


Figure 1. CODS Framework (adapted from Bourrie et al., 2014). Selected characteristics of teaching approaches, faculty, students, and the institution are listed in order of importance, as ranked by Delphi process participants.

2 Institutional Context and Objectives

We applied the CODS model to an effort to increase cohesion between courses in the biological sciences curriculum at the University of Maryland. Specifically, we sought to

- Tighten the linkages between the first four courses in the biological sciences curriculum to help students build a coherent base of knowledge and skills
- Strengthen faculty commitment to active pedagogies by engaging them in an iterative cycle of developing, assessing, evaluating, and refining instructional activities
- Gain student buy-in for learning approaches that require students to be actively engaged and exert greater effort

Creating curricular cohesion had long been a challenge for several reasons. First, the biological sciences major is not situated within a single department, but is instead collaboratively sponsored by three departments: Biology, Entomology, and Cell Biology and Molecular Genetics. It enrolls roughly 1,700 undergraduate students, and more than 90 faculty members teach courses in the program. The program is overseen by a leadership team comprised of a college-level administrator who serves as biological sciences program director and undergraduate directors from each of the departments. The leadership team provides a degree of coordination among instructors, but there are few opportunities for the biological sciences faculty as a whole to discuss teaching-related issues and priorities.

Biological sciences students can choose among five areas of specialization at the upper level, but all complete a sequence of four courses that provide a common foundation for the major (Table 1). Some of these courses are also required or recommended for students in a variety of other science majors and those who intend to apply to graduate programs in the health professions. In addition to this diversity in student majors and career aspirations, there is considerable heterogeneity in academic preparation among students because there are multiple pathways through the curriculum. First, the first-year courses can be taken in either order, as can the second-year courses. In addition, students outside of the biological sciences may opt to take only one of the first-year courses and one of the second-year courses. Thus, there is considerable heterogeneity amongst the students enrolled in a given course.

Table 1. Gateway courses within the biological sciences curriculum

Course	Lecture sections/year	Annual enrollment
Principles of Evolution and Ecology	9	700
Principles of Cell and Molecular Biology	13	1500
Principles of Biology III—Organismal Biology	7	700
Principles of Genetics	6	850

Each of the biological sciences departments has multiple faculty members who have been deeply engaged in transforming their courses to make greater use of active learning approaches. Despite their efforts, reform has occurred in somewhat isolated pockets, and the locus of change has primarily been the individual faculty member or individual course. Thus, students encounter active learning sporadically through the curriculum. This has created a situation where some students are hesitant to enroll in courses with active pedagogies. Some are simply unfamiliar with the expectations of these learning environments. Others are quite vocal in their preference for traditional, passive modes of instruction, despite compelling evidence from well-validated diagnostic measures that they are learning much more in the active classroom (E.F. Redish, unpublished data).

3 Using the CODS Framework to Guide Implementation and Assessment Activities

The CODS framework was originally conceptualized as linear, which implies that changes in faculty behavior do not affect other elements of the system (Figure 1). However, we view the change process as recursive in that changes in faculty teaching behaviors may directly affect students' attitudes and motivation and their own attitudes, as well as the attitudes of their colleagues and even administrators. To account for this recursive nature, we reconceptualized the process as cyclical (Figure 2), which implies that the system will evolve over time. Viewing the process as cyclical allowed us to identify multiple points at which the system might be perturbed, which then guided our choice of interventions and activities.

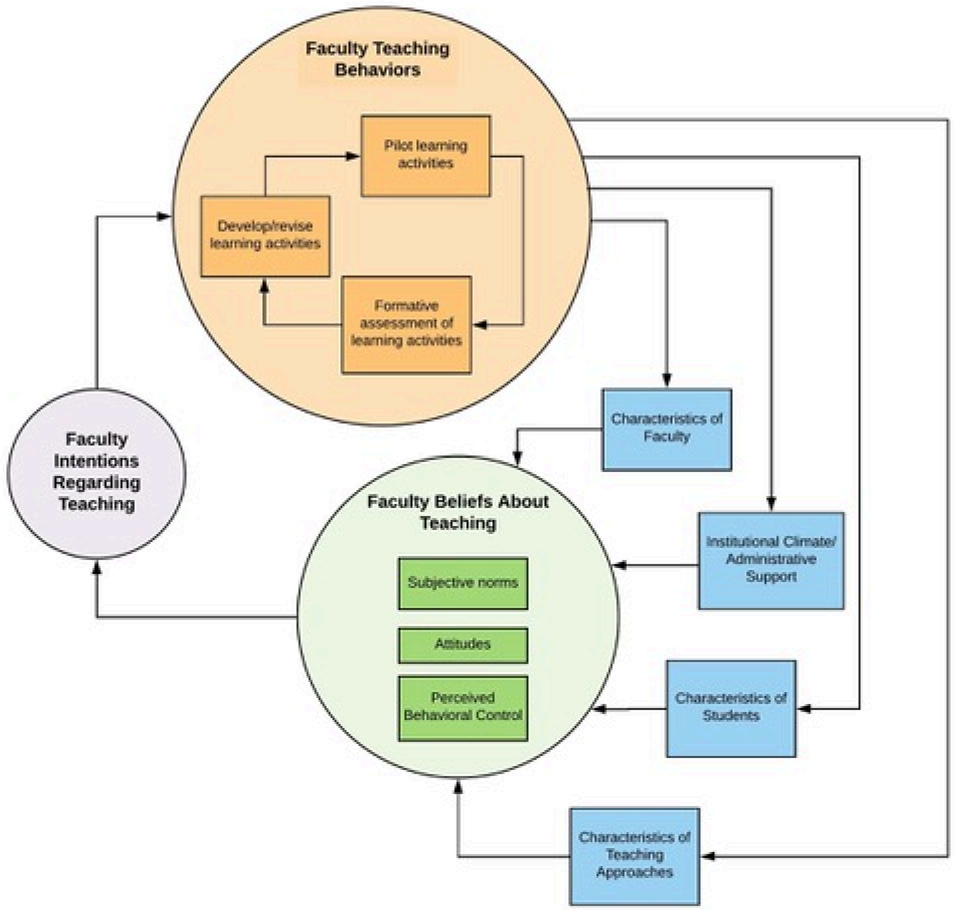


Figure 2. CODS Framework as Adapted for Changing the Culture of Teaching and Learning in the Biological Sciences at the University of Maryland.

3.1 Faculty Learning Community

As our core intervention, we established a faculty learning community (FLC) consisting of faculty who taught one or more of the first four courses in the biological sciences curriculum, which serve as a gateway to the major. It was clear that achieving greater cohesion in content and pedagogy would require a cultural shift towards viewing teaching as a collaborative, rather than solitary, endeavor. Learning communities are recognized as a powerful strategy for scaling up the spread of innovations beyond individual early adopters, helping to ensure their widespread impact and long-term sustainability (Kezar, 2011). Importantly, the FLC approach allowed us to simultaneously address multiple levels of the CODS framework, from individual beliefs (e.g., self-efficacy) to context (e.g., departmental climate for teaching) (Figure 2). This approach is congruent with the Four Frames model of systemic change, which emphasizes the need for interventions to take into account people, the power relationships among them, the institutional structures in which they operate, and the symbols of their institutional culture (Reinholz & Apkarian, 2018; Pilgrim, et al., this volume).

We recognized that this collaborative effort would encompass a great deal of diversity in content emphases, teaching styles, and teaching philosophies, even within a single multi-section course. Rather than insisting that all participating faculty subscribe to a particular view or adopt a specific pedagogy, we believed that FLC interactions would cultivate a shared vision that respected faculty expertise and autonomy. We sought for faculty to engage together in a *process*, rather than achieving a prescribed outcome, an approach that has been touted as promising for achieving institutional change (Henderson et al., 2011; Earl et al., this volume).

3.2 FLC Activities

The FLC met biweekly over a 2.5-year time period to 1) create progressive, active learning activities, 2) engage in an iterative process of assessing and refining instructional activities, and 3) develop metacognitive teaching strategies to help students recognize evidence of their learning to gain student buy-in for approaches that require greater effort and engagement. The biweekly meetings were supplemented with day-long teaching retreats held at the end of each semester, which provided an opportunity for the group to reflect on its progress and set priorities for the upcoming semester. Each retreat also provided an opportunity for the FLC to interact with invited speakers, who introduced a variety of new pedagogical and assessment methods. During selected retreats, faculty members teaching at the upper level were also invited to join in, as a way of propagating the group's efforts and amplifying culture change.

Each activity undertaken by the FLC was designed to reinforce multiple components of the CODS framework. For example, one recurrent activity during the biweekly meetings and retreats was "Show and Tell," where members of the FLC shared their teaching strategies for particular learning outcomes. These Show and Tell sessions provided opportunities to influence faculty *beliefs about subjective norms* by raising awareness of the extent to which active learning was being used by peers. The sessions also could be expected to increase faculty *teaching self-efficacy* by demonstrating how various approaches could be applied effectively. Furthermore, Show and Tell sessions highlighted *characteristics of specific teaching approaches*, which helped faculty better understand their feasibility and adaptability. According to the CODS model, these factors collectively influence faculty intentions regarding their choice of teaching approaches.

Another major focus was implementing activities to help students develop their metacognitive skills. During one of our full-day retreats, we held a workshop with an invited speaker from the campus learning assistance center, followed by a panel of science faculty who were currently using metacognitive approaches. We then provided every faculty member with a copy of Nilson's (2013)

Creating Self-Regulated Learners, which contains numerous practical strategies for developing students' metacognitive skills. Before leaving the workshop, each faculty member created an implementation plan for introducing one or more metacognitive activities into their course. We later surveyed faculty as to which metacognitive strategies they were employing and which strategies they were interested in learning more about. We held a workshop in which experienced faculty shared their strategies, then were matched with those wishing to learn more for further discussion. This effort to increase student metacognition touched on several aspects of the CODS model: it raised awareness of *the characteristics of particular teaching approaches*, bolstered faculty *self-efficacy* with those approaches, and had the potential downstream effect of influencing *characteristics of students* by increasing their awareness of the impact of active pedagogies on their learning.

3.3 Using CODS to Understand Change

Our evaluation strategy was designed to document changes in multiple components of the CODS cycle (e.g., faculty attitudes, faculty behaviors, student attitudes, administrative support for teaching) over the course of the initiative. This process is ongoing, and we share below our strategic evaluation plan.

We are using a mixed methods approach that integrates quantitative and qualitative evidence to evaluate our progress in fostering changes to the culture of teaching and learning. In addition to gathering data on faculty adoption of evidence-based teaching methods, we are examining multiple factors identified in the CODS framework as influencing faculty adoption of new teaching methods, including characteristics of the faculty, their students, and the institutional context in which they operate. Specific tools and approaches are detailed in Table 2.

We surveyed all participating faculty four times over the course of the initiative (in conjunction with teaching retreats). The surveys gathered data on current teaching practices, faculty intentions regarding active pedagogies, their attitudes towards specific educational goals, and individual characteristics thought to influence these (e.g., teaching self-efficacy, receptivity to change). While we originally planned to use surveys to also gather information on institutional factors such as climate for teaching, perceived rewards for teaching excellence, and peer support, we later realized that faculty might hesitate to respond to questions on these sensitive topics. We instead opted to address these issues in semi-structured interviews with participating faculty and administrators.

We simultaneously gathered survey data on student characteristics that might influence faculty attitudes, intentions, and behaviors, such as motivation for learning biology, science self-efficacy, and receptivity to active learning. These surveys were administered each semester in every gateway course (for enrolled students of all majors) and at graduation (for biological sciences majors only).

Table 2. Assessment approaches for evaluation of the CODS framework.

Focus	Construct	Instrument	Sample item
Characteristics of students	Engagement	Student Engagement Scale, cognitive engagement (Gunuc & Kuzu, 2015)	I try to do my best during class.
	Self-efficacy	Science Self-efficacy survey (Estrada et al., 2011)	I am confident that I can generate a research question to answer.
	Motivation to learn	Patterns of Adaptive Learning Scales (Hernandez et al., 2013)	An important reason why I do my work in school is because I want to get better at it.
	Receptivity to change	Hercovitch & Meyer (2002)	I believe in the value of this change [to greater use of active learning].
Characteristics of faculty	Behavior	Postsecondary Instructional Practices survey (Walter et al., 2016)	I use student assessment results to guide the direction of my instruction during the semester.
	Attitudes and intentions	Science Teaching Beliefs and Practices survey (Marbach-Ad et al., 2014)	Rate the importance of the following approaches to teaching undergraduate students: Using a variety of teaching methods
	Receptivity to change	Hercovitch & Meyer (2002)	I believe in the value of this change [to greater use of active learning].
	Value of teaching in relation to research	Structured interviews	How do you balance competing responsibilities (e.g., teaching, advising, and research)?
	Self-efficacy	College Teaching Self-Efficacy Scale (Prieto-Navarro, 2005)	How confident are you in your ability to create a positive classroom climate for learning?
	Supportive faculty community	Sense of Community Index 2 (Chavis et al., 2008)	People in this community have similar needs, priorities, and goals.
Administrative and institutional climate	Rewards for innovation	Structured interviews	
	Perceived institutional support	Structured interviews	

In designing the evaluation plan, we paid particular attention to characteristics that were identified by the CODS Delphi study as being highly influential (Bourrie et al., 2014). This resulted in the inclusion of constructs that are not usually considered in studies of faculty teaching. For example, receptivity to change was identified as an important influence on faculty, students, and administrators. For this construct, which became part of the evaluation measures for both students and faculty, we adapted items that were originally developed for workplace change efforts (Hercovitch & Meyer, 2002).

Our preliminary analyses (Marbach-Ad et al., 2019) indicated that one of the strengths of the FLC was that it contained some more-experienced and confident “innovative teachers” that inspired and assisted those who have less experience or confidence with active pedagogies. While participation in the FLC did not change the teaching self-efficacy of the most confident instructors, it did appear to boost the confidence of those who were initially less confident. Faculty reflected that through their interactions with other FLC members, they learned new teaching and assessment techniques and ways of promoting student metacognition. They also expressed a desire for more cross-course interactions (e.g., sharing syllabi, observing each other’s classes, building a library of student-centered activities, collaborating to create assessment questions), indicating a shift towards a more collaborative culture of teaching.

4 Conclusions

Using the CODS framework to guide project planning has enabled us to develop professional development activities that foster a supportive community around teaching, bolster faculty self-efficacy in teaching, and raise awareness of the changing departmental norms regarding use of active pedagogies. We suspect that these coordinated efforts will have a positive impact on student engagement and motivation to learn, although it is still too early to measure that impact. Using the CODS model as an evaluation framework has enabled us to collect the data necessary to construct a comprehensive understanding of the current culture to teaching and learning in the biological sciences. As we continue to collect and analyze our data, this approach will help us identify strategies that can be used as levers for institutional change and points in the process where additional interventions might be necessary. As such, this theory of change is a powerful tool in shaping institutional culture in support of more effective teaching.

5 About the Authors

Katerina V. Thompson is the Assistant Dean for Science Education Initiatives in the College of Computer, Mathematical, and Natural Sciences at the University of Maryland.

Gili Marbach-Ad is the Director of the Teaching and Learning Center (TLC) in the College of Computer, Mathematical, and Natural Sciences at the University of Maryland.

6 References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211.

Austin, A. E. (2011). *Promoting evidence-based change in undergraduate science education*. National Academies National Research Council Board on Science Education. http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072578.pdf

Bourrie, D. M., Cegielski, C. G., Jones-Farmer, L. A., & Sankar, C. S. (2014). Identifying characteristics of dissemination success using an expert panel. *Decision Sciences Journal of Innovative Education, 12*(4), 357–380. https://doi.org/10.1111/dsji.1249

Brownell, S. E. & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and… tensions with professional identity? *CBE—Life Sciences Education, 11*(4), 339–346. https://doi.org/10.1187/cbe.12-09-0163

Chavis, D. M., Lee, K. S., & Acosta, J. D. (2008). *The Sense of Community (SCI) revised: The reliability and validity of the SCI-2* [Paper presentation]. 2nd International Community Psychology Conference, Lisboa, Portugal.

Dancy, M. & Henderson, C. (2010). Pedagogical practices and instructional change of physics faculty. *American Journal of Physics, 78*, 1056–1063. https://doi.org/10.1119/1.3446763

Doyle, T. (2008). *Helping students learn in a learner-centered environment: A guide to facilitating learning in higher education*. Stylus Publishing, LLC.

Earl, B., Viskupic, K., Marker, A., Moll, A., Roark, T., Landrum, R. E., & Shadle, S. (this volume). "Driving change: Using the CACAO framework in an institutional change project." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 1). Pressbooks.

Ebert-May, D., Derting, T. L., Hodder, J., Momsen, J. L., Long, T. M., & Jardeleza, S. E. (2011). What we say is not what we do: Effective evaluation of faculty development programs. *BioScience, 6*(17), 550–558. https://doi.org/10.1525/bio.2011.61.7.9

Estrada, M., Woodcock, A., Hernandez, P., & Schultz, P. W. (2011). Toward a social influence model that explains minority student integration into the scientific community. *Journal of Educational Psychology, 103*(1), 206–222. https://doi.org/10.1037/a0020743

Fagen, A. P., Crouch, C. H., & Mazur, E. (2002). Peer instruction: Results from a range of classrooms. *The Physics Teacher, 40*(4), 206–209. https://doi.org/10.119/1.1474140

Foote, K. T. (2014). Factors underlying the adoption and adaption of a university physics reform over three generations of implementation. *Electronic Journal of Science Education, 18*(3). http://ejse.southwestern.edu/article/view/12495/8791

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the USA, 11*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Gunuc, S. & Kuzu, A. (2015). Student engagement scale: Development, reliability and validity. *Assessment and Evaluation in Higher Education, 40*(4), 587–610. https://doi.org/10.1080/02602938.2014.938019

Hazen, B. T., Wu, Y., & Sankar, C. S. (2012). Factors that influence dissemination in engineering education. *IEEE Transactions on Education, 55*(3), 384–393. https://doi.org/10.1109/TE.2011.2179655

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952–984. https://doi.org/10.1002/tea.20439

Henderson, C., Dancy, M., & Niewiadomska-Bugaj, M. (2012). The use of research-based instructional strategies in introductory physics: Where do faculty leave the innovation-decision process? *Physical Review Special Topics—Physics Education Research, 8*(2), 020104. https://doi.org/10.1103/PhysRevSTPER.8.020104

Henderson, C. & Dancy, M. H. (2007). Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Physical Review Special Topics—Physics Education Research, 3*(2), 020102. https://doi.org/10.1103/PhysRevSTPER.3.020102

Henderson, C. & Dancy, M. H. (2008). Physics faculty and educational researchers: Divergent expectations as barriers to the diffusion of innovations. *American Journal of Physics, 76*(1), 70–91. https://doi.org/10.1063/1.2177045

Hercovitch, L. & Meyer, J. P. (2002). Commitment to organizational change: Extension of a three-component model. *Journal of Applied Psychology, 87*(3), 474–487. https://doi.org/10.1037/0021-9010.87.3.474

Hernandez, P. R., Schultz, P. W., Estrada, M., Woodcock, A., & Chance, R. C. (2013). Sustaining optimal motivation: A longitudinal analysis of interventions to broaden participation of underrepresented students in STEM. *Journal of Educational Psychology, 105*(1), 89–107. https://doi.org/10.1037/a0029691

Kezar, A. (2011). What is the best way to achieve broader reach of improved practices in higher education? *Innovative Higher Education, 36*(4), 235–247. https://doi.org/10.1007/s10755-011-9174-z

Kezar, A., Gehrke, S., & Elrod, S. (2015). Implicit theories of change as a barrier to change on college campuses: An examination of STEM reform. *The Review of Higher Education, 38*(4), 479–506. https://doi.org/10.1353/rhe.2015.0026

Kober, N. (2015). *Reaching students: What research says about effective instruction in undergraduate science and engineering*. National Academies Press.

Labov, J. B., Singer, S. R., George, M. D., Schweingruber, H. A., & Hilton, M. L. (2009). Effective practices in undergraduate STEM education, part 1: Examining the evidence. *CBE—Life Sciences Education, 8*(3), 157–161. https://doi.org/10.1187/cbe.09-06-0038

Marbach-Ad, G., Bertke, M., Manyak Davis, A., & Thompson, K. (2019, April). *Participation in a biology faculty learning community increases college teaching self-efficacy* [Paper presentation]. American Education Research association (AERA), Toronto, Canada.

Marbach-Ad, G., Schaefer, K. L., Orgler, M., & Thompson, K. V. (2014). Science teaching beliefs and reported approaches within a research university: Perspectives from faculty, graduate students, and undergraduates. *International Journal of Teaching and Learning in Higher Education, 26*(2), 232–250. https://files.eric.ed.gov/fulltext/EJ1060872.pdf

Marbach-Ad, G., Schaefer, K. L. & Thompson, K. V. (2012). Faculty teaching philosophies, reported practices, and concerns inform the design of professional development activities of a disciplinary teaching and learning center. *Journal on Centers for Teaching and Learning, 4*, 119–137.

Mayne, J. (2015). Useful Theory of Change models. *Canadian Journal of Program Evaluation, 30*(2), 119–142. https://doi.org/10.3138/cjpe.230

National Science Foundation. (2019). *Improving undergraduate STEM education: Education and human resources (IUSE:HER)*. https://nsf.gov/pubs/2019/nsf19601/nsf19601.htm

Nilson, L. B. (2013). *Creating self-regulated learners*. Stylus.

Pilgrim, M. E., McDonald, K. K., Offerdahl, E. G., Ryker, K., Shadle, S. E., Stone-Johnstone, A., & Walter, E. M. (this volume). "An exploratory study of what different theories can tell us about change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 7). Pressbooks.

President's Council of Advisors for Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. https://files.eric.ed.gov/fulltext/ED541511.pdf

Prieto-Navarro, L. (2005). *Las creencias de autoeficacia docente del professorado universitario*. Universidad Potificia Comillas.

Reinholz, D. L., & Apkarian, N. (2018). Four frames for systemic change in STEM departments. *International Journal of STEM Education, 5*(1), 1–10. https://doi.org/10.1186/s40594-018-0103-x

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). The Free Press.

Seidel, S. B. & Tanner, K. D. (2013). "What if students revolt?"—Considering student resistance: Origins, options, and opportunities for investigation. *CBE—Life Sciences Education, 12*(4), 586–595. https://doi.org/10.1187/cbe-13-09-0190

Walter, E. M., Henderson, C. R., Beach, A. L., & Williams, C. T. (2016). Introducing the Postsecondary

Instructional Practices Survey (PIPS): A concise, interdisciplinary, and easy-to-score survey. *CBE—Life Sciences Education, 15*(4), ar53. https://doi.org/10.1187/cbe.15-09-0193

Wieman, C. E., Perkins, K., & Gilbert, S. (2010). Transforming science education at large research universities: A case study in progress. *Change, 42*(2), 6–14. https://doi.org/10.1080/00091380903563035

Weimer, M. (2002). *Learner-centered teaching: Five key changes to practice*. John Wiley & Sons.

3. Bringing an Asset-Based Community Development (ABCD) Framework to University Change Work

STEPHEN M. BISCOTTE AND NAJLA MOUCHREK

1 Look at the Bright Side of Higher Education Change

In higher education, the impetus for change is often the identification of a specific need, problem area, or area of under-performance. Examples include institutions recognizing that their retention rates for female students in STEM are too low; students from underrepresented groups appear underprepared for the rigors of calculus; or instructors lack pedagogical content knowledge to teach large introductory courses effectively. Interventions are designed and implemented to address these perceived deficits, which are too often identified as personal characteristics and limitations of specific groups (e.g. “those bad teachers” or “those unprepared students”). Instead, leaders could focus on growing, celebrating, and leveraging the strengths of the community involved. In this paper, the authors will introduce a strengths-based mindset utilized in community-development work, Asset-Based Community Development (ABCD), to the area of higher education change.

Throughout this paper, the authors use general education curriculum reform examples and prompts. However, readers can use their own higher education reform efforts as a practical context in which to consider this approach. This article follows the structure and participatory design nature of the workshop presented at the 2019 Transforming Institutions Conference hosted by the Accelerating Systemic Change Network (ASCN). Those in attendance were invited to consider their own goals for institutional change (such as increasing content alignment of 2-year and 4-year STEM programs or reforming pedagogy across introductory chemistry courses) and envision how the framework might guide their work.

Prompt 1: Your Introduction

Hi my name is __________. I’m from ___________ (institution). And I’m interested in changing ______________on my campus.

1.1 Higher Education Change is Complex

Welcome __________ (insert your name here). We are glad you made it. We are all here because we have taken on the daunting task of changing something at our institution. This is a safe space… you are among friends.

In her book, *How Colleges Change*, Kezar (2018) points to the many narrowly focused change models available. These models often fail to account for the nature of the change itself, the complexity of higher education structure, and the diverse contexts in which change happens. A leader equipped with one model for change (e.g. scientific management theory) will likely use this tool to drive each reform effort (e.g. introducing course-embedded experiential learning for all undergraduate students) as if it were the “proverbial nail.” This primarily top-down effort may work in some cases. However, without attending to the context of the change and the people involved, the change leaders may suffer significant setbacks in the process or conclude with only a short-term, superficial impact.

In addition, there is immense variation among the roles of those involved (e.g. adjunct instructors vs full professors), the structures in which each one operates (e.g. hierarchical organizational structure within student affairs vs loose coupling of instructors in a department), and the institutional mission each one pursues (e.g. comprehensive state university vs small liberal arts college). While leveraging technology to support student interaction in foundational STEM courses might prompt change at one institution, it might fail at another, due to lack of infrastructure for change, misconception of the nature of the problem in different contexts, or misalignment with the values and perspectives on learning.

In their review of the literature on reform in STEM undergraduate teaching, Henderson et al. (2010) conclude that some change approaches are more commonly used, even if the results are mixed at best. For example, it is quite common for change leaders to invest in a pilot cohort of champions to develop best practice tools and resources to then share with the greater community. Unfortunately, it is also quite common for these efforts to go no further than the pilot stage. Therefore, to achieve desired goals it is imperative that change leaders develop a thorough understanding of diverse change theories and a versatile toolbox of strategies to deploy as needed (Kezar, 2018). Our work echoes Pilgrim et al. (this volume) on the importance of not only understanding a range of theories of change, but also aligning those with goals within particular contexts. With this framework and knowledgebase, leaders can better recognize the scope and the type of change, avoid pitfalls resulting from a mismatch of the type of change and strategies utilized, and achieve lasting results.

1.2 Change Leaders are Busy and Changing a Culture is Hard

> *Prompt 2: Time to Completion*
>
> *I was given _________ (length of time) to complete this reform. And my job includes doing ________________ that are NOT tied to this reform.*

Kezar (2018) makes it clear that "one of the most significant challenges is that leaders tend to focus on interventions and programs but ignore the change process" (p. xiii). However, personnel are already quite busy doing various things to support students. Administrators participate in shared governance, support the curriculum and academic programs, manage the day-to-day operations of the institution, and report to external stakeholders like policymakers and accreditors. Instructors teach courses, advise students, participate in shared governance, and manage research and publications. Student affairs professionals support student growth and progress outside of the classroom, as well as partnerships in the classroom. With this level of complexity, uncertainty, and time needed for success, it is no wonder that change leaders often fall back onto timeworn strategies or ill-suited change theories that do not match the environment. Time for reform is a rare commodity.

In addition, the drive to "change the culture" is plagued by another fundamental problem: does the university even have a tangible culture (Silver, 2003), a set of institutional values and beliefs shared by its members, to be changed? Perhaps not. Alternative change models, such as the ABCD model proposed here, require we recognize the university as a networked community of individuals and groups with strengths, values, and subcultures. Here we align with Bangera et al. (this volume) about the importance of connecting and supporting adaptive and hierarchical networks with a wide range of stakeholders. If we consider that a higher education institution is a community (instead of an organization with a culture), we can find in the community development literature a framework that meets the needs of over-stretched professionals and also supports the deployment of a variety of change theories and strategies as needed within the complex cultural and organizational structure of the academy. We can let go of the notion that we need to change an institution's "culture," when a shared campus-wide culture may not even exist. Instead, we can focus on something more concrete, which is changing some practices and norms of the individuals that make up the institution's community through leveraging the assets and strengths of those involved.

2 ABCD as a Framework for Facilitating Change in Higher Education

Prompt 3: Who are the stakeholders involved with and/or impacted by this topic or issue?

a) ***Academic units****: ______________*
b) ***Administrative units****: ______________*
c) ***Interest Groups****: ______________*
d) ***Student groups****: ______________*
e) ***Beyond campus organizations****: ______________*

Prompt 3 Example: In the context of General Education Reform

a) ***Academic units****: All departments and colleges*
b) ***Administrative units****: Registrar's Office, advising network, admissions, and recruiters*
c) ***Interest Groups****: Strategic planning taskforce*
d) ***Student groups****: Student Government Association, professional fraternities*
e) ***Beyond campus organizations****: State and regional accreditors, community college and state transfer committees*

Asset-Based Community Development provides a strengths-based approach to growth and change (Kretzmann & McKnight, 1993). It is a clear mindset shift and digestible framework, perfect for the busy change agent "on the go," but is robust enough to allow for the deployment of rigorous theories of change as needed over an extended period of time to achieve lasting success. It is not a quick fix or "silver bullet." ABCD is a guide to complex, long-term, bottom-up higher education reform efforts.

ABCD serves as a roadmap to relationship development and a celebration of every member's contributions. The role of change agents is to identify community assets and strengths, rather than deficits and needs, and to provide opportunities for relationship-building and asset mobilization for ongoing reflection and improvement (Kretzmann & McKnight, 1993). For lasting positive change, reformers must first recognize that every individual, association, and institution has assets to contribute to ongoing community development; these are not clients that need to "buy in," but citizens ready to participate (Mathie & Cunningham, 2003).

Different versions of a growth-focused, asset-based perspective might be seen also in other works in this volume, like for example in Pilgrim et al. The centrality of developing strong relationships in change networks is highlighted also in the work of Bangera et al. (this volume).

Community workers are using the principles of ABCD to guide their work in localities around the world (Kretzmann & McKnight, 1993). Good examples include: the Bagot Community, an aboriginal network situated in a suburb of Darwin, Australia (Ennis & West, 2013); the youth of Lhasa, Tibet looking to capitalize on their tourism assets (Wu & Pearce, 2013); and local groups in Ethiopia collaborating with various non-governmental organizations (Mathie & Peters, 2014).

Through an ABCD lens, a college or university can be framed as a community of individuals (students, faculty, staff, administration, and local town), associations (student government, faculty senate and committees, housing and residence life, community coalitions, and non-profit organizations), and institutions (academic colleges, dining and residence halls, administrative offices, town hall, and local parks) working toward common goals of student learning and growth. To avoid work being done in isolation, change leaders can do much to facilitate and support constructive collaboration by following the ABCD framework.

2.1 ABCD Contextualized for Higher Education Reform

In Asset-Based Community Development (Kretzmann & McKnight, 1993), change agents conduct the following five steps to incite positive change in a community: 1) map individual assets; 2) build relationships between community-members and stakeholders; 3) mobilize identified assets and share useful information among the constituencies, 4) bring the community together in ongoing discussion to develop a plan and mission for the future; and finally 5) leverage outside resources to support local initiatives.

In this article, Step 1 will be the focus as it is critical to laying a strong foundation on which to build the community development work and to shift the mindset of those involved. However, so that the reader can see the rest of the framework in action, in Figure 1 we provide the five steps of ABCD overlaid with potential strategies to guide the change agent and have included examples related to general education curriculum reform. For instance, within Step 1, change agents may *engage* curricular planning teams to develop new outcomes, while in Step 3, change agents may *educate* faculty and advisors on the general education website and resources.

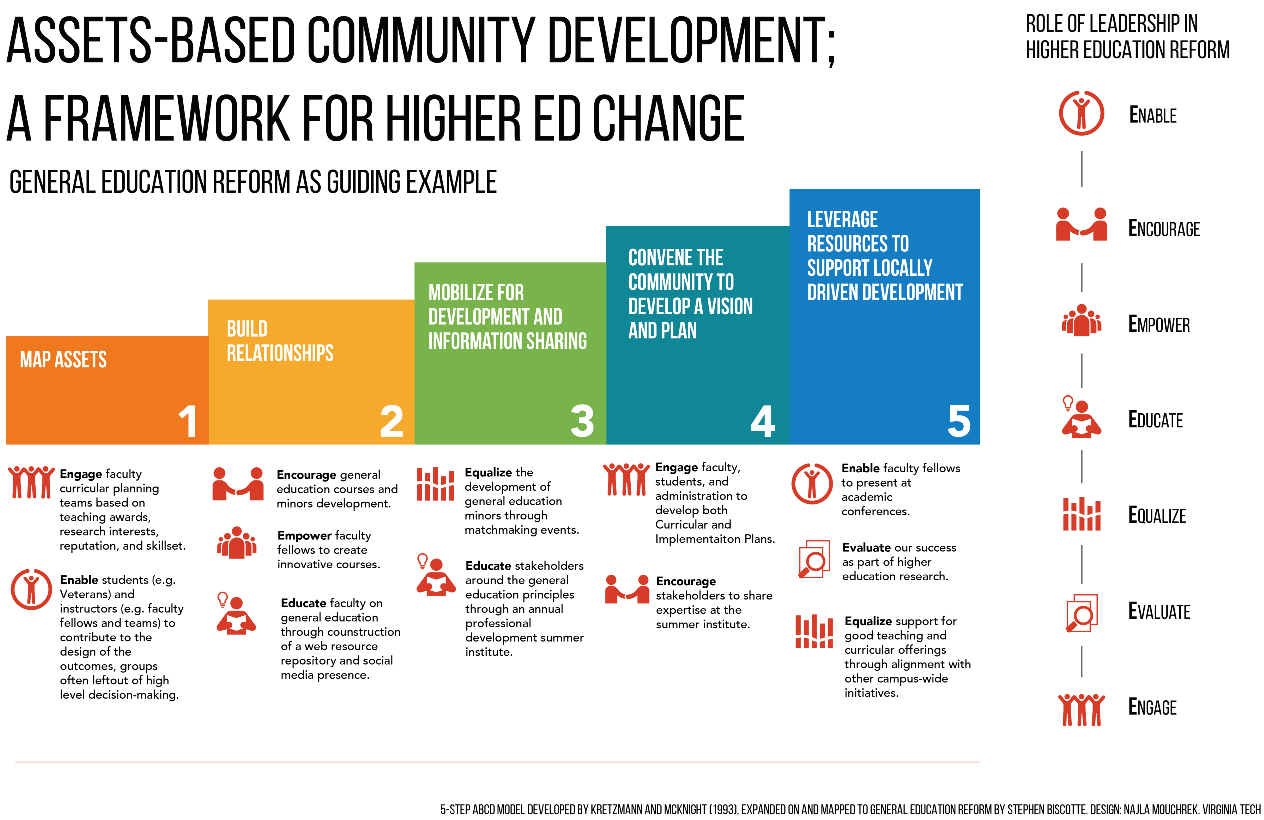


Figure 1: 5-Step ABCD model developed by Kretzmann and McKnight (1993), expanded on and mapped to general education reform by Stephen Biscotte. Design: Najla Mouchrek.

2.2 Step 1: Mapping the Assets

Prompt 4: A purpose statement to get started

By ________ (end date), _______________ will be accomplished by ______________ (who involved) by doing __________________ to address/achieve _________________ (problem/topic/issue at hand).

Prompt 4 Example: In the context of General Education Reform

By the end of one academic year, we will map the assets of the gen ed community to explore gen ed reform.

In a general education reform context, change agents would conduct an assets inventory to identify faculty with expertise in the general education outcome areas and a track record of high-quality teaching in foundational undergraduate courses. Reformers would identify administrative units, staff, committees, faculty interest groups, and student organizations with knowledge, experience, and a shared interest in achieving change. In addition, reformers could consider physical assets like new or innovative campus buildings or learning spaces. An assets inventory can help change agents to identify and celebrate local resources that are important to building an institutional foundation for lasting change.

Prompt 5: What are the assets on campus related to the following?

a) ***Physical****:* ____________________
b) ***Individual People****:* ___________________
c) ***Associations (unpaid)****:* ________________
d) ***Institutions (paid)****:* ___________________
e) ***Connections****:* ______________________

Prompt 5 Example: In the context of General Education Reform

a) ***Physical****: New classroom building, ropes course*
b) ***Individual People****: "Dr. Smith" (a certain person with great historical knowledge or experience, the gen ed committee chair)*
c) ***Associations (unpaid)****: Student government, gen ed curriculum committee*
d) ***Institutions (paid)****: Offices of Registrar, Provost, or Admissions*
e) ***Connections****: Interdisciplinary team-teaching instructors, faculty study groups*

An asset-map will look something like a more robust, "messy version" of the following examples from general education reform and experiential learning (from the workshop):

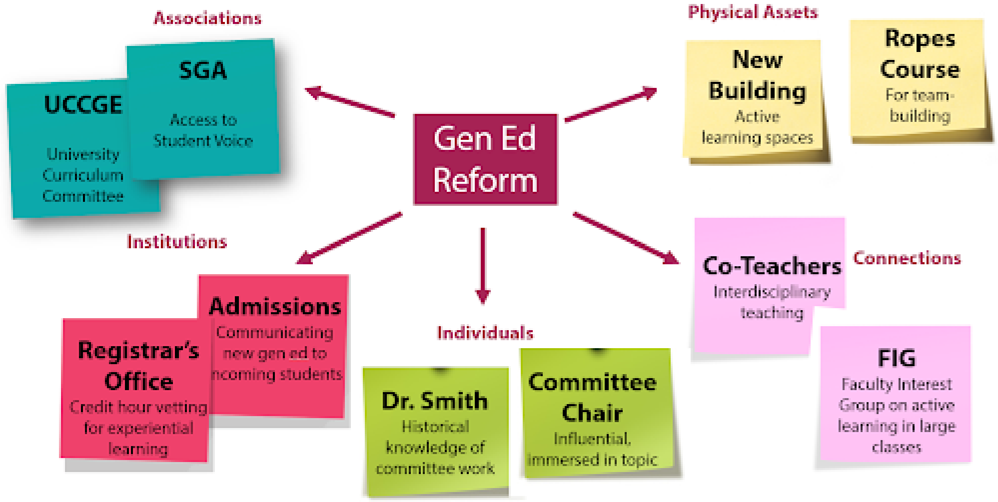


Figure 2: Example Asset-Map for General Education Reform

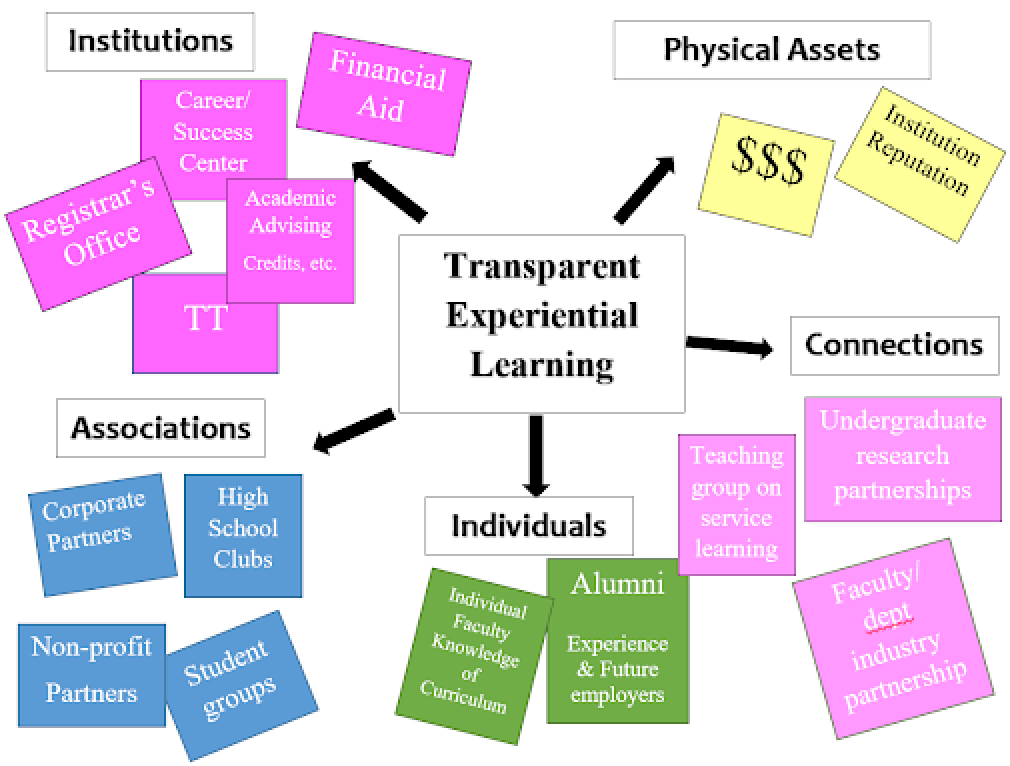


Figure 3: Example Asset-Map from Workshop for Experiential Learning Initiative

2.3 The Role of the Change Agent in ABCD

As facilitators of community development, the role of change agents is to "support networks that foster mutual learning and shared commitments so that people can work … together in relatively coherent and equitable communities" (Gilchrist, 2009, p. 21). According to the steps of ABCD (Kretzmann & McKnight, 1993), community workers first map the university assets. Secondly, to help foster relationships among the community members that "promote respect, trust, and mutuality" (Gilchrist, 2009, p. 131) and go beyond superficial interactions, "meta-networking strategies" are employed. These strategies include: a) coordinating bi-weekly meetings and social engagements; b) helping develop structures that will support network sustainability; c) supporting member travel to conferences; and d) monitoring relevant networks to deal with tensions that can decouple a network bridge. This last responsibility is crucial to the health of the community.

If (when) there is ongoing conflict among community members, change agents ought to bring them in to help find common ground and "mediate, translate, and interpret between people and agencies that are not in direct or clear communication with one another" (Gilchrist, 2009, p. 116). Throughout the process, the change agent serves as a transformational leader and broker, developing trust while building and leveraging social capital (Purdue, 2011). The change-agent will wear the many hats of policymaker, event planner, and even conflict mediator to support the community development process.

At each stage of a higher education institutional reform effort, the change agent should strive to "expand the table" (Kretzmann & McKnight, 1993) to comprise a far more inclusive and diverse membership to help ensure internal assets of our students, both undergraduate and graduate, faculty of all levels, community partners, and administration are not missed. "Robust and diverse community networks are vital for effective and inclusive empowerment because they encourage a wider range of people to become active citizens and enable those who do take on civic roles to perform their roles as community representatives and leaders" (Gilchrist, 2009, p. 17.) Another important aspect is that the exchanges in these community networks must be fundamentally participatory and iterative in nature (a point that is also made in this volume by Ngai et al.)

Despite the "turf wars" and financial and political debating, campus change efforts offer a common venue for community members to step outside of their titles and silos to participate in the democratic process, but only if provided the opportunity. Continuing with the general education reform example, by funding graduate assistants and including them in professional development opportunities and working groups, administration can provide opportunities for them to build social capital (e.g. NSF funding on CV, networking with full faculty) while gaining the expertise and voice to teach their peers and colleagues. Pre-tenured faculty belong at the table as well. As members of Faculty Learning Communities or Departmental Action Teams (as described elsewhere in this volume), these early career faculty can learn lessons and develop connections that can pay off in future committee appointments, scholarly collaborations, or tenure support. If reformers do not take these steps to "expand the table," it is consequently difficult to identify (and later mobilize) the assets of these internal collaborators.

3 Conclusion

The ABCD framework has been used by the community development world for several decades. ABCD can provide busy higher education administrators and change agents the clear reframing they need to, as one workshop attendee put it, “see bridges rather than walls” that can so easily pop up throughout a reform process. It is a useful 5-step framework and strengths-based mindset to reorient higher education change theories and strategies (like the CODS or CACAO frameworks described elsewhere in this volume). Although there are proofs of concept from community development, empirical research across the higher education domain would be fruitful to measure the potential impact of this framework on higher education change.

“ABCD is not done to communities by ABCD experts” (Mathie & Cunningham, 2003, p. 484), just as reform is not accomplished in the university by faculty, administrators, or accreditation agencies. With guidance, change agents can leverage Step 1 of the framework to identify and map the assets of their own institution related to a given issue, a key foundation on which the rest of the reform effort can build. As one attendee at the workshop put it, “there are so many people impacted by a change that you really have to involve them from the beginning. The asset map reminds you that they exist and also have something to offer.” The change agent can then increase the opportunities for community building by a diverse and talented array of networked members. At the very least, this approach offers change agents the opportunity to re-envision their role as connection-makers and trust-builders rather than just “problem-solvers and fixers.”

4 Acknowledgments

This framework is guiding work supported by the NSF CCE STEM (ER2) grant #1737042.

5 About the Authors

Stephen Biscotte is the Director of General Education and an Instructor of Educational Psychology at Virginia Tech.

Najla Mouchrek is the Program Director for Interfaith Leadership and Holistic Development at Virginia Tech.

6 References

Bangera, G., Vermilyea, C., Reese, M., & Shaver, I. (this volume). “On the RISE: A case study of institutional transformation using idea flow as a change theory." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 5). Pressbooks.

Ennis, G., & West, D. (2013). Using social network analysis in community development practice and research: A case study. *Community Development Journal, 48*(1), 40–57. https://doi.org/10.1093/cdj/bss013

Gilchrist, A. (2009). *The Well-Connected Community*. The Policy Press.

Henderson, C., Finkelstein, N., & Beach, A. (2010). Beyond dissemination in college science teaching: An introduction to four core change strategies. *Journal of College Science Teaching, 39*(5), 18–25.

Kezar, A. J. (2018). *How colleges change: Understanding, leading, and enacting change*. Routledge. https://doi.org/10.4324/9781315121178

Kretzmann, J. P., & McKnight, J. L. (1993). *Building communities from the inside out: A path towards finding and mobilizing community assets*. ACTA Publications.

Mathie, A., & Cunningham, G. (2003). From clients to citizens: Asset-Based Community Development as a strategy for community-driven development. *Development in Practice, 13*(5), 474–486. https://doi.org/10.1080/0961452032000125857

Mathie, A., & Peters, B. (2014). Joint (ad)ventures and (in)credible journeys evaluating innovation: Asset-based community development in Ethiopia. *Development in Practice, 24*(3), 405–419. https://doi.org/10.1080/09614524.2014.899560

Ngai, C., Corbo, J. C., Quan, G. M., Falkenberg, K., Geanious, C., Pawlak, A., Pilgrim, M. E., Reinholz, D. L., Smith, C., & Wise, S. (this volume). "Developing the Departmental Action Team theory of change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 5). Pressbooks.

Pilgrim, M. E., McDonald, K. K., Offerdahl, E. G., Ryker, K., Shadle, S. E., Stone-Johnstone, A., & Walter, E. M. (this volume). "An exploratory study of what different theories can tell us about change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 7). Pressbooks.

Purdue, D. (2001). Neighbourhood governance: Leadership, trust and social capital. *Urban Studies, 38*(12), 2211–2224. https://doi.org/10.1080/00420980120087135

Silver, H. (2003). Does a university have a culture? *Studies in Higher Education, 28*(2), 157–169. https://10.1080/0307507032000058118

Wu, M. Y., & Pearce, P. L. (2013). Asset-Based Community Development as applied to tourism in Tibet. *Tourism Geographies, 16*(3), 438–456. https://10.1080/14616688.2013.824502

4. Scaffolding Research into Undergraduate STEM Curricula and Cultures: An Emerging Model for Systemic Change

MITCHELL MALACHOWSKI, JEFFREY M. OSBORN, KERRY K. KARUKSTIS, JILLIAN KINZIE, AND ELIZABETH L. AMBOS

Undergraduate research is one of ten high-impact practices that have gained considerable traction in undergraduate education (Kuh, 2008), serving as a mechanism for enhancing student learning, faculty research, and institutional missions. Engagement of undergraduates in research benefits students across demographic groups and disciplines, providing even greater gains for students traditionally underserved by higher education (Kuh et al., 2007; Osborn & Karukstis, 2009; Lopatto, 2009; Brew, 2010; Laursen et al., 2010; Eagan et al., 2013; Collins et al., 2017; Carpi et al., 2017). Undergraduate research exemplifies high levels of academic rigor, fosters active and collaborative learning, builds student-faculty interactions, and lends itself to student-centered, supportive campus environments. The involvement of undergraduates in research is a proven and powerful pedagogy in view of the many benefits gained by students related to their cognitive, intellectual, professional, and personal growth (Osborn & Karukstis, 2009; Hensel, 2012).

Since 1996, the Council of Undergraduate Research (CUR) has offered multi-day Institutes to help institutional teams develop plans to create and institutionalize undergraduate research efforts (Malachowski et al., 2014). For the last 10–15 years, almost without exception, one major goal set by each campus has been to create a more research-rich, scaffolded curriculum. Two key motivations for this are to provide valuable undergraduate research opportunities for all students and to enhance student learning through more intentional curricular planning by the faculty. However, teams invariably discover the significant challenges and long time horizon needed for curricular reform. Challenges include such issues as understanding the different disciplinary cultures among STEM departments/programs; rethinking faculty workload and reward systems for both tenure-track and non-tenure-track faculty; establishing partnerships between faculty and administrators; scaffolding curricular elements linked to student learning outcomes; and partnering with students to fundamentally change the learning process (Malachowski et al., 2015a–c).

With support from the National Science Foundation (Malachowski et al., 2016), CUR—with Indiana University's Center for Postsecondary Research—is working with 24 departments at 12 institutions across the U.S. over a five-year period on a project we term "CUR Transformations." These institutions are a mix of public and private; large and small; Carnegie classifications; racial and ethnic demographics, including Historically Black Colleges & Universities and Hispanic-serving institutions; and are geographically spread across the country. The five Principal Investigators (PIs) are leading fundamental research on student, faculty, departmental, and disciplinary influences on the process of integrating and scaffolding research into four-year undergraduate STEM curricula. To achieve a cohesive four-year curriculum that initiates students into a culture of inquiry and research in the discipline, the participating departments are using a backward-design approach to develop scaffolded, research-rich courses that strategically build-in deliberate practices/experiences across the four years to guide students to greater independence and ownership of their learning. Providing all students with more equitable access to the benefits of undergraduate research is critically dependent on: adapting curricula; engaging faculty, students, and administrators; and changing departmental and institutional cultures.

This chapter describes the goals and activities of the CUR Transformations project to delineate a process for departments to integrate and scaffold research across the undergraduate STEM curriculum. By describing the activities and interventions, we are outlining an emerging Theory of Change—a roadmap between the activities and the desired Transformations project outcome—to create a tested framework for other departments and institutions seeking to implement research-rich undergraduate curricula.

1 Undergraduate Research as a Vehicle to Drive and Understand Systemic Change

The 12 participating institutions in CUR Transformations were recruited through a national, three-stage proposal competition. A total of 88 colleges/universities applied, each with two departments among the disciplines of biology, chemistry, physics, and psychology proposed as participants. The final selection of institutions was based on their existing commitment to undergraduate research, as demonstrated by faculty and administrative buy-in, and a capacity for transformative change. Importantly, however, they did not yet have a mature, backward-designed, research-rich curriculum in place but were committed to comprehensive curricular change.

1.1 Selecting Design Factors to Accelerate Systemic Change

The substantial institutional interest in the project reflects a significant demand for curricular transformation that broadens the population of students who gain the benefits of undergraduate research. Participating in a project of national scope can also help advance the transformation process. Building on our past experience with undergraduate research Institutes and NSF-sponsored initiatives (Hensel et al., 2006; Malachowski et al., 2010, 2014), the framework of the CUR Transformations project was crafted with several design factors to accelerate systemic change and enhance the likelihood of sustainability. These include:

- requiring the involvement of two departments per institution with defined departmental and institutional teams, each with an effective leader;

- assigning two experienced consultants to each departmental team for sustained guidance, communication, and annual site-visits;
- providing effective curricular and cultural development tools;
- enhancing accountability via annual meetings of project participants and consultant site-visits to campuses;
- using discipline-based education research to help structure the curricular reform process;
- providing departmental incentive funds;
- offering resources and dissemination avenues; and
- providing high-quality research and assessment tools.

The rhythms of these yearly activities begin in the fall with a meeting of institutional/departmental team members, consultants, and PIs, where the approximately 130 participants meet to share and learn from each other, and to plan for the upcoming year. Consultant teams make a visit to each of their two campuses sometime between November and May, site-visit reports are shared soon after, and then teams conduct their data collection and submit an annual report in June. The PIs use these materials to study progress and plan for the subsequent year's activities. The provision of this design is key to facilitating systemic change.

1.2 Using Backward-Design as a Curricular Catalyst

From the outset, each institutional/departmental team made a four-year commitment to work on Transformations project goals, including the creation of a compendium of materials such as student learning objectives, annual curriculum mapping and scaffolding plans, annual reports, and internal assessment data. The work of each department began with their choices on team composition and a decision-making scheme. They then examined their curriculum, generating learning outcomes for each major and mapping the current curriculum to the learning outcomes. This approach identified redundancies and gaps to ensure that learning goals are uniformly addressed for all tracks within the major. Using backward-design principles forces departments to make tough decisions about what content and skills are really needed for students to achieve learning goals. Additionally, faculty are encouraged to think in advance about the evidence needed to document that learning has been achieved. Backward-design also leads to greater coherence among desired results, evaluation criteria, and teaching and learning experiences, ultimately leading to better student performance (Wiggins & McTighe, 1998, pp. 13–34). The goal for the project—and each team—is to understand how these cohesive, research-rich curricula are developed within diverse disciplinary, departmental, and institutional cultures and practices.

1.3 Implementing Integrated, Scaffolded Research-Rich Experiences

Once curriculum mapping was complete, each department determined their scaffolding plan for research-rich experiences. Several departments completed detailed analyses of science practices, experimental design strategies, and laboratory methods, and the progression of these in each of their existing (or new) courses and laboratories. These scaffolded curriculum matrices helped departments identify specific expectations for student learning, and when and where these should occur in courses and labs.

Some departmental efforts were also guided by student input about research skill development and perceptions of their research experience, faculty workload and reward factors, and institutional data about student involvement in undergraduate research. Notably, most departments were already using a range of assessment tools to collect baseline, formative, and summative data. For example, home-grown surveys about students' research experiences, end-of-course evaluations, student scores on lab practicals and final exams, surveys of perceptions of scientific identity, and assessments of capstones for research skill development helped inform scaffolding decisions. Combined, these studies helped departments identify needs and potential sites to enhance existing, and develop new, research experiences in their curriculum.

The 24 departmental designs of scaffolded, research-rich experiences varied. Understandably, many departments focused their reform efforts on integrating research into entry-level courses and renovating lab experiences. These efforts typically emphasized incorporating learning activities that developed specific research skills or introduced students broadly to inquiry or specifically to the scientific method. For example, a Biology department reformed its two-semester introductory core to include authentic research experiences. This required changing the labs to a more extensive inquiry-based approach by teaching students all aspects of research, from experimental design to data collection and analyses to dissemination of research results. The reform also included a reduction in the number of first-year student lab reports and an expansion of methods and results sections to more closely reflect presentation in the discipline.

In contrast, other departments focused on upper-division, research-based, and/or capstone courses. One institution emphasized expanded integration of course-based undergraduate research experiences (CUREs) in second-, third-, and fourth-year required and elective courses. This department also enhanced standard lecture courses by integrating extensive in-class discussions of research design, data analysis, and interpretation.

2 Examining How Transformation Occurs and Its Impact

As we study the curricular transformation process, we are working to understand a) how students view and experience a research-rich curriculum, b) how differing STEM disciplinary cultures influence transformation, and c) the efficacy of different strategies to catalyze transformative change. Our overarching objective is to determine why the systematic institutionalization of undergraduate research occurs more rapidly in some environments and not in others. These fundamental questions are allowing us to create a Theory of Change model—the "hows and whys" of transformation to scaffolded, research-rich undergraduate STEM curricula—that will be portable and transferable to institutions of all types.

2.1 Methodology

To address our research questions, we are using a mixed-methods approach, including surveys, focus groups with students and faculty, observations and interviews with faculty teams and consultants, annual departmental and consultant progress reports, and in-depth site-visits. Also, a novel aspect is the development and testing of experimental questions about research-rich experiences for the National Survey of Student Engagement (NSSE) and the Faculty Survey of Student Engagement (FSSE). These common assessment tools allow for comparison among participating institutions, provide a measure of change within departments over time, and offer evidence of reformed student experiences for reporting and benchmarking. The survey tools will ultimately be available to other departments interested in assessing undergraduate research reform efforts.

2.2 Assessing Students' Research-Rich Experiences

Assessments of students' experiences, behaviors, perceptions, attitudes, and learning outcomes offer rich sources of evidence for curricular change and can help guide faculty decisions about instructional improvements (Borrego & Henderson, 2014). The CUR Transformations project simultaneously emphasizes the consideration of both departmental assessment evidence and results from a common, project-wide assessment tool to gauge students' views and experiences of research-rich curricula.

CUR Transformations' common assessment tool is a survey asking students about research-driven experiences in their courses (a companion survey that asks faculty about the undergraduate research experiences integrated into their courses is in development). The student survey was administered to over 1,000 students in 2018–2019 to secure baseline data about students' experiences and evidence of early progress in re-designed courses. These short assessments were most useful to departments' identification of research-rich strengths and areas for curricular growth. For example, some departments learned that their students were primarily participating in literature review and data collection and that little collaboration was occurring among students. Another discovery made by many departments was that modules and/or stand-alone courses in statistical methods needed to be introduced much earlier in the curriculum. These insights are key assists to curricular reform efforts. Our methodology has similarities to that of Thompson and Marbach-Ad, as each of us gathered survey data on student characteristics that could influence faculty attitudes, intentions, and behaviors (Thompson & Marbach-Ad, this volume).

Broader observations about transformation can also be drawn from the dataset. For example, students identified laboratories as the leading context (50%) for their research-rich experiences, followed by discussion sections (35%). Only a small fraction (8%) identified lecture as the site for research-rich experiences. Regarding what motivated students' interest in a research experience, the greatest share identified that their career goals involve doing research. Interestingly, a significant proportion of students indicated that they were not interested in research prior to their current experience. This finding corroborates and builds on other studies that demonstrate that early research-rich experiences connect students to research (Killion et al., 2019; Sandquist et al., 2019). Finally, students generally expressed only modest levels of confidence in their research skills, and moderate agreement that their research experience increased their knowledge of technical skills, comfort discussing scientific concepts, ability to explain research to others, and readiness for more demanding research, among other outcomes. These results suggest significant room for enhancing research-rich experiences. We are currently expanding the survey applications to further examine the influence of student characteristics, including first-generation status and racial-ethnic groups.

2.3 Understanding Different Approaches and Faculty Receptivity to Transformation

Companion annual reports from departments and consultants provide information on departmental, institutional, and disciplinary approaches to curricular change. These reports have contributed emerging insights related to such issues as understanding faculty receptivity to the principles of backward-design, faculty views on course-based research as an authentic experience with high value, and challenges of shifting "ownership" for course-based research from the control of individual faculty members to the department. All of these factors are currently being examined to learn more about key influences on the change process.

3 Transformative Change through Undergraduate Research: An Emerging Theory of Change

At the half-way point in CUR Transformations, departments have determined decision-making processes, developed learning outcomes, mapped curricula and outcomes to identify redundancies and gaps, initiated and considered assessment results to inform planning, and shifted to faculty revising curricula/courses in groups vs. independently. These steps appear to be influencing the Transformations outcome of more research-rich curricula since more students are experiencing research, and several departments are reporting that these students have an increased perception of their research skills and an enhanced sense of scientific agency. We are also observing a broader culture shift, exemplified by the following departmental quote:

> There is broad participation in the project … There is also the acknowledgement that this type of work is essential to fostering productive post-graduate outcomes for our students, serves to distinguish [us] from competitor institutions, and reflects authentic changes in the obligations of 21st century higher education. In sum, there is a shared acknowledgement that undergraduate research is not only the work that we want to do, but the work that we need to do.

Our initial findings point to several factors indicative of transformational change, providing insight into promising conditions to achieve scaffolded, research-rich curricula. These factors represent practical steps to make changes, and core components of an emerging Theory of Change Model, which will be solidified as the project proceeds. The central finding thus far, and congruent with previous research, is that departments that use evidence-based principles for curricular redesign and actively align faculty and student expectations and rewards to promote curricular change goals meet with success. Six specific conditions appear to correlate with progress:

1. *Identifying multiple and diverse campus leaders to maintain interactions among undergraduate research advocates to sustain the curricular and cultural transformation momentum*. For example, departments are more successful if they engage a significant number of the tenure-track and non-tenure-track faculty members with teaching responsibilities. Success is also predicted if departments connect their curricular change process to the priorities of multiple administrators, including chairs, deans, provosts, institutional research professionals, sponsored programs staff, and faculty development centers.
2. *Developing an understanding of—and using—the many levers for change on campus*. Which lever (usually a practice or policy) should be "pulled"? When should it be activated? Who should be the dominant force behind the lever? These are significant questions to consider in creating a critical path toward curricular transformation. For example, departments that have taken the time to understand the nuances of their cultural and political landscapes and to plan their transformational work strategically have been the most effective.
3. *Using assessment results to help drive the curricular revision process*. Ongoing assessment of the learning environment and student outcomes is an integral component in department change efforts. Departments that have made greater progress have conceptualized action research within the department, assessed degree goals and desired outcomes in terms of research-related components, and are acting on research and assessment findings to improve both student learning and departmental culture. For example, a department is piloting research-based "signature assignments" to systematically assess students' progression through the curriculum. They also learned from assessments that a key research rotation experience was not helping underrepresented students feel that they were a part of the science community. The notion of assessment as action research—a process in which participants use research techniques to examine their educational practice systematically, to plan, develop solutions, and gauge effect—appears to be a useful frame.
4. *Having communication and decision-making strategies that keep undergraduate research efforts front-and-center.*For example, departments that frequently include discussion of their CUR Transformations work at faculty meetings, undertake a department retreat at least once a year to work on shared curricular transformation aims, and report to administrators at regular intervals, are making demonstrably more progress in their transformation efforts.In addition, departments that are creating curriculum review and approval processes that involve all faculty (including non-tenure-track colleagues who have significant teaching responsibilities) are perceived to be on a more sustainable transformation pathway.
5. *Exploiting synergies among the CUR Transformations work with related initiatives on STEM*

student success and/or high-impact practices. Several institutions/departments also have other major change projects underway (e.g., Howard Hughes Medical Institute) that align with the CUR Transformations aims. By explicitly and transparently interconnecting these efforts, siloing is reduced, synergies among different funding resources (internal and external) are created, and long-term sustainability is all the more likely.

6. *Aligning the goals of the CUR Transformations work on curricular and cultural transitions to broader departmental and institutional goals.* The ability of departments to interface their CUR Transformations work with institutional imperatives is a strong predictor of their success in transformation and the likelihood of long-term sustainability. Several departments have linked their CUR Transformations efforts with periodic program reviews, disciplinary certification/accreditation practices, and/or institutional accreditation processes.

In addition to these factors that correlate with success, our findings also suggest several obstacles that impede progress. One of the strongest deterrents to effecting change is the lack of sufficient faculty buy-in for curricular transformation *before* launching the effort. Even when the work will be accomplished by a subset of the department, or will impact a small array of courses, effective and sustainable change can be thwarted by a group of disinterested individuals. It is also essential to consider the impact on faculty and student workload, both during the transformation process and after the new curriculum is in place. Added responsibilities will dampen enthusiasm and inhibit moving forward unless there is a commitment to build this work into faculty load. It is important to note that some *perceived* deterrents—lack of financial resources, changes in administrators, department size (large or small)—do not necessarily constrain progress. The key for those institutions in the CUR Transformations project who are making significant headway is that they have found innovative ways to address their challenges within their own institutional contexts. These approaches will be documented further as the project concludes.

As we continue to develop the Theory of Change Model for this project, we intend to look more closely at the organizational networks described by Bangera et al. (this volume). In their chapter, they consider the challenges of melding the Adaptive Network with the Hierarchical Network found in most organizations in ways that lead to the integration of the novel curricular forms.

4 Conclusions

This project will have impacts beyond the 24 participating departments, their 12 institutions, and the hundreds of thousands of students whom they teach. The Theory of Change model that is emerging will allow a broad and diverse range of institutions and departments/disciplines to: a) assess their readiness for research-scaffolded curricula and new faculty workload and leadership models, b) understand the cultural change process within the context of different STEM disciplinary cultures, and c) take focused steps toward achieving sustained transformations. CUR Transformations is developing and disseminating tools to measure the effectiveness and extent of reform, providing key insights into its effects on student achievement and organizational and cultural change.

5 Acknowledgments

This chapter is based upon work supported by the National Science Foundation under EHR-DUE grant #16-25354. The opinions, findings, conclusions, and recommendations expressed here are those of the authors and do not necessarily reflect the views of the NSF. We thank the many faculty and staff members working on the project at the participating institutions and the expert consultants working with these institutional teams.

6 About the Authors

Mitchell Malachowski is a Professor of Chemistry at the University of San Diego.

Jeffrey M. Osborn is Provost and Vice President for Academic Affairs at The College of New Jersey.

Kerry K. Karukstis is the Ray and Mary Ingwersen Professor of Chemistry at Harvey Mudd College.

Jillian Kinzie is Associate Director Indiana University Center for Postsecondary Research and NSSE Institute.

Elizabeth Ambos is a former Executive Officer for the Council on Undergraduate Research in Washington, DC.

6 References

Bangera, G., Vermilyea, C., Reese, M., & Shaver, I. (this volume). “On the RISE: A case study of institutional transformation using idea flow as a change theory.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 6). Pressbooks.

Borrego, M., & Henderson, C. (2014). Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. *Journal of Engineering Education, 103*(2), 220–252. https://doi.org/10.1002/jee.20040

Brew, A. (2010). Imperatives and challenges in integrating teaching and research. *Higher Education Research & Development, 29*(2), 139–150. https://doi.org/10.1080/07294360903552451

Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching, 54*(2), 169–194. https://doi.org/10.1002/tea.21341

Collins, T. W., Grineski, S. E., Shenberger, J., Morales, X., Morera, O. F., & Echegoyen, L. E. (2017). Undergraduate research participation is associated with improved student outcomes at a Hispanic-serving institution. *Journal of College Student Development, 58*(4), 583–600. https://doi.org/10.1353/csd.2017.0044

Eagan, M. K., Hurtado, S., Chang, M. J., Garcia, G. A., Herrera, F. A., & Garibay, J. C. (2013). Making a difference in science education: The impact of undergraduate research programs. *American Educational Research Journal, 50*(4), 683–713. https://doi.org/10.3102/0002831213482038

Hensel, N. (Ed.). (2012). *Characteristics of Excellence in Undergraduate Research*. Council on Undergraduate Research.

Hensel, N., Karukstis, K., Osborn, J., Malachowski, M., & Singer, J. (2006). A workshop initiative by the Council on Undergraduate Research to establish, enhance, and institutionalize undergraduate research (Project no. NSF-DUE #0618721) [Grant].

Killion, P., Page, I. B., & Yu, V. (2019). Big-data analysis and visualization as research methods for a large-scale undergraduate research program at a research university. *Scholarship and Practice of Undergraduate Research, 2*(4), 14–22. https://doi.org/10.18833/spur/2/4/7

Kuh, G. D. (2008). *High-impact educational practices: What they are, who has access to them, and why they matter*. Association of American Colleges and Universities.

Kuh, G. D., Kinzie, J., Cruce, T., Shoup, R., & Gonyea, R.M. (2007). *Connecting the dots: Multi-faceted analyses of the relationships between student engagement results from the NSSE, and the institutional practices and conditions that foster student success* (Report prepared for Lumina Foundation for Education). Indiana University Center for Postsecondary Research. https://scholarworks.iu.edu/dspace/bitstream/handle/2022/23684/Connecting%20the%20dots-%20Multi-faceted%20analyses%20of%20the%20relationships%20between%20student%20engagement%20results%20from%20the%20NSSE,%20and%20the%20institutional%20practices%20and%20conditions%20that%20foster%20student%20success.pdf?sequence=1

Laursen, S., Hunter, A.B., Seymour, E., Thiry, H., & Melton, G. (2010). *Undergraduate research in the sciences: Engaging students in real science*. Jossey-Bass.

Lopatto, D. (2009). *Science in solution: The impact of undergraduate research on student learning*. The Research Corporation for Science Advancement.

Malachowski, M., Ambos, E., Karukstis, K., & Osborn, J. (2010). Collaborative research: Transformational learning through undergraduate research: Comprehensive support for faculty, institutions, state systems and consortia (Project no. NSF-DUE #0920275, #0920286) [Grant].

Malachowski, M., Hensel, N., Ambos, E. L., Karukstis, K. K., & Osborn, J. M. (2014). The evolution of CUR institutes: From serving individuals to serving campuses, systems, and consortia. *CUR Quarterly, 35*(1), 34–35.

Malachowski, M., Osborn, J.M., Karukstis, K.K. & Ambos, E.L. (Eds.). (2015a). Enhancing and expanding undergraduate research: A systems approach [Special issue]. *New Directions for Higher Education, 169*.

Malachowski, M., Osborn, J. M., Karukstis, K. K. & Ambos, E. L. (2015b). Realizing student, faculty, and institutional outcomes at scale: Institutionalizing undergraduate research, scholarship, and creative activity within systems and consortia. *New Directions for Higher Education, 169*, 3–13. https://doi.org/10.1002/he.20118

Malachowski, M., Osborn, J. M., Karukstis, K. K., Ambos, E. L., Kinkaid, S. L. & Weiler, D. (2015c). Fostering undergraduate research change at the system and consortium level: Perspectives from the Council on Undergraduate Research. *New Directions for Higher Education, 169*, 95–106. https://doi.org/10.1002/he.20126

Malachowski, M., Ambos, E., Karukstis, K., Kinzie, J. & Osborn, J. (2016). Integrating and scaffolding research into undergraduate STEM curricula: Probing faculty, student, disciplinary, and institutional pathways to transformational change (Project no. NSF-DUE #1625354) [Grant].

Osborn, J. M. & Karukstis, K. K. (2009). The benefits of undergraduate research, scholarship, and creative activity. In M. Boyd & J. Wesemann (Eds.), *Broadening participation in undergraduate research: Fostering excellence and enhancing the impact* (pp. 41–53). Council on Undergraduate Research.

Sandquist, E. J., Cervato, C., & Ogilvie, C. (2019). Positive affective and behavioral gains of first-year students in course-based research across disciplines. *Scholarship and Practice of Undergraduate Research, 2*(4), 45–57. https://doi.org/10.18833/2/4/9

Thompson, K. V., & Marbach-Ad., G. (this volume). "The Characteristics of Dissemination Success (CODS) model as a framework for changing the culture of teaching and learning." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 2). Pressbooks.

Wiggins, G. & McTighe, J. (1998). *Understanding by Design*. Association for Supervision and Curricular Development.

5. Developing the Departmental Action Team Theory of Change

COURTNEY NGAI, JOEL C. CORBO, GINA M. QUAN, KAREN FALKENBERG, CHRISTOPHER GEANIOUS, ALANNA PAWLAK, MARY E. PILGRIM, DANIEL L. REINHOLZ, CLARA E. SMITH, AND SARAH B. WISE

1 Introduction

The transformation of education in university departments is a pressing issue. Research suggests that the success of a given intervention is dependent on the local context, and so change efforts should attend to the culture in which the change is embedded (Kezar, 2013; Schein, 2010). Because departments tend to have a stable culture, we argue that a department is a sensible scale to focus change efforts (Corbo et al., 2016; Ngai et al., 2020; Quan et al., 2019; Reinholz et al., 2017).

Our project cultivates department-level changes in university departments through Departmental Action Teams (DATs) (Corbo et al., 2016; Reinholz et al., 2017). DATs consist of faculty, students, and staff in a single department working on a broad-scale issue related to undergraduate education. External facilitators with expertise in education, organizational change, and facilitation support DAT members in enacting departmental change and growing as change agents. DATs have chosen to focus on a variety of issues including curricular changes (e.g., improved curricular alignment) and cultural changes (e.g., improving recruitment and retention of women and underrepresented minority students). While our project does not prescribe the specific changes DATs make, our long-term goal is that the DAT and the DAT's department make progress toward the following six Core Principles (Quan et al., 2019):

1. Students are partners in the educational process.
2. Work focuses on achieving collective positive outcomes.
3. Data collection, analysis, and interpretation inform decision-making.
4. Collaboration among group members is enjoyable, productive, and rewarding.
5. Continuous improvement is an upheld practice.
6. Work is grounded in a commitment to equity, inclusion, and social justice.

These principles guide our facilitation of DATs and describe what we consider to be an ideal departmental culture.

The DAT Project is an NSF-funded project spanning four years. Two components of the DAT Project are running DATs (17 over two campuses) and refining the DAT model. The DAT Project team is comprised of researchers and facilitators. All authors of this paper have contributed to research and/or facilitation of DATs. One result of the DAT Project is a refined DAT model and a Theory of Change

(TOC) for the DAT model. The DAT TOC articulates how our project activities (i.e., DAT formation, facilitation) lead to our long-term goal (departmental culture aligned with our Core Principles). Information about implementing DATs can be found at our website (www.dat-project.org) and in our book *Facilitating Change in Higher Education: The Departmental Action Team Model* (2020). Within this paper, we present a description of our process of developing our TOC for two purposes:

1. To allow others doing change work to follow similar processes for developing their own Theories of Change and
2. To give others the opportunity to apply aspects of our TOC to their own work.

Through creating opportunities for others to engage with and critique our work, we hope to improve upon our model and add nuance to our field's understanding of institutional change.

1.1 Development of the DAT TOC

Our motivation for developing a TOC was to better understand, evaluate, and improve upon the DAT model. Similar to Malachowski et al. (this volume), our Theory of Change linked our specific project activities to our project outcomes. Articulating our assumptions about why we thought our intervention would lead to certain outcomes allowed us to critique and ultimately refine our practice (Connolly & Seymour, 2015; Weiss, 1995). Externalizing our TOC also enabled us to empirically test these assumptions and better understand the impact of our model (Anderson, 2006; Vogel, 2012). Finally, having a TOC helped us as facilitators to track and evaluate DATs' progress.

The development of the TOC began with the entire project team identifying our long-term outcome for departments with DATs (Taplin & Rasic, 2012). Drawing on our collective experiences facilitating DATs, we then backwards-mapped the intermediate outcomes that were necessary to reach this long-term outcome. After several team meetings, a subteam formed to refine our TOC diagram and write explanatory text. These components have undergone several revisions since we initially began TOC development in 2017.

Although the first three authors spent the most time reflecting on and developing the DAT TOC, we frequently engaged with others during this process. For example, other DAT facilitators and researchers provided feedback on the modifications made to the TOC and referred to specific experiences with DATs that led them to question or confirm parts of the TOC. We also solicited feedback from several people outside of the DAT project. An organizational change expert who has developed TOCs for other projects helped us to formalize our intermediate outcomes. Versions of the DAT TOC were presented at several conferences, where change agents in discipline-based education research fields commented on the TOC's utility and logic.

We used the DAT TOC to inform facilitation and research. The TOC was used to guide facilitator moves, and facilitators regularly reflected on which TOC outcomes the DATs were making progress towards. This served to check the content of the outcomes as well as the relationships between the outcomes. The TOC was also used as a research tool to code the meeting minutes of DATs. This process resulted in better-delineated outcomes that eliminated redundancies uncovered by coding and provided evidence that the TOC could be a valuable research tool.

1.2 The DAT TOC

To develop the DAT TOC, we completed a guided activity from *The Community Builder's Approach to Theory of Change: A Practical Guide to Theory Development* (Anderson, 2006) based on "Project Superwoman," a program to support women who are survivors of domestic violence. The Project Superwoman TOC is depicted in Figure 1. While this TOC provided a good starting point, we found that we had to modify some of its structures. Departmental change is a complex process, and the DAT TOC had to reflect that complexity.

The basic structure provided in the Project Superwoman example included these components:

- A set of *outcomes*, represented by the boxes in the diagram
- *Relationships* among the outcomes, represented by the arrow in the diagram
- *Narrative text*, which describes the assumptions, justifications, and indicators for the outcomes and their relationship

In the Project Superwoman example, nearly all of the outcomes referred to the same *stakeholder* (the women in the program) and there was one outcome identified as the *Long Term Outcome* (LTO). The outcomes were all related via *pre-conditions*; if one outcome is a pre-condition for another, then achieving the latter outcome depends on the achievement of the former outcome.

PROJECT SUPERWOMAN: A THEORY OF CHANGE

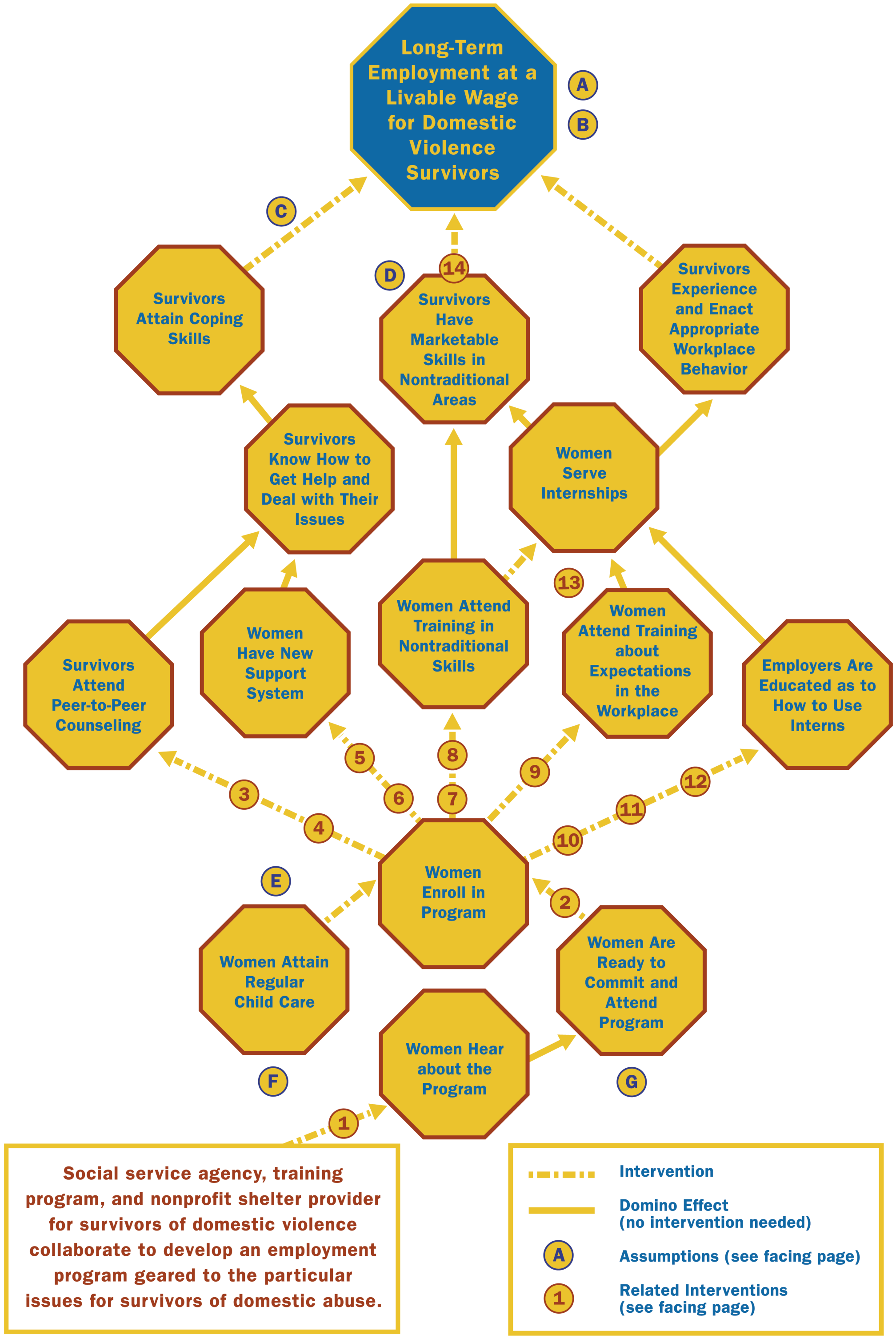


Figure 1: Project Superwoman Theory of Change, from "The Community Builder's Approach to Theory of Change. A practical guide to theory development" (Anderson, 2006) (web: click on image to enlarge)

In the following sections, we define the major components of the DAT TOC so that its structure can be interpreted. We primarily focus on deviations in the basic structure from the Project Superwoman example, and we describe their rationale and relationship to our project. To illustrate these components, we refer to specific elements of the DAT TOC (Figures 2-5).

2 The Outcomes

Each box in the DAT TOC, whether standalone or embedded in another box, represents an outcome that we hope to achieve as part of our change process. The content of the outcomes was informed by literature on organizational change and high functioning teams as well as our experience working with DATs. During our revision process, we examined the outcomes for redundancy.

2.1 Defining Stages, the Long-Term Outcome (LTO), and Intermediate Outcomes

The first major deviation in the DAT TOC is that rather than constructing one TOC to encompass the entire DAT model, we instead divided the TOC into three *stages*. The stages describe processes before a DAT is formed (Stage 1, see Figure 2), while a DAT is running (Stage 2, see Figures 3 and 4), and after the DAT has ended (Stage 3, which is still under revision as of the writing of this manuscript). We decided to do this because each stage represents a distinct, relatively independent period in the life cycle of a DAT. We have also constructed an overview of the entire TOC to see the stages combined (Figure 5).

The DAT project's LTO, "The department is supported by its members in making sustainable, positive, iterative changes that are aligned with the Core Principles," is the final outcome in Stage 3 (and therefore of the TOC as a whole). The LTO underwent several revisions during our development process. For example, an earlier version was "The department has made positive and sustainable change in undergraduate education." We changed this language to reflect our realization that our goal is not solely for change to happen in a department, but that department members continue to drive change even after a DAT has ended. We also realized that while the Core Principles are infused into our facilitation of DATs, it is also essential that alignment of department culture with the principles be an explicit piece of the final outcome.

Stages 1 and 2 of the TOC also have a final outcome (or outcomes), which we refer to as *intermediate outcomes*. We view these as accomplishments in their own right and also as the outcomes that are necessary for the subsequent stage to begin. For example, the Stage 1 intermediate outcome is Outcome 4, "A DAT forms in the department," which is necessary for the DAT to proceed in Stage 2. The Stage 2 intermediate outcomes define the state that the department (Outcome 7), the DAT (Outcome 8), and the DAT's members (Outcomes 9 and 10) need to have reached in order for departmental change to continue to happen outside the formal DAT context in Stage 3.

2.2 Defining the Stakeholders

Stakeholders play many roles in change efforts, from guiding the effort as change agents to providing feedback and support as allies. The DAT model requires the interaction of multiple stakeholders, and thus we explicitly identify which stakeholder is associated with each outcome through the use of language (the stakeholder is always the subject of sentences in the TOC diagram) and color:

- Navy = Individual department members (in Stage 1) or DAT members (in Stage 2)
- Teal = The DAT's department or its leadership
- Light blue = The DAT as a unit
- Orange = Facilitators
- Beige = Stakeholders external to the department, such as administrators

These constitute all of the stakeholders who are essential to the DAT model. We are careful to make these distinctions because they help a user of the TOC identify the stakeholders who are relevant in their context and to clearly specify who is achieving what outcome.

In some cases, more than one stakeholder plays a role in an outcome (e.g., Outcome 1, "Facilitators, department members, and department leadership communicate about having a DAT in the department"). To indicate this, we use multiple colors to reflect the multiple stakeholders: orange to represent facilitators, navy to represent individual department members, and teal to represent departmental leadership (Figure 2).

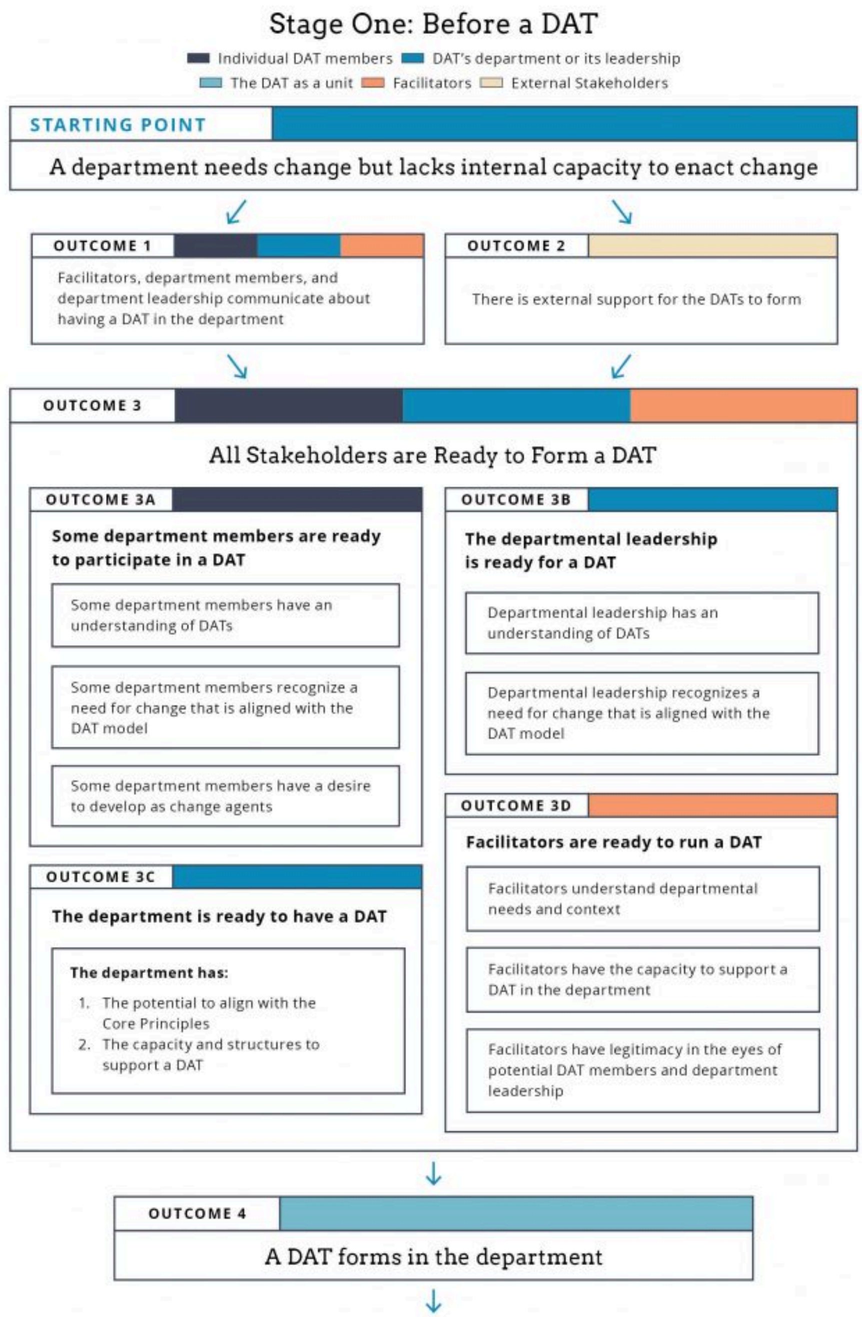


Figure 2: Stage 1 of the DAT TOC (web: click on image to enlarge)

An additional role of the intermediate outcomes is to demarcate when stakeholders enter or leave the change process. For example, the DAT as an entity enters the TOC in Outcome 4 for Stage 1, so this is the first time that an outcome is colored light blue. Similarly, there is no intermediate outcome in Stage 2 associated with the facilitators because their role has finished by the end of Stage 2.

3 The Relationships

In addition to clearly defined outcomes, the TOC defines the relationships among the outcomes and uses a variety of visual representations to distinguish them. Our current understanding of these relationships emerged and shifted during the development process, as we articulated the logic of how one outcome impacts the others based on our experience facilitating DATs and relevant literature. This logic is spelled out in the narrative text that accompanies the TOC. While we have converged on Stages 1 and 2 of the TOC, we view the relationships among outcomes as subject to revision, based on future data.

3.1 Defining Pre-Conditions and "Sufficiency"

The basic relationship between two outcomes is a *pre-condition* and is represented by an arrow between two outcomes. For example, Outcome 2, "There is external support for a DAT to form," is a pre-condition for Outcome 3, "All stakeholders are ready to form a DAT," because without external support for DATs (e.g., from administrators or funders), stakeholders will be unable to form a DAT. Thus, there is an arrow in the TOC pointing from Outcome 2 to Outcome 3.

Most of the outcomes in the TOC do not describe discrete events but rather ongoing processes (i.e., they are more like progress bars than ready lights). Thus, implicit in our TOC is the concept of "sufficiency." For example, sufficient progress must be made on Outcome 5, "Facilitators support DAT members in creating change and developing as change agents," before progress can be made on Outcome 6, "The DAT engages in its work," because without the work of the facilitators, the DAT cannot proceed. Moreover, just because progress on a subsequent outcome has begun, progress on earlier outcomes need not stop. It is possible (and often necessary) to continue making progress on previous outcomes even as later outcomes are progressing. In this example, the DAT will continue working while the facilitators continue to support the DAT and its members.

3.2 Defining Co-Conditions

There were many situations in which we found the pre-condition concept to be insufficient to describe the relationship between two outcomes, because we recognized that each outcome could be a pre-condition for the other. In this situation, we refer to those outcomes as *co-conditions*. We describe this relationship further in the next section.

3.3 Defining Sub-Outcomes

Finally, we recognized that some outcomes could be productively divided into discrete components that were important enough to represent in the TOC in their own right. We refer to these components as *sub-outcomes*. The sub-outcomes that comprise an outcome are equivalent to the outcome in the sense that achieving all of the sub-outcomes is equivalent to achieving the outcome.

Because we wanted to represent both the sub-outcomes and the larger outcome in the TOC, we developed a "box within a box" structure. For example, Outcome 6D, "The DAT builds a positive relationship with the department," has three sub-outcomes ("The DAT regularly communicates progress, outcomes, and successes to the department," "The DAT cultivates department allies for its work," and "The DAT seeks department input for its work"; see Figure 3). Achieving these three sub-outcomes is what we mean by achieving the outcome of a positive relationship between the DAT and the department.

There are three variations of the sub-outcome structure:

1. The sub-outcomes have a pre-conditional relationship, in which case they are connected by an arrow (for example, the sub-outcomes of Outcome 6C, "The DAT engages in a change effort").
2. The sub-outcomes have a co-conditional relationship, in which case there is no arrow connecting them (for example, the sub-outcomes of Outcome 6D, "The DAT builds a positive relationship with the department").
3. The sub-outcomes are not dependent on each other (although they may still interact), in which case we put them in a numbered list (for example, the sub-outcomes of Outcome 6A, "DAT members and facilitators co-create the DAT's culture").

Any of these can be nested or combined with any of the others. For example, Outcome 6B, "DAT members grow as change agents" (which is a sub-outcome of Outcome 6, "The DAT engages in its work") consists of two sub-outcomes related to DAT members increasing capacities relevant to change and DAT members increasing feelings related to change. These sub-outcomes are co-conditions: increasing their capacity helps DAT members feel more like change agents, while feeling more like a change agent will motivate them to increase their capacities. Each of these sub-outcomes consists of four sub-outcomes which are neither pre-conditions nor co-conditions of each other. For example, there are four capacities that DAT members can build, and increasing each is an outcome in its own right. However, none of the capacities are *required* for the growth of the others (although they may impact each other).

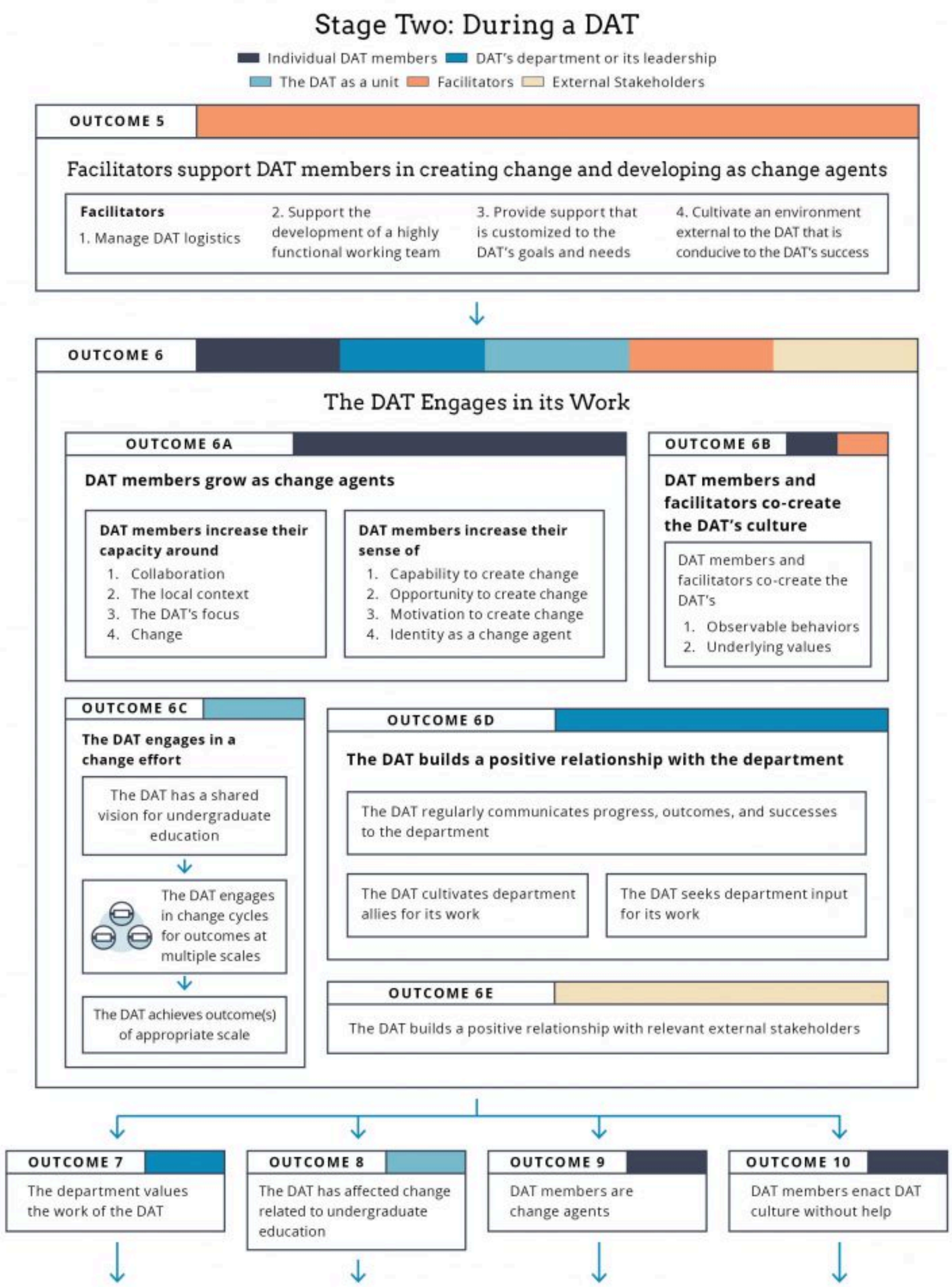


Figure 3: Stage 2 of the DAT TOC (web: click on image to enlarge)

3.4 Defining Cycles

Because relationships in a TOC focus on which outcomes are necessary for other outcomes to proceed, it is not possible to create closed cycles in a TOC using just pre/co-conditional relationships.

However, the work that DATs do to accomplish their goals for departmental change *is* cyclic and iterative. To address this issue, we developed a *DAT change cycle* (Figure 4) that visually represents the temporal cycle that DATs engage in to create change. This cycle is embedded in the sub-outcome of Outcome 6C, “The DAT engages in change cycles for outcomes at multiple scales.” We do not define the number of cycles the DAT needs to go through before this outcome has been sufficiently achieved to move to the next outcome because that will be highly dependent on the context of the department.

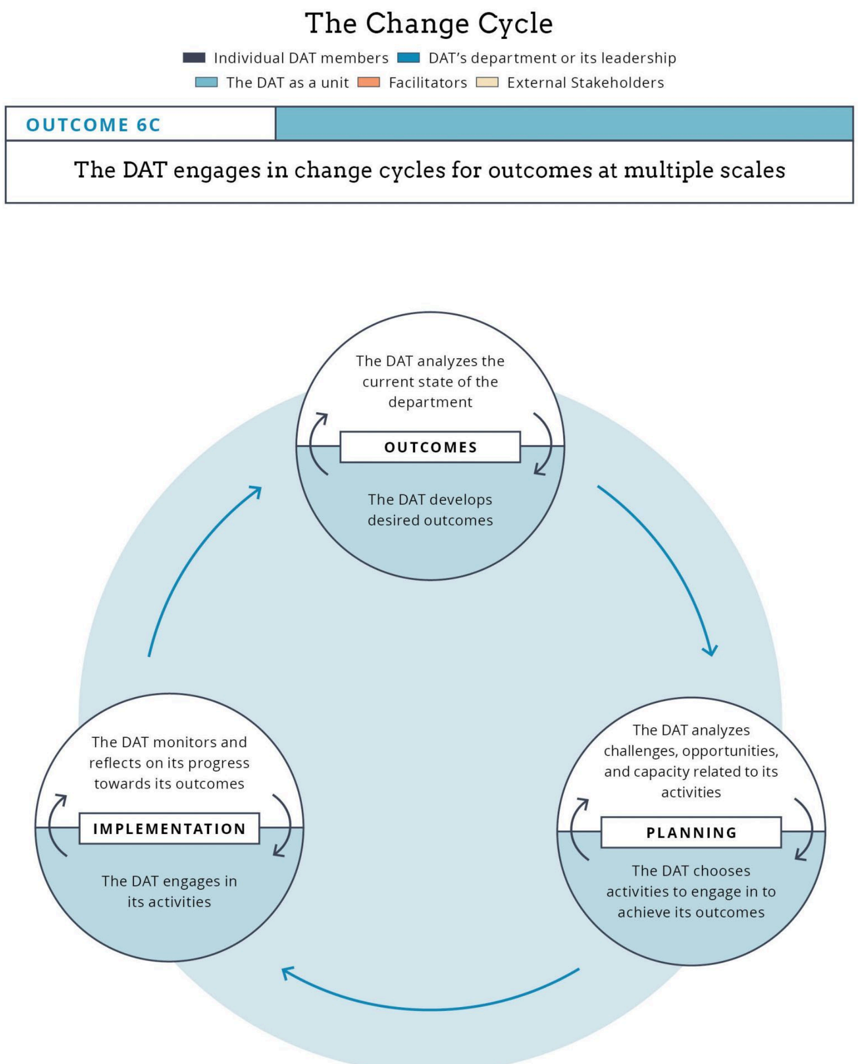


Figure 4: The DAT change cycle, which is embedded in outcome 6C (web: click on image to enlarge)

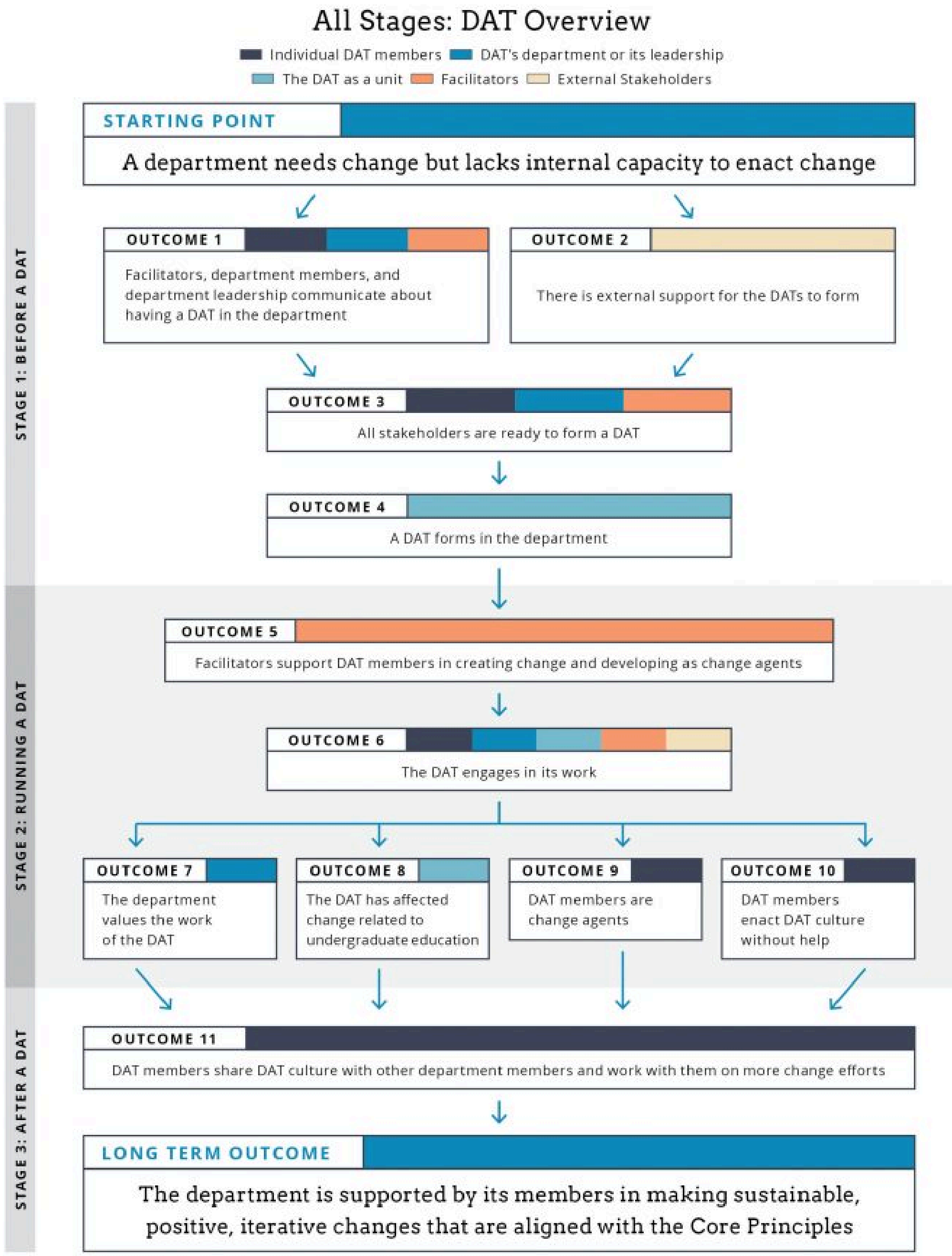


Figure 5: Overview of the TOC (web: click on image to enlarge)

4 Implications

How the TOC is enacted depends on the departmental context. For example, what counts as sufficient for one department may be insufficient for another. In that sense, the TOC is providing an abstract, idealized view of the conditions that must be met for a DAT to succeed, but what those outcomes look like in practice and how they are achieved will vary given the departmental context.

Our Theory of Change has implications beyond the DAT model. The DAT TOC demonstrates the complexity of departmental change efforts, especially those that intend to enact change equitably and sustainably. Change efforts are enacted by people who are embedded within communities, so it is important to pay attention to people's capacities within the local context. It is not enough to just focus on enacting change; groups should also work on building relationships with the department, growing individuals' ability to make change, and functioning well as a team. The interconnectedness of these components illustrates why complex change can sometimes be slow. Change is ultimately an iterative process that involves many moving parts.

Our TOC can be a helpful tool for researchers and facilitators who are interested in cultivating change. By including multiple components and inventing ways of describing relationships between components, our model presents a more nuanced way of describing change than most TOCs. For those engaged in change efforts already in progress, we hope our TOC draws their attention to aspects of change they may not have considered but could address. For those who have already engaged in change efforts, we hope our tool can help them analyze the successes and challenges of their work. It is our intention that this TOC can help the field move forward with a deeper understanding of how to enact change in higher education.

5 Acknowledgements

There are a number of people whose contributions made this work possible. We would like to thank Stephanie Chasteen, Noah Finkelstein, Andrea Beach and members of DATs for their feedback. We would also like to thank Oath Agency for their design work on the TOC. This material is based upon work supported by the National Science Foundation under Grant No. 1626565.

6 About the Authors

Courtney Ngai is a Research Scientist in the Institute for Learning and Teaching (TILT) at Colorado State University.

Joel C. Corbo is a Senior Research Associate in the Center for STEM Learning at the University of Colorado Boulder.

Gina M. Quan is an Assistant Professor in the Physics & Astronomy Department at San José State University.

Karen Falkenberg is the Director of Teaching Excellence and a Team Development Specialist at The Institute for Teaching and Learning (TILT) at Colorado State University.

Christopher Geanious is an Instructional Designer with The Institute for Teachiing and Learning at Colorado State University.

Alanna Pawlak is a Postdoctoral Researcher in the Center for STEM Learning at the University of Colorado Boulder.

Mary E. Pilgrim is an Assistant Professor in the Department of Mathematics and Statistics and Associate Director of the Math and Stats Learning Center at San Diego State University.

Daniel Reinholz is an Assistant Professor in the Department of Mathematics and Statistics at San Diego State University.

Clara E. Smith is Diversity & Inclusion Training & Development Specialist in the Human Resources Department at the University of Colorado Boulder.

Sarah Wise is Research Faculty in the Center for STEM Learning at University of Colorado Boulder.

7 References

Anderson, A.A. (2006). *The community builder's approach to theory of change: A practical guide to theory development*. The Aspen Institute Roundtable on Community Change.

Connolly, M. R., & Seymour, E. (2015). *Why theories of change matter* [WCER Working Paper No. 2015-2]. https://wcer.wisc.edu/docs/working-papers/Working_Paper_No_2015_02.pdf

Corbo, J. C., Reinholz, D. L., Dancy, M. H., Deetz, S., & Finkelstein, N. (2016). Framework for transforming departmental culture to support educational innovation. *Physical Review Physics Education Research*, 12(1), 010113. https://doi.org/10.1103/PhysRevPhysEducRes.12.010113

Kezar, A. (2013). *How colleges change: Understanding, leading, and enacting change.* Routledge.

Malachowski, M., Osborn, J. M., Karukstis, K. K., Kinzie, J., & Ambos, E. L. (this volume). "Scaffolding research into undergraduate STEM curricula and cultures: An emerging model for systemic change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 4). Pressbooks.

Ngai, C., Corbo, J. C., Falkenberg, K., Geanious, C., Pawlak, A., Pilgrim, M. E., Quan, G. M., Reinholz, D. L., Smith, C., & Wise, S. B. (2020). *Facilitating Change in Higher Education: The Departmental Action Team Model*. Glitter Cannon Press.

Ngai, C., Pilgrim, M. E., Reinholz, D. L., Corbo, J. C., & Quan, G. M. (2020). Developing the DELTA: Capturing cultural changes in STEM departments. *CBE—Life Sciences Education, 19*(2), ar15. https://doi.org/10.1187/cbe.19-09-0180

Quan, G. M., Corbo, J. C., Finkelstein, N. D., Pawlak, A., Falkenberg, K., Geanious, C., Ngai, C., Smith, C., Wise, S., Pilgrim, M. E., & Reinholz, D. L. (2019). Designing for institutional transformation: Six principles for department-level interventions. *Physical Review—Physics Education Research*, 15(1), 010141. https://doi.org/10.1103/PhysRevPhysEducRes.15.010141

Schein, E. H. (2010). *Organizational culture and leadership*. John Wiley & Sons.

Taplin, D., & Rasic, M. (2012). *Facilitator's source book: Source book for facilitators leading theory of change development sessions*. ActKnowledge.

Reinholz, D. L., Corbo, J. C., Dancy, M., & Finkelstein, N. (2017). Departmental action teams: Supporting faculty learning through departmental change. *Learning Communities Journal, 9*, 5–32.

Vogel, I. (2012). *ESPA guide to working with theory of change for research projects*. Isabel Vogel in association with LTS/ITAD. https://www.espa.ac.uk/files/espa/ESPA-Theory-of-Change-Manual-FINAL.pdf

Weiss, C.H. (1995). Nothing as practical as good theory: Exploring theory-based evaluation for comprehensive community-based initiatives for children and families. In J. P. Connell, A. C. Kubisch, L. B. Schorr, & C. H. Weiss (Eds.). *New Approaches to Evaluating Community Initiatives: Vol. 1. Concepts, methods and contexts* (pp. 65–92). Aspen Institute.

6. On the RISE: A Case Study of Institutional Transformation Using Idea Flow as a Change Theory

GITA BANGERA, CHERYL VERMILYEA, MICHAEL REESE, AND IRENE SHAVER

In the 21st century, a significant number (39%) of all undergraduates start their education at community colleges, and the percentage is even higher for groups historically underserved in higher education (Ginder et al., 2017). Community colleges therefore need to not only develop innovative practices that allow students to succeed but also scale up those innovations to have the greatest impact. In this article, we will share the development of the RISE Learning Institute as a case study in institutional transformation at a community college. We place this case study in the context of the "Idea Flow" concept articulated and curated by Leith Sharp (2019), Director of Executive Education for Sustainability Leadership, Center for Health and the Global Environment at the Harvard Chan School of Public Health. We present our analysis to encourage change agents at other institutions to use the concept of Idea Flow to identify strategies for long term sustainable implementation of their innovative ideas.

1 Theory of Change: Idea Flow

What happens to ideas in an organization? Why do some ideas become absorbed into an institution and some flare up for a while and then quietly disappear?

To understand the trajectories of ideas, Sharp (2019) encourages a process of forensic mapping. In forensic mapping, the individuals responsible for the successful institutionalization or struggling with the demise of a concept, trace the actual path from the original concept to the current stage and unearth all the stages of forward movement and setbacks. Sharp reasons that at the beginning of most projects, there is a well laid-out plan that looks very linear, but when the plan is actually implemented, the path is more of a squiggle (Figure 1a). Success is achieved because individuals use their "unconscious competencies" to tackle challenges. Unfortunately, once success has been achieved, the squiggle story is replaced by the original linear plan in all the reporting. What is the cost or missed opportunity of telling a story of transformation as if it were direct, completely conscious, and safe from failure? The story of exponential improvement and linear change hides a lot of the learning. It does not attribute transformation to the people that actually create it or do justice to the actual nebulous process that change is. Through forensic mapping, the organization can become conscious of the underlying skills and strategies and then apply those to a "forward mapping" process for new ideas so as to increase the chances of their success.

Figure 1: Idea Flow—Real vs Official Story

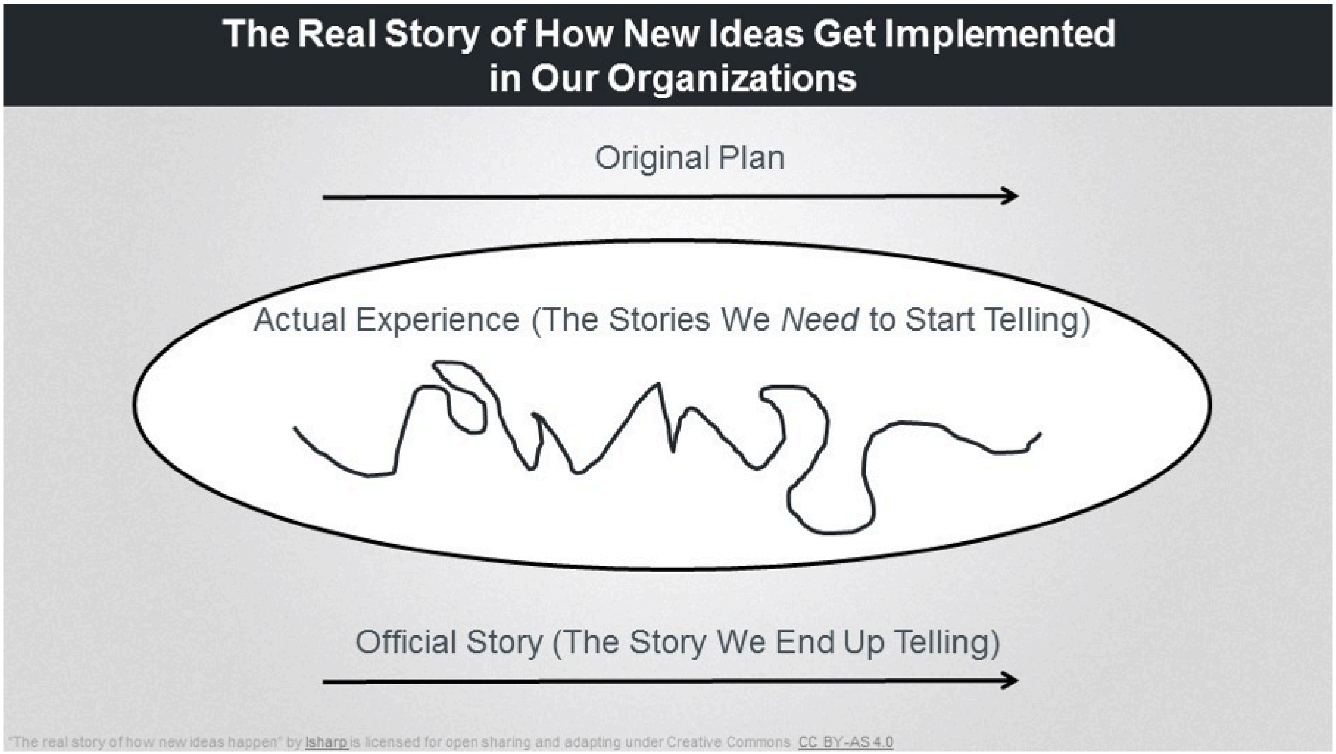


Figure 1a: The Official Story

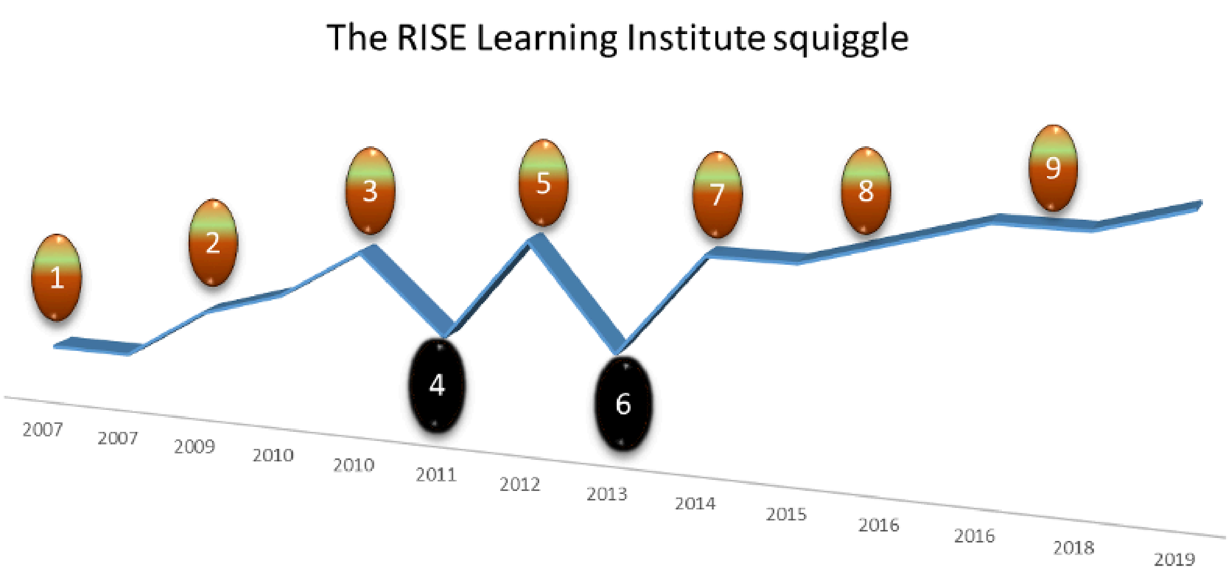


Figure 1b: The Real Story

In analyzing the idea flows from many different organizations, Sharp found that the squiggles in the forensic map of change are caused by interactions, collaborations, synergies, or conflict between people in the organization that have positional power and those that do not. The Adaptive Network (**AN**) is made up of individuals who may not have positional power but who are aware of the needs of institution and are focused on the idea itself—what it is, why, and how to implement it. The Hierarchical Network, (**HN**, traditionally known as management) performs the critical role of integrating the new idea into everything that already exists. It is important to focus on the interactions between these two networks in an organization to see how they propel change, redirect it, constrain it, normalize it or amplify the implementation of an idea. These two networks of people in an organization have different strategies and ways that they contribute to a process of institutional change. Ideas and projects get successfully institutionalized when there is a constant flow of information and support between the two networks. The AN senses needs, engages the community, pilots, de-risks, and socializes the idea while the HN provides permission, invitation, alignment with mission, resources, sponsorship, and assimilation into the system and scaling (Figure 2) (Sharp, 2019).

Figure 2: The Two Networks Concepts

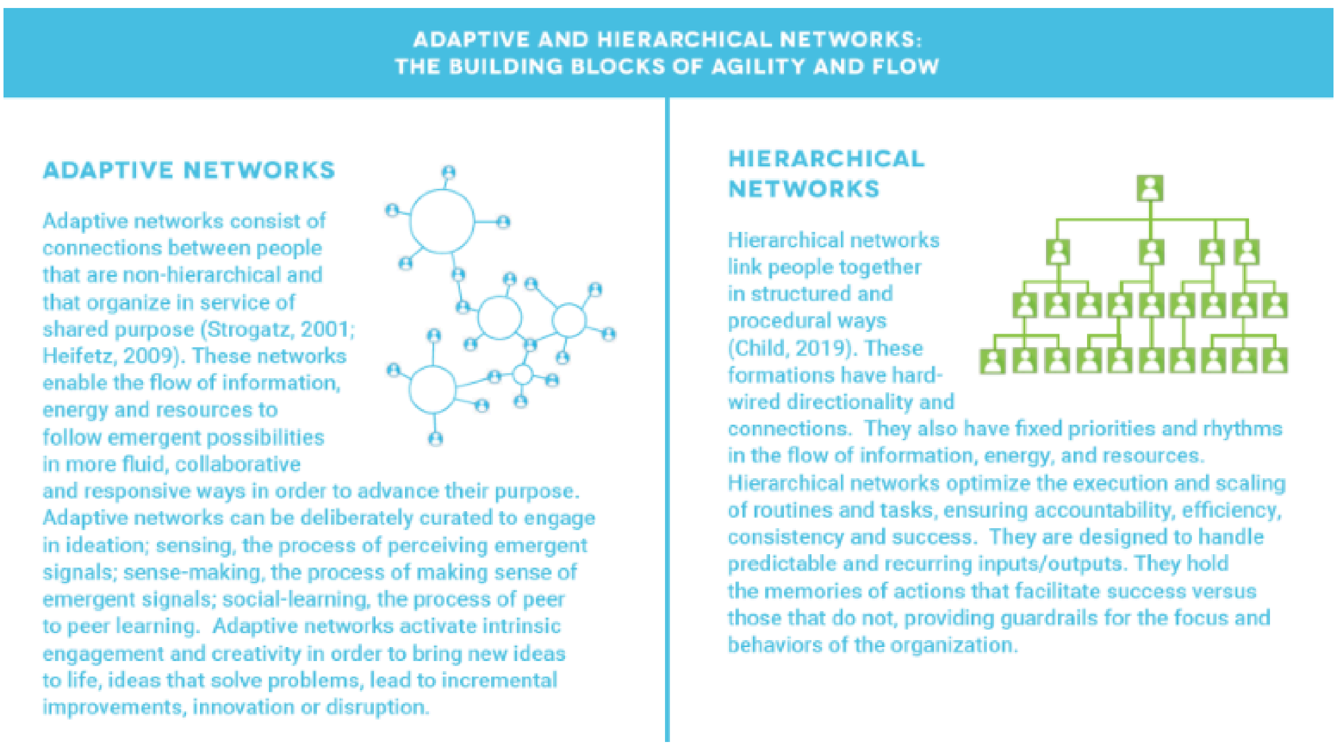


Figure 2a: The Hierarchical and Adaptive Networks

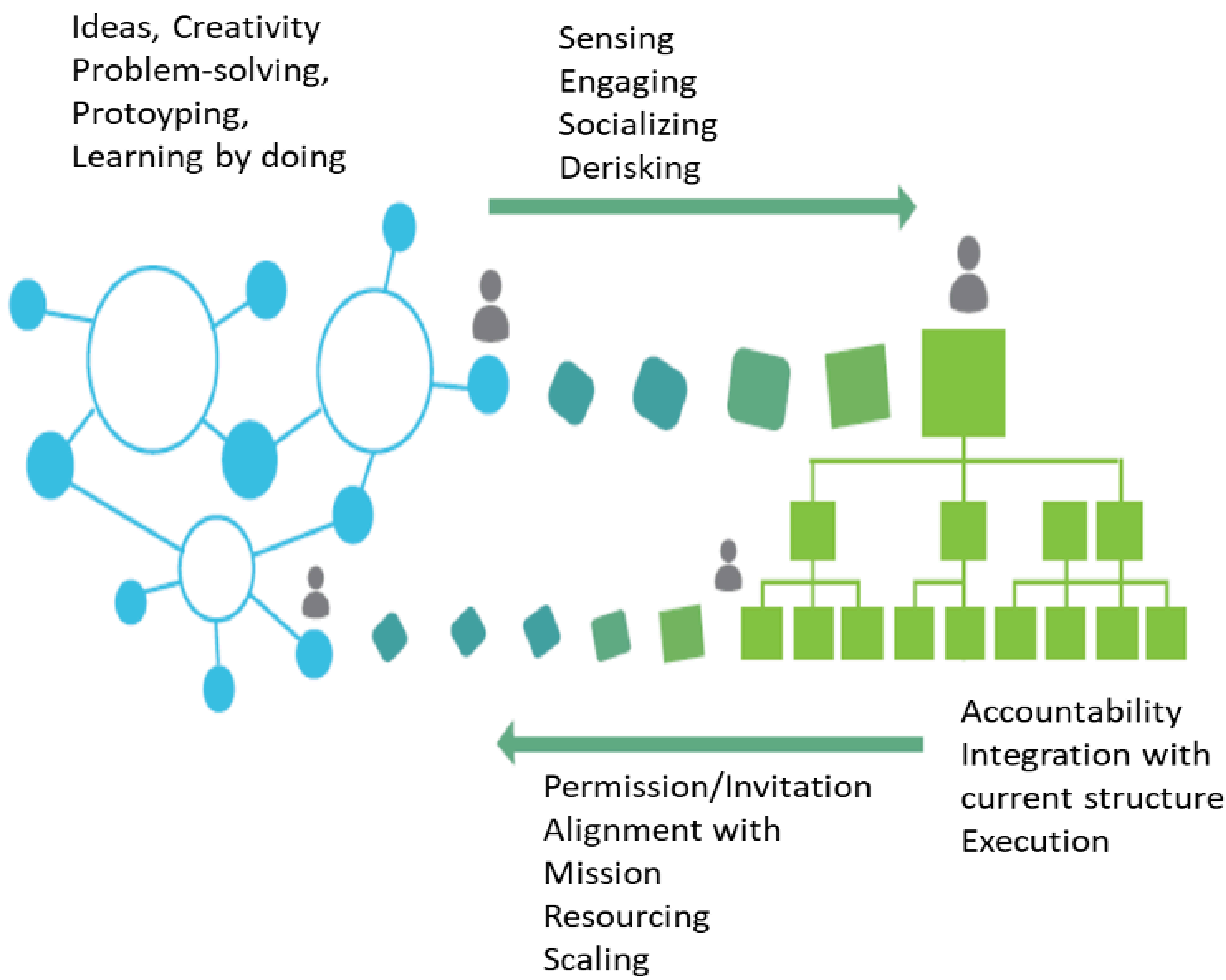


Figure 2b: Idea Flow Happens with Optimal Interaction of the Two Networks

In the context of Idea Flow, we now present the development of the RISE Learning Institute first as a linear story and then as an Idea flow story with the squiggles.

2 RISE Learning Institute—The Linear Story

At our institution, we have engaged in a thirteen-year process of institutional change, with the development of the RISE Learning Institute starting from a few undergraduate research courses begun with National Science Foundation (NSF) funding. The program was disseminated throughout the state of Washington with a community of practice involving faculty from 24 community colleges.

In 2015, the college created the RISE Learning Institute. The Institute is led by a Dean, a new position created by the college, has multiple full-time positions, and includes the Center for Career Connection as well as the Neurodiversity Navigators. RISE also has two impactful student learning spaces—a state of the art multi-use laboratory space used for research, experiential learning courses, and student-run maker space, as well as a Collaboratory space for making the creative process explicit. From 2015–2019, RISE has built three Faculty Learning Communities (FLCs) in undergraduate research, service learning, and project-based learning, and engaged 6,184 students in transformative learning including service learning, project-based learning, undergraduate research, maker space activities, minority- and disability-related learning communities, and career development. RISE has increased student engagement in transformative learning by 42% from 2016–2019.

The RISE Learning Institute brings High Impact practices (Kuh, 2008) to scale across all disciplines. These practices include internships, service learning, undergraduate research, project-based learning, career exploration, and learning communities. Transformative learning requires students to integrate, synthesize, and make meaning; address authentic, complex, real-world issues; reflect on their own experiences and learning; and identify, articulate, and apply their strengths. The most impactful transformative learning experiences include strengths-based approaches and career development. Undergraduates who engaged in these experiences were markedly more likely than their peers to feel that they were engaged and thriving in life and the workplace after graduation (Ray & Marken, 2014; Table 1). Yet, most students at community colleges do not experience these impactful learning modalities because of the barriers to innovation that exist in community colleges and other institutions of higher education.

RISE also helps to combat what could be termed as the “firefly effect.” Individual faculty follow their passion to develop undergraduate research, service learning or other course materials, or even entire courses. However, when the faculty member leaves or loses steam due to burn out, the program ends and does not scale up to the department or institutional level. By creating a college-wide Institute focused on supporting faculty through the development and implementation of these experiences in the classroom, RISE allows true scaling of these transformative learning experiences.

RISE is also a vehicle to increase educational equity. While it is important to bring transformative learning to students, incorporating them into the classroom is key from an equity perspective (Bangera & Brownell, 2014). Students of color, first-generation students, and those from lower socio-economic status may not have the bandwidth, financial resources, and/or time to take advantage of optional opportunities outside of their regular coursework. They may also not have the cultural capital to know the importance of these experiences or the confidence to apply for the opportunity. Incorporating transformative learning into regular courses also ensures sustainability of these programs by ensuring that these activities are built into the normal revenue generation process (i.e. tuition) for the institution. We are currently building these transformative learning activities into the curriculum of high enrolled courses (reaching 300–400 or more students) to democratize access and maximize impact in a financially sustainable model.

Table 1: Data on Impact of College Experiences on Employee Engagement and Well-Being from the 2014 Gallup Purdue Index Report.

The odds of being engaged at work are:			
2.6x	Higher if … [College] prepared me well for life outside of college.	2.4x	Higher if … [College] passionate about the long-term success of its students.
2.2x	Higher if … I had a mentor who encouraged me to pursue my goals and dreams.	2.0x	Higher if … I had at least one professor at [College] who made me excited about learning.
1.9x	Higher if … My professors at [College] cared about me as a person.	2.3x	Higher if … graduates experience all three.
2.0x	Higher if … I had an internship or job that allowed me to apply what I was learning in the classroom.	1.8x	Higher if … I was extremely active in extracurricular activities and organizations while attending [College].
1.8x	Higher if … I worked on a project that took a semester or more to complete.	2.4x	Higher if … graduates experience all three.
The odds of thriving in all areas of well-being are:			
4.6x	Higher if … Engaged at work.	2.0x	Higher if … Emotionally attached to school.
2.5x	Higher if … [College] prepared me well for life outside of college.	1.9x	Higher if … [College] passionate about the long-term success of its students.
1.7x	Higher if … I had a mentor who encouraged me to pursue my goals and dreams.	1.7x	Higher if … My professors at [College] cared about me as a person.
1.5x	Higher if … I had at least one professor at [College] who made me excited about learning.	1.9x	Higher if … graduates experience all three.
1.5x	Higher if … I had an internship or job that allowed me to apply what I was learning in the classroom.	1.4x	Higher if … I was extremely active in extracurricular activities and organizations while attending [College].
1.1x	Higher if … I worked on a project that took a semester or more to complete.	1.3x	Higher if … graduates experience all three.

3 RISE Learning Institute—Idea Flow Story

Figure 2b shows the real story of the RISE Learning Institute—our squiggle. Each number below describes the circumstances of the steps in the squiggle image in Figure 2b. Upward movements were times when the idea grew and advanced, and downward movements show the backward steps in the process.

1. The AN sensed the need for introducing undergraduate research experiences into the curriculum and proposed a project called ComGen. By seeking external NSF funding for the ComGen project, the AN de-risked the process by piloting pedagogical innovation. The HN provided support for grant development and for purchasing required equipment.
2. The AN used grant funds to develop faculty capacity to incorporate the innovative pedagogical tools into courses. This also led to the development of an applied baccalaureate degree that contributed to the revenue of the college, allowing for long-term financial sustainability of the innovation. The HN provided resources in the form of dedicated research lab space to support the development of the program. Additional NSF funding allowed development of a ComGen community of practice that included faculty from Bellevue College and from 22 other community colleges in the state.
3. A possibility for building a collaborative program encompassing additional disciplines emerged with the potential development of a larger multi-disciplinary laboratory space.
4. A change at the mid-level leadership caused a disruption in the collaboration between HN and AN, and the project was shelved
5. A new project for fundraising for the expanded laboratory was started.
6. Changes in the administration again caused disruption of the collaboration between the AN and the HN, resulting in the project being shelved.
7. Developing stronger relationships with the HN, the AN was able to show a need for development of a new expanded structure, including a Dean position, and combining career exploration, service learning, and experiential learning along with undergraduate research to form the RISE Learning Institute. (There were some squiggles within this story as well that we have not described.)
8. Initial work within RISE showed impact and allowed the AN to request and obtain funding for key personnel.
9. The HN and the AN worked collaboratively to bring High Impact Practices to scale by implementing the Provost award for Innovation. The award provides funding for faculty teams incorporating high impact practices into courses with 300–400 or more students per term.

Comparing the straight line and idea flow story, it is apparent that the idea and work began far before 2015, when RISE Learning Institute as a program was created. It is also clear that the plan was constantly rearticulated, gained complexity and better form, and became better aligned with the institutions goals until it was fully incorporated. The dips in the squiggle were caused by experiencing a constraint or misalignment between the HN and AN, but there are some durable levers or strategies that seemed to change things and get us back on track.

Lessons learned from our squiggle

- Almost all institutions, especially community colleges, run on tight budgets, and while there may be support for innovation, there may be financial constraints that the HN faces. By seeking external funding for the piloting of the project and demonstrating success, the AN got commitment for future funding from the HN. Similarly, it was helpful to move the innovation into courses or other normal functions of the institution to allow the innovations to become revenue neutral or revenue generating.
- It is important to bring innovation into existing structures that are directly accessible to the population you want to serve and can be stepping stones to scaling up innovation. For example, we used courses as the primary innovation space, as they have the highest access to all student populations and are already part of the student pathway. Faculty control that course space and can innovate there with a high degree of autonomy. More courses with high-impact practices results in better education for more students and produces evidence of success in a short time frame (i.e., over the period of a course).
- It is helpful for the AN and HN members to develop strong trust relationships and take advantage of opportunities at appropriate times. In our case, the construction of a new building provided an opportunity for a dedicated research laboratory. Due to the existing trust and relationship, the HN invited us, the AN, to take advantage of this opportunity.
- As changes happen within the AN and the HN, both networks can be proactive in establishing and re-establishing relationships with leaders to ensure continuity of the flow of communication. If a new administrator or faculty or staff leader joins the institution, it is helpful for both networks to engage and invite them to be an advocate for their idea. This is the critical lesson learned from steps 4 and 6 in the squiggle.
- The HN can influence change by supporting the most influential resource in the institution. In our case, this is the faculty and staff, who have the primary institutional relationship with and create the learning experiences for our students. By the same token, faculty and staff need to participate fully as a key part of the AN and institution by developing relationships with the HN, and sensing, responding to, socializing, and de-risking ideas (Figure 2b).
- Both the AN and the HN are most effective when they work at multiple places at the same time and are patient. The AN can provide peer-to-peer influence/socializing, while the HN can provide strategic support where needed. In our case, the HN provided funding and space and incorporated the concepts of transformative learning into the institution's strategic plan and promotion criteria for faculty. The AN participated in open curriculum sharing, FLCs, and communities of practice to share best practices and support each other in bringing these new, high-impact practices into the classroom.
- Both networks can work together to institutionalize the innovative practices by building on successful programs. Once the FLC for service learning was established, the barriers for developing the subsequent FLCs (for project-based learning and research) were much lower. Rather than having to reinvent the wheel, we were able to take the successful approaches, lessons learned, and assessment instruments developed and adapt them from one domain to another. Similarly, our experience with the ComGen community of practice prepared us to support course-based undergraduate research across multiple disciplines. Our composite

structure thus allowed us to harness synergies by reducing the time cost of innovation and by "flattening the learning curve" of deploying innovation in new domains.

4 Conclusion

In conclusion, we plan to apply the lessons learned from the Idea Flow analysis to develop and sustain future innovations on our campus. We also found that what appeared to be a significant setback provided space for the idea to evolve into a more impactful project. We encourage other institutions to consider forensic mappings of both successful and unsuccessful implementation of ideas, to uncover the squiggle, and apply the lessons learned in a forward mapping process to ensure sustainability of innovative and impactful initiatives.

5 About the Authors

M. Gita Bangera is the Dean of the RISE Learning Institute at Bellevue College.

Cheryl Vermilyea is the founder of the Center for Career Connections at Bellevue College and the Minority Science and Engineering Program at the University of Washington.

Michael Reese is the Director of Program Development in the RISE Learning Institute at Bellevue College.

Irene Shaver is a Program Manager in RISE at Bellevue College.

6 References

Bangera, G., & Brownell, S.E. (2014). Course-based undergraduate research experiences can make scientific research more inclusive. *CBE—Life Sciences Education, 13*(4), 602–606. https://doi.org/10.1187/cbe.14-06-0099

Ginder, S.A., Kelly-Reid, J.E., & Mann, F.B. (2017). *Postsecondary institutions and cost of attendance in 2016–17; Degrees and other awards conferred, 2015–16; and 12-month enrollment, 2015–16: First look (provisional cata)* (NCES 2017-075rev). U.S. Department of Education. https://nces.ed.gov/pubs2017/2017075rev.pdf

Kuh, G. D. (2008). *High-impact educational practices: What they are, who has access to them, and why they matter*. Association of American Colleges and Universities.

Ray, J. & Markam, S. (2014). Life in college matters for life after college. *Gallup*. https://news.gallup.com/poll/168848/life-college-matters-life-college.aspx

Sharp, L. (2019). *Leading organizational agility and flow to deliver on corporate purpose in purpose-driven leadership for the 21st century: How corporate purpose is fundamental to reimagining capitalism. 2017–2019 Global multi-year CEO study* (C. Gyori, T. Kazakova, B. Gyori, Eds.). Leaders on Purpose.

7. An Exploratory Study of What Different Theories Can Tell Us about Change

MARY E. PILGRIM, KELLY K. MCDONALD, ERIKA G. OFFERDAHL, KATHERINE RYKER, SUSAN SHADLE, AMELIA STONE-JOHNSTONE, AND EMILY M. WALTER

1 Introduction

National efforts to transform undergraduate STEM education are numerous and diverse, striving to effect change by working with individual faculty, departments, and institutions. Because change is so complex, it can be difficult to determine which theories to use and what affordances specific theories provide. However, without a firm connection to theory, communicating and extending lessons learned from one change project to another is challenging. Presently, there is a need for STEM scholars to become more adept at applying theory to inform STEM transformation initiatives and scholarship.

Institutions are complex systems and instigating change within them is seldom a linear process (Austin, 2011). Organizational change experts argue that catalyzing and sustaining institutional change requires a systems approach (e.g., Henderson et al., 2011; Kezar, 2011). This method explicitly acknowledges that the desired change (e.g., reformed instruction) requires shifts in individual faculty behavior (e.g., instructional practice), and that individuals are embedded in and influenced by a complex institutional context (e.g., Austin, 2011; Kezar, 2011; Reinholz & Apkarian, 2018). From a practical perspective, undergraduate STEM transformation efforts tend to target one or two levels. For example, Departmental Action Teams (Reinholz et al., 2019) and summer institutes (Howard Hughes Medical Institute, 2019) target only departmental and individual levels, respectively. This is out of necessity, as it is often impractical for change agents and scholars to implement and study change across an entire system. Understanding the efficacy of an effort, how to improve it, and how to apply the successes of one project to another requires mutual understanding of how efforts at one level (e.g., individual, department) function within the larger system.

We adopted an Appreciative Inquiry approach (Cooperrider & Srivastva, 1987) to gain clarity about how theory operates to help one understand change generally and how theory can help one understand change from a systems perspective. Appreciative Inquiry is an approach that seeks to affirm and build on existing strengths, potentials, and successes to generate practical and sociorational (interpretive) knowledge about a complex system. Within the context of the exploration described here, the Appreciative Inquiry approach was appropriate because it helped make explicit the various affordances and insights revealed by applying multiple lenses to an existing dataset. It also generated practical implications from grounded observations and collaborative dialogue. We describe here how a team of STEM researchers, discipline-based educational research scholars, and change practitioners applied three commonly used change theories that operate at different scales (e.g., individual, department, organization) to examine a single set of data from an institutional change project. This work serves as a rich case study in the application of theory to STEM education change efforts.

2 Methods

2.1 Data

We used data that had been collected at the start of a department-level change project for undergraduate STEM departments. The change effort was informed by the Change, Adopters, Change Agent, Organization (CACAO) model (Dormant, 2011). During department meetings, faculty were introduced to a vision statement outlining a desired future state for STEM teaching consistent with the use of evidence-based instructional practices (EBIPs). Faculty wrote down ideas about what might support movement toward the vision (drivers) and what might get in the way of achieving the vision (barriers). In the original project, this barrier and driver data was collected and used to understand the context for change in each department (Shadle et al., 2017). For the inquiry reported in this study, a subset of the full data set was used; barrier and driver data from two STEM departments with different contexts (having different barrier-driver profiles) were examined.

2.2 Selection of Theories

We reviewed a variety of theories both familiar and unfamiliar to our research team in order to understand the purpose and function of different change theories. From this list, we selected three that operate across different organizational scales: the Four-Frame model (e.g., Bolman & Deal, 2008; Reinholz & Apkarian, 2018); Rogers' (2003) Innovation-Decision model; and Ajzen's (1985) Theory of Planned Behavior (TPB). The Four-Frame model operates at a department/unit, institutional, or organizational level and recognizes that each is comprised of individuals. The Innovation-Decision model examines stages through which individuals make decisions to adopt instructional innovations as influenced by information that comes to/from others or the institution (Rogers, 2003). Lastly, the TPB focuses on individual behaviors and behavioral intent within an institutional context, which are determined by the person's attitudes, perceived norms, and perceived behavioral controls (Ajzen, 1985).

2.3 Appreciative Inquiry Approach

We approached this process through the lens of Appreciative Inquiry, "an ongoing co-construction of reality" (Cooperrider & Srivastva, 2017, p. 6) that melds theory and practice in action research. In their foundational work, Cooperrider and Srivastva (1987) pose the question, "To what extent does this theory present provocative new possibilities for social action, and to what extent does it stimulate cooperative and normative dialogue about how we can and should organize ourselves?" (p. 98). We responded to this call by posing the following questions:

- What new insights does each theory reveal about the change project?
- In what ways does each theory constrain interpretations of the data?
- How does each theory lead to identification of additional data collection and analyses?
- What next steps does each theory suggest for change agents?

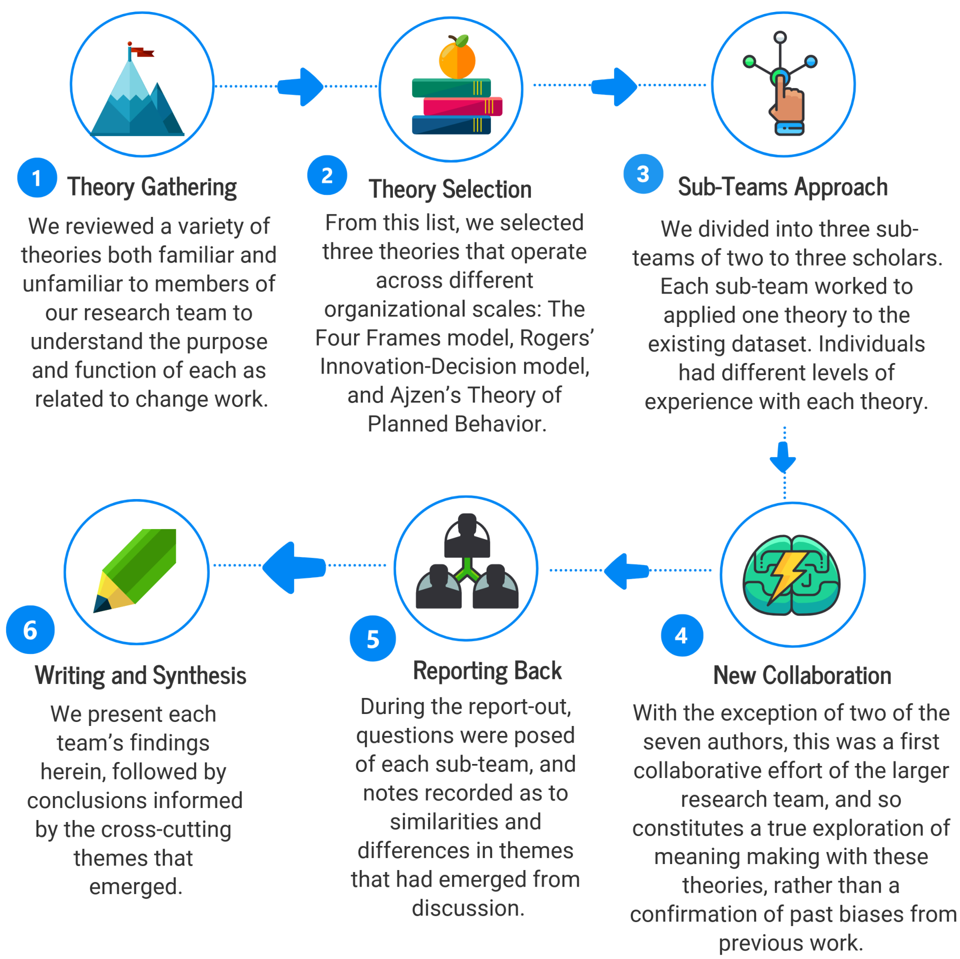


Figure 1. Our Appreciative Inquiry Process.

We divided into three teams of two to three scholars (see Figure 1). Each team applied one of the theories (section 2.2) to the data. Team members coded individually and then met to review applied codes, discussing challenges and emerging themes. This iterative cycle of analysis (moving back and forth between individual and team discussions) occurred multiple times so that each team co-constructed a common understanding of the data. Following analysis, each team then reported back to the larger group to provide a summary of the team's findings.

We present each team's findings below, followed by assertions informed by the cross-cutting themes that emerged.

3 Results and Insights

3.1 The Four-Frame Model

We applied Bolman and Deal's Four-Frame model (2008) as adapted by Reinholz and Apkarian (2018) for higher education. This perspective of the Four-Frame model provides four perspectives from which a change initiative within a STEM department can be examined, namely *people*, *structures*, *power*, and *symbols* (Reinholz & Apkarian, 2018). These four frames constitute the culture in a department, which Reinholz and Apkarian define as "a historical and evolving set of *structures* and *symbols* and the resulting *power* relationships between *people*" (p. 3). We first attempted to apply the theory as a rudimentary codebook to characterize the barriers and drivers for change as identified by individual stakeholders within a department. This approach was not fruitful for two reasons. First, the descriptions of barriers and drivers in this dataset were brief, so it was difficult to know at which level they were operating (i.e., individual barrier vs. department or institutional barrier). Second, most of the barriers and drivers could be viewed through multiple frames. Ultimately, we shifted our approach to instead query the data to understand each response as evidence that an individual was viewing the change initiative through each of the four frames.

This approach yielded two new insights. First, individuals were more likely to attend to issues as they relate to *structures* and *people*, and less likely to attend to issues of *power* and *symbols*. For example, common responses included comments about who taught courses and potential collaborations, as well as curriculum concerns. Statements such as "More sharing of approaches & perspectives in common areas of teaching" and "Pressure to cover many topics" highlight this. Less common responses, such as "No current culture for this" and "Administrators with no real understanding of discipline specific issues could create an environment of rigidly applied but counter-productive standards" capture a focus on culture and positional power as drivers or barriers of change. This suggests changes to *structures* and *people* may be perceived as more accessible than shifts in *symbols* and *power*. Second, we surmised that as change agents, our work in responding to these barriers and drivers might begin by leveraging individuals' perceptions of more "proximal" frames (i.e., structures and people) and work purposefully to cultivate thinking about how to view the change initiative through more "distal" frames (i.e., power and symbols). Our hypothesis is that individuals who can shift perspectives between all the frames will be more likely to support and sustain the change initiative. A limitation of the Four-Frame model is that it does not highlight readiness to change at the *individual* level. Change at the individual level is better understood through Roger's (2003) Innovation-Decision model or Ajzen's TPB (1991).

3.2 Rogers' Innovation-Decision Model

Rogers' (2003) Innovation-Decision model has been applied in diverse contexts to understand how individuals adopt an innovation. In the field of education, such an innovation could be new curriculum, classroom technology, or pedagogical strategies. The Innovation-Decision model identifies stages through which individuals progress as they decide whether or not to adopt an innovation: knowledge, persuasion, decision, implementation, and confirmation. However, an individual's adoption of an innovation may be influenced by "prior conditions" such as previous experience with the proposed innovation, recognition of the need for innovation, level of innovativeness, or norms of the social system in which the innovation will occur (Rogers, 2003, p. 163). The model has subsequently been modified to explain the actions/decisions of faculty in higher education (Andrews & Lemons, 2017) and has been integrated with other models like Hall and Hord's Concerns theory (1987) to identify specific apprehensions or concerns an individual or group may have regarding adoption of an innovation.

Hall and Hord (1987) identify concerns having to do with the self (need for additional information or a concern about persisting in the field), task (implementation of innovation), or impact (long-term effects of innovation). Similar to other researchers (e.g., McLean, 2005), we found it useful to pair Hall and Hord's Concerns theory with Innovation-Decision because we could further categorize participants' responses by type of concern (self, task, or impact). For example, the response, "Not so beneficial to me, personally, in that teaching is not in my experience a strong criterion for obtaining tenure and promotion" is aligned with Rogers' prior conditions about the norms of the social system. While we are limited to the assumption that this respondent is not yet at the implementation stage, we can classify this statement with greater certainty as a *self* concern in which the respondent is addressing a concern about persisting in the field.

The attitudes expressed in the participants' responses also provided insight into how a change agent might effectively address the barriers or concerns. In the previous example, we can surmise that a change agent might seek to create incentives for teaching effectiveness to motivate participant buy-in to institutional change efforts. In a second example, we can deduce that the respondent who indicates "Everyone has different ideas about teaching so why say one way is better than others" is in an early stage of the Innovation-Decision model (e.g., knowledge) and may benefit from an introduction to the literature on EBIPs. A limitation of both Rogers' model and Hall and Hord's theory was the finding that barriers and concerns align more clearly than drivers and concerns, thus making the model easier to apply to the barriers half of the dataset.

3.3 Ajzen's Theory of Planned Behavior

While Roger's Innovation-Decision model considers the individual level, the TPB is an interaction between the individual and the system in which the individual resides. According to the TPB, the individual's intent to engage in a behavior is reinforced through continual feedback loops that connect their personal attitudes (based on behavioral beliefs and evaluations of outcomes), perceived norms (based on normative beliefs and motivation to comply), and perceived behavioral controls (based on control beliefs and perceived power) (see Figure 2). Note that the barriers and drivers do not hold equal weight for the individual and may influence one another.

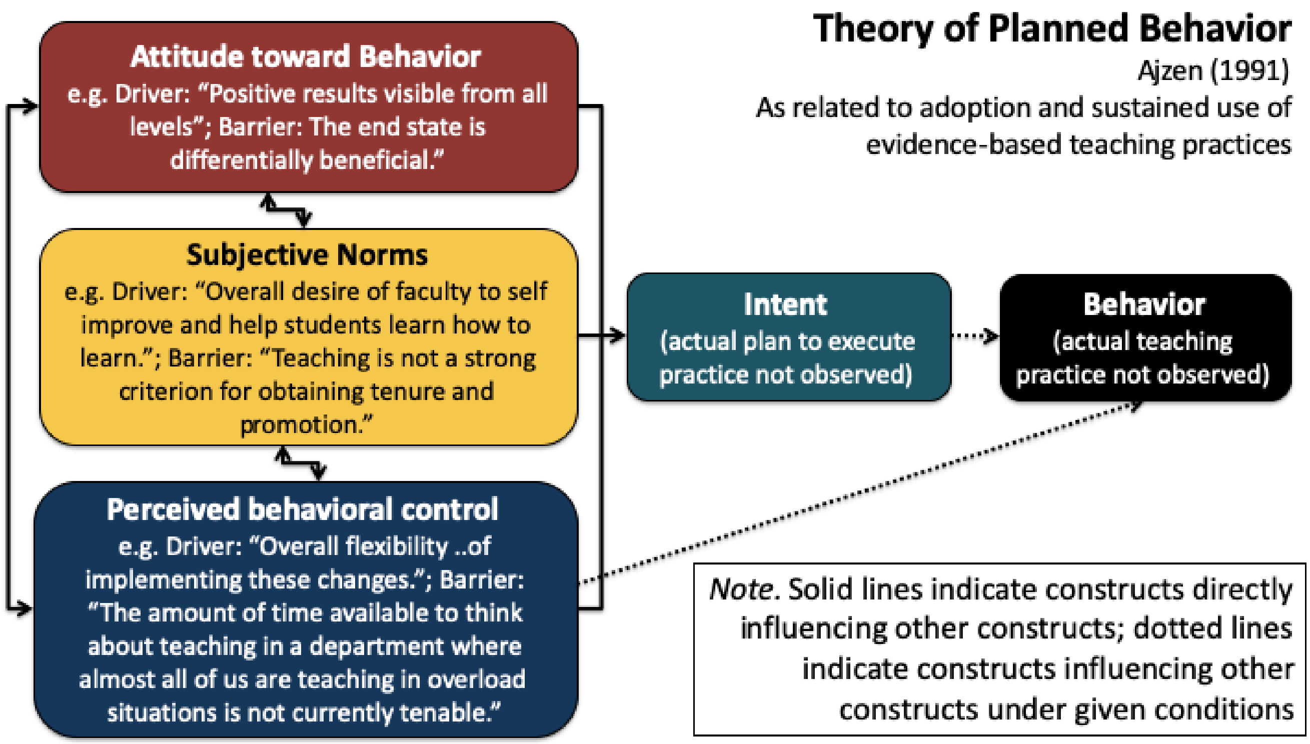


Figure 2. An Example of One Individual's Barriers and Drivers, as Mapped onto Ajzen's Theory of Planned Behavior.

As with the application of other theories, the application of TPB to this particular dataset was difficult. However, we found it more challenging to code the barriers data than the drivers half of the dataset. Part of this challenge may come from the nature of the TPB, which examines the things (attitudes, norms, perceived behavioral controls) that determine behavioral intent. It is possible that respondents are inherently more likely to respond with positive beliefs about these constructs in the context of the study. Another possible explanation is that there are sufficiently high drivers in these two samples to positively influence behavioral intent, and that barriers would have been easier to code for a department more prone to negative beliefs about EBIPs. This could be further examined by documenting behaviors, or sampling of additional departments.

We tended to code barrier data primarily as *perceived behavioral control*. This included themes of time, class size, and personal motivation. The tenure/promotion process was frequently cited as something that seemed to touch on both behavioral controls and subjective norms (i.e., departmental expectations). If the individual perceived that they had less control of these things, it may be that they are less likely to intend and/or engage in the use of EBIPs. However, a noted limitation to examining these data alone is the absence of a second piece of data to confirm if these behaviors are actually occurring.

Most drivers we coded were consistent with attitudes (feelings; desires for change) or norms (expectations from others; adherence to those expectations). Within these codes, we noted that most drivers were attitude-based, not normative. This could be because teaching norms can be intangible and challenging to elicit (Fishbein & Ajzen, 2010). Conner and Armitage (1998) also note that norms may be the weakest of the TPB constructs in its ability to predict intent and behavior. Alternatively, the original question could have limited how faculty articulated norms; or, because the data we coded were all from one of two departments, faculty may have been influenced by similar norms, and therefore we had difficulty noting those themes in the dataset. If norms are intangible but present (i.e., implicit), we also wonder to what extent that faculty, subscribing to a norm of autonomy, have difficulty acknowledging how they are influenced by others (Hamilton, 2007).

One limitation in using TPB with this particular dataset is that the behavior itself is not captured. Likewise, it is unclear exactly whether participants *intended* to do the behavior of interest. A necessary next step for change agents is to understand whether the behavior itself was actually enacted, and whether any one lever or combination of levers was most central to driving or preventing change in this department. Though most barriers fell into the Perceived Behavioral Control category, it is possible that sufficiently positive drivers in the attitudes or norms categories helped to overcome those barriers. A potential intervention to explore would be to see how changes in attitudes can help faculty navigate barriers, perhaps through the normative influence of change agents. In essence, these leaders could support a personal norm of resilience to explicitly identify barriers and foster positive attitudes among other change agents in a department, so that others may adhere to those attitudes as well. For example, an intervention to help faculty re-conceptualize or expand upon their perceived behavioral controls around time, space, and tenure may be helpful. Although time is a common *perceived* barrier, it was not clear across all cases whether the time was a limitation for planning or enacting EBIPs. By helping faculty build supportive attitudes (e.g. moral obligation to teach with best practice; willingness to make mistakes in trying active learning), they can build a willingness to face constraints and achieve change in the classroom.

4 Conclusion

In well-designed research, theory is used to frame and design studies, guide data collection, and inform data interpretation. It is not surprising, then, that our post-hoc analyses with new theories presented challenges—with some theories easier to apply to the data (or half of it) than others. The raw data were collected to enumerate the drivers and barriers for a change initiative as perceived by *individual* faculty members. Yet the brevity of the individual responses meant that the contextual detail necessary to interpret the data from some theoretical perspectives was lacking and limited the degree to which new inferences might be drawn from the data. This held true even for theories that function to explain individual behavior (e.g., innovation-decision). In practice, change agents might similarly find that data collected to evaluate an initiative are insufficient. Using theory to select or design appropriate evaluation instruments can guard against this, especially if those instruments are initially field-tested to see if they are producing sufficient data. Our approach was instructive in thinking about how theory should be used to gather evidence of the efficacy of change efforts. We found that our use of Appreciative Inquiry throughout the process revealed several other lessons, which we describe below.

First, this process provided our research group with a broader sense of affordances and limitations of different theories. The scale of this project does not allow us to propose a definitive process for choice of theory for any given project. However, the appreciative inquiry provided each of us with insights that will inform our future use of theory. These include: *On what level does the theory operate?*, *What kind of data would be needed to use this theory?*, and *What role does context play?*

Second, the analysis conducted with each theory yielded concrete and valuable ideas regarding actions change agents might take, additional data to be collected, and/or new lines of inquiry for scholars. This suggests that an application of different theories may be useful for moving a study or implementation project forward, especially if it were conducted at a juncture when an expansion of ideas could help scholars or change agents move beyond a bounded view based on a single theory.

Third, the application of theories that operate at different levels of analysis revealed interesting ideas about what is important for change. No theory captures all the components of the complex system of higher education at once. However, using multiple theories provided a glimpse into different components of the system. For example, our analysis yielded insights about both individual perspectives and how those individuals viewed the larger context in which change was to take place. By exploring the dataset with the constructs of each theory, we gained insight into the whole. Further, the absence of depth in the dataset indicates that there is more to be uncovered and affirms what Bangera et al. discuss in their chapter of this volume, in that change is not linear and is more of a “squiggle.” Capturing the nuances that impact a change project is important in understanding how change occurs and may be sustained.

In the future, such explorations may yield insights into how to integrate different theories across different levels of the system. This invites scholars to move beyond expertise in a particular theoretical area because stretching ourselves to explore different theories gives us new perspective. The work presented here suggests that STEM education change scholars and agents should be familiar with a variety of theories. This would allow one to look for opportunities in which a particular result might be able to be examined through a different theoretical lens. As an example, the theory of change outlined in the Ngai et al. chapter of this volume provides indicators for a department’s readiness for change, which, if grounded in local context as recommended by Earl et al. (this volume), may better position a change effort for success. Such an activity could yield insights that may cross levels of focus, which may be particularly important as we seek to illuminate how change works across components of the larger system.

Our appreciative inquiry surfaced several important findings with respect to the use of theory in the analysis of an educational change project. Certainly our work reinforced that change scholars and agents should choose theories that operate with a focus aligned with one's research question or intended scope of change. We argue, however, that change scholars and agents should also give attention to context and determine how much of the context needs to be considered for their work.

In summary, our exploration shows that the application of new theory provides a fresh perspective from which initial interpretations can be further inspected, alternative hypotheses generated, and new directions for change agents identified. We encourage other scholars to build on this work to illuminate additional insights of relevance to scholars and change agents seeking a richer understanding of the use of theory for STEM education change.

5 About the Authors

Mary E. Pilgrim is an Assistant Professor in the Department of Mathematics and Statistics and Associate Director of the Math and Stats Learning Center at San Diego State University.

Kelly McDonald is a Professor of Biological Sciences and the Director of the Science and Math Success Center for the College of Natural Sciences and Mathematics at California State University, Sacramento.

Erika G. Offerdahl is an Associate Professor of Biochemistry and Associate Director of Undergraduate Programs in the School of Molecular Biosciences at Washington State University.

Katherine Ryker is an Assistant Professor of Geoscience Education in the School of the Earth, Ocean and Environment at the University of South Carolina.

Susan E. Shadle is the Vice Provost for Undergraduate Studies and a Professor of Chemistry at Boise State University.

Amelia Stone-Johnstone is a Doctoral Candidate in the Math and Science Education Doctoral program at San Diego State University.

Emily M. Walter is an Assistant Professor of Biology and Director of the STEM Education Center at California State University – Fresno.

6 References

Ajzen, I. (1985). From intentions to action: A theory of planned behavior. In J. Kuhl & J. Beckman (Eds.), *Action control: From cognitions to behaviors* (pp. 11–39). Springer.

Ajzen, I. (1991). The theory of planned behavior. O*rganizational Behavior and Human Decision Processes, 50*(2), 179–211.

Andrews, T.C. & Lemons, P. P. (2015). It's personal: Biology instructors prioritize personal evidence over empirical evidence in teaching decisions. *CBE-Life Sciences Education, 14*(1), 1–18. https://doi.org/10.1187/cbe.14-05-0084

Austin, A. E. (2011). *Promoting evidence-based change in undergraduate science education*. National Academies National Research Council Board on Science Education. https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072578.pdf

Bangera, G., Vermilyea, C., Reese, M., & Shaver, I. (this volume). On the RISE: A case study of institutional transformation using idea flow as a change theory. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 6). Pressbooks.

Bolman, L. G., & Deal, T. E. (2008). *Reframing organizations: Artistry, choice, and leadership*. Jossey-Bass.

Conner, M., & Armitage, C. J. (1998). Extending the theory of planned behavior: A review and avenues for further research. *Journal of Applied Social Psychology, 28*(15), 1429–1464. https://doi.org/10.1111/j.1559-1816.1998.tb01685.x

Cooperrider, D., & Srivastva, S. (2017). The gift of new eyes: Personal reflections after 30 years of Appreciative Inquiry in organizational life. In *Research in organizational change and development* (Vol. 25, pp. 81–142). Emerald Publishing Limited. https://doi.org/10.1108/S0897-301620170000025003

Cooperrider, D., & Srivastva, S. (1987). Appreciative Inquiry in organizational life. In W. Pasmore & R. Woodman (Eds.), *Research in organization change and development* (Vol. 1, pp. 129–169). JAI Press

Dormant, D. (2011). *The chocolate model of change*. lulu.com.

Earl, B., Viskupic, K., Marker, A., Moll, A., Roark, T., Landrum, R. E., & Shadle, S. (this volume). Driving change: Using the CACAO framework in an institutional change project. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 1). Pressbooks.

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. Routledge. https://doi.org/10.4324/9780203838020

Hall, G. E. & Hord, S. M. (1987). *Change in schools*. State University of New York Press.

Hamilton, N. W. (2007). Faculty Autonomy and Obligation. *Academe*, *93*(1), 36–42.

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952–984. https://doi.org/10.1002/tea.20439

Howard Hughes Medical Institute (2019). Summer Institutes on Scientific Teaching. https://www.summerinstitutes.org/

Kezar, A. (2011). What is the best way to achieve broader reach of improved practices in higher education? *Innovative Higher Education, 36*(4), 235–247. https://doi.org/10.1007/s10755-011-9174-z

McLean, J. (2005). Addressing faculty concerns about distance learning. *Online Journal of Distance Learning Administration, 8*(4), 1–13. https://www.academia.edu/download/48971937/mclean84.pdf

Ngai, C., Corbo, J. C., Quan, G. M., Falkenberg, K., Geanious, C., Pawlak, A., Pilgrim, M. E., Reinholz, D. L., Smith, C., & Wise, S. (this volume). Developing the Departmental Action Team theory of change. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 5). Pressbooks.

Reinholz, D. L., & Apkarian, N. (2018). Four frames for systemic change in STEM departments. *International journal of STEM education, 5*(1), 1–10. https://doi.org/10.1186/s40594-018-0103-x

Reinholz, D. L., Pilgrim, M. E., Corbo, J. C., & Finkelstein, N. (2019). Transforming undergraduate education from the middle out with Departmental Action Teams. *Change: The Magazine of Higher Learning*, *51*(5), 64–70. https://doi.org/10.1080/0091383.2019.1652078

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). The Free Press.

Shadle, S. E., Marker, A., & Earl, B. (2017). Faculty drivers and barriers: Laying the groundwork for undergraduate STEM education reform in academic departments. *International Journal of STEM Education, 4*(1), 8. https://doi.org/10.1186/s40594-017-0062-7

SECTION II

CHANGE ACROSS SCALES

Introduction: Change Across Scales

GABRIELA WEAVER AND LINDA SLAKEY

The introduction to this volume outlined a progression that has taken place over about a 20-year period in the types of change efforts that have been funded—from innovations for an individual course that were dependent on a specific instructor's efforts to more sustained, institutional, or multi-institutional, change efforts. This evolution reveals an underlying shift in the field of educational research overall. It is in the midst of testing the hypothesis that the odds of institutionalization go up if the work is carried out in a peer network—either within an institution or across them. The hypothesis is intrinsic in the theory of change for networked improvement communities (NICs) (Bryk, Gomez & Grunow, 2011).

In the final reflection in the preceding volume of this series, Slakey and Gobstein (2016) observed that the implementation of frameworks for change within networks has added visibility and credibility to efforts for reform. Desmarais et al. (2017) further highlight that intentional networks have now come to occupy a central role in the effort to transform approaches to STEM undergraduate pedagogy. Their report presents an analysis of the network structures, kinds of goals, and modes of action that were discussed in an Association of Public and Land-grant Universities-hosted workshop for leaders of networks concerned with bringing about widespread use of evidence-based STEM pedagogy. The analysis draws on constructs in the work of Plastrik et al. (2014) and Kezar and Gehrke (2015) among others. One such construct is shown in Table 1, following Plastrik (2014).

Table 1: Plastrik et al. (2014)'s Kinds of Networks

Type	Focus of activity
Connectivity	Link individuals to facilitate flow of information
Alignment	Connect people to share and spread a collective value proposition, so as to solve a problem
Production	Foster collective action, create products, to advance a shared goal

In addressing change across scales, the chapters that comprise this section of the volume exemplify different ways in which change efforts utilize networks and different scales for those networks—from departmental to national. As the scale of the change effort shifts, the network takes on a different role in propelling the effort forward. We also note that the use of networks in these projects reflect different levels of intentionality—in some cases emerging as a result of the work and in other cases being established in order to engage in the work in the first place. Plastrik et al.'s (2014) types weave across these scales.

To motivate willingness to explore new approaches to teaching, Marbach-Ad and her colleagues invite faculty to report the value they place on particular learning outcomes and what they perceive their students value, and compare their responses with what students report in a parallel survey. The work is done in meetings of the faculty by departments within a College of Computer, Mathematical and Natural Sciences. While the scale is small, the discussion among colleagues is of the essence of the intervention; that is, the study is structured to draw on connectivity in an established community of colleagues and seeks to achieve a degree of alignment.

Kezar and Miller report on activities within the STEM Education Network established among member institutions of the Association of American Universities. The chapter describes outcomes that resulted at multiple scales, from the level of the department to federal legislation. Within the member campuses, there are multiple instances of production networks, but the larger network focuses on connectivity.

Funding sources can be a catalyst for the formation of networks, as is evident in the chapter by Gardner and colleagues describing a program supported by the National Science Foundation's (NSF) Research Coordination Networks initiative. This multi-institutional program takes on educational change by focusing on future faculty through professional development for graduate student teaching assistants. Because it is based in a discipline, it promotes change at the department level but also across institutions, and thus serves as both an alignment and production network.

A different example of funding-catalyzed network formation is described in the chapter by Wojdak et al., in which four institutions who separately were awarded Howard Hughes Medical Institute Inclusive Excellence grants were organized into clusters of institutions by the agency and prompted to use that network to further their individual or a collective effort. In uncovering the common themes and using these in their work, this network has functioned in a connectivity capacity.

The chapter by Margherio and colleagues reports on research on the process of cultivating strategic partnerships. The study subjects are Engineering Departments or Colleges, funded by the NSF to undertake various new approaches to undergraduate education, including changes in course structure, assessment of student learning, and infusion of social justice in the curriculum. The focus of their work presumed prior development of working relationships within each subject group, and examined their discovery of their need for partners outside their departments in order to achieve their goals, for example with departments teaching gateway courses, or industrial groups that hired their students. The anecdotes they share provide interesting examples of the development of alignment.

The last two chapters in this section are both connected to the multi-institutional Teaching Evaluation (TEval) project. TEval emerged as a deliberate network to strengthen the work of the individual campuses on developing and implementing new forms of teaching evaluation. Andrews and colleagues describe the details of the TEval effort on one campus, with particular emphasis on working with departments as the unit of change. The following chapter by Finkelstein and colleagues describes the project as a whole, including the ways in which the multi-institutional nature of the project has been critical in its scaling and linking with other existing national networks.

As a group, the chapters of this section provide multiple perspectives into the ways in which scaling and networking can be synergistic. Moving from one scale to another requires that new groups become part of the project or process, and that means that heterogeneity will increase with scale. This, in turn, leads to the need to work together *across* and *with* differences. A network can assist this process by providing diverse views on the process being studied or implemented. Indeed, both scaling and networking are intertwined with explicitly paying attention to inclusion as part of the change effort. As multiple voices become engaged in the effort, the ability of the project to serve a more diverse audience also has the potential to increase.

References

Andrews, S. E., Keating, J., Corbo, J. C., Gammon, M., Reinholz, D. L., & Finkelstein, N. (this volume). "Transforming teaching evaluation in disciplines: A model and case study of departmental change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 13). Pressbooks.

Bryk, A., Gomez, L., & Grunow, A. (2011). *Getting Ideas Into Action:Building Networked Improvement Communities in Education*. Carnegie Foundation for the Advancement of Education. Available at https://www.carnegiefoundation.org/resources/publications/getting-ideas-action-building-networked-improvement-communities-education/

Desmarais, M., Redd, K., Finkelstein, N., and Goldstein, B. (2017, June 22). *Guidance for Network Leaders* [Presentation]. Networks of STEM Education Centers' Network Leaders Workshop, New Orleans, LA. https://osf.io/w4uxp

Finkelstein, N., Greenhoot, A.F., Weaver, G., & Austin, A. E. (this volume). "A department-level cultural change project: Transforming the evaluation of teaching." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 14). Pressbooks.

Gardner, G., Ridgway, J., Schussler, E., Miller, K., & Marbach-Ad, G. (this volume). "Research coordination networks to promote cross-institutional change: A case study of graduate student teaching professional development." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 10). Pressbooks.

Kezar, A., & Gehrke, S. (2015). *Communities of transformation and their work scaling STEM reform*. Pullias Center for Higher Education. https://pullias.usc.edu/wp-content/uploads/2016/01/communities-of-trans.pdf

Kezar, A., & Miller, E. R. (this volume). "Using a systems approach to change: Examining the AAU Undergraduate STEM Education Initiative." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 9). Pressbooks.

Marbach-Ad., G., Hunt, C., & Thompson, K.V. (this volume). "Using data on student values and experiences to engage faculty members in discussions on improving teaching." In K. White, A.

Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 8). Pressbooks.

Margherio, C., Doten-Snitker, K., Williams, J., Litzler, E., Andrijcic, E., & Mohan, S. (this volume). "Cultivating strategic partnerships to transform STEM education." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 12). Pressbooks.

Plastrik, P., Taylor, M., & Cleveland, J. (2014). *Connecting to change the world*. Island Press

Slakey, L. & Gobstein, H. (2016). "Toward a New Normal." In G. C. Weaver, W. D. Burgess, A. L. Childress, & L. L. Slakey (Eds.), *Transforming Institutions: Undergraduate STEM Education for the 21st Century* (pp. 485–496). Purdue University Press.

Wojdak, J., Phelps-Durr, T., Gough, L., Atuobi, T., DeBoy, C., Moss, P., Sible, J., & Mouchrek, N. (this volume). "Learning together: Four institutions' collective approach to building sustained inclusive excellence programs in STEM." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 11). Pressbooks.

8. Using Data on Student Values and Experiences to Engage Faculty Members in Discussions on Improving Teaching

GILI MARBACH-AD, CARLY HUNT, AND KATERINA V. THOMPSON

1 Introduction

There is a consensus among employers (Hart Research Associates, 2015, 2018), policymakers (e.g., AAMC-HHMI, 2009; AAAS, 2011, 2015; Heron et al., 2017; PCAST, 2012) and education researchers (Hora, 2016; Matusovich et al., 2014) that undergraduate students need to develop skills such as collaboration, communication, and problem solving. These skills have been variously referred to as twenty-first-century skills (Jang, 2016), soft skills (Finch et al., 2013), and employability skills (Rosenberg et al., 2012). In addition to these widely applicable skills, STEM fields also rely on skills that are somewhat general but not unique to a specific STEM discipline (e.g., computation, data interpretation). We refer to the entire suite of general and STEM-specific skills as cross-disciplinary skills. Cross-disciplinary skills are best developed using evidence-based teaching approaches that actively engage students in learning, such as having students work in groups. However, faculty often rely on traditional lecturing methods, which is at odds with stakeholder recommendations and ineffective in helping students hone these skills (Bok, 2006; Handelsman et al., 2004; Kezar, 2001; Seymour, 2001).

We describe here a strategy employed by the College of Computer, Mathematical, and Natural Sciences (CMNS) Teaching and Learning Center (TLC) at the University of Maryland to help shift our faculty members' teaching approaches towards practices more effective for building cross-disciplinary skills. Faculty members at research universities identify primarily as researchers, who regularly collect, interpret, and make decisions based on data (Anderson et al., 2011; Brownell & Tanner, 2012; Robert & Carlsen, 2017; Savker & Lokere, 2010). We are using this deeply-rooted professional identity as a lever to design professional development activities that motivate faculty members to reconsider their beliefs, values, and behaviors towards teaching. Our activities were designed not only to relate to the faculty members' identities as researchers, but also to their departmental and disciplinary identities.

2 Theoretical Background

2.1 Faculty Member Identity and Social Network Membership

We conceptualize faculty members as having individual professional identities as well as identities as members of disciplinary and departmental communities. Regarding individual professional identity, faculty members begin a socialization process in their doctoral programs where they are often encouraged to prioritize research over teaching (Fairweather, 2008). Austin (2011) explains that doctoral education is an "apprenticeship experience" where doctoral students adopt the values and beliefs of their research mentors. They receive implicit and explicit messages from their mentors that they should avoid allocating too much time towards teaching, that teaching detracts from research, and that teaching excellence will be rewarded to a lesser degree than research productivity. These formative experiences result in faculty members identifying as researchers first and as instructors second, which impacts the decisions they make about allocating their time (Brownell & Tanner, 2012; Robert & Carlsen, 2017; Savker & Lokere, 2010) and has direct implications for teaching professional development (TPD). To effectively address issues of identity in TPD, some authors (Robert & Carlsen, 2017) have suggested that TPD activities be designed to respect faculty members' identities as researchers. Specifically, they propose that interventions that integrate teaching and research could be a point of entry in engaging research-oriented professors more deeply in conversations about teaching.

Faculty members also belong to departments and disciplines (Kezar, 2014; Quardokus & Henderson, 2015; Robert & Carlsen, 2017), which are social systems with unique characteristics (Donald, 1997; Hativa, 1995; Smart & Ethinton, 1995). Therefore, it is critical that teaching and learning reform efforts and professional development activities be sensitive to disciplinary and departmental contexts (Austin, 2011; Bradforth et al., 2015; Coppola & Krajcik, 2013, 2014; Henderson & Dancy, 2011; Quardokus & Henderson, 2015; Wieman et al., 2010). Furthermore, education policymakers have emphasized that university-wide changes in teaching "are sustainable only if combined with changes at the colleges (subsets of universities) and departmental levels that foster a team culture of continuous teaching improvement" (Bradforth et al., 2015, p. 284). They term this the "middle out" approach, where change efforts are situated in colleges and departments. This is distinct from approaches that are "bottom up" (i.e., change instigated by the faculty members who provide instruction to students) or "top down" (i.e., change instigated by senior university administrators). Middle out change initiatives are seen as more likely to be successful and sustained because of their ability to exert influence at all levels of institutional structure (i.e., individual, departmental, and administrative). Consistent with this perspective, there are change theories in the literature that provide rationales for intervening on the department level as well as on the individual level. We elaborate on these theoretical perspectives below and describe how they informed our TPD activities. Additionally, please note that Andrews et al. (this volume) provide another example of a departmental-level approach to change.

2.2 Theory of Change

Change theories have implications for the intervention efforts of change agents (Andrews et al., 2016; National Research Council, 2012), such as TLCs and discipline-based education researchers (DBERs). To guide our efforts, we drew on cultural and social cognitive perspectives of institutional change (Kezar, 2013, 2014). The cultural perspective on change asserts that organizations (e.g., departments) hold unique norms, values, and beliefs that influence individuals within the culture. By implication, change ensues from shifts in department-level values and beliefs. Change agents like DBERs and TLCs must know the current values of a department and align their interventions with those values (Corbo et al., 2016). The social cognitive perspective on change emphasizes the role of individual values and beliefs in guiding behavior, as well as the role of thought processes (Bandura, 1997; Pajares, 1992). The social cognitive perspective asserts that one way change agents can shift beliefs is to introduce new information that will encourage individuals to confront and modify their prior beliefs.

Here we describe our efforts to promote a shift in faculty member beliefs that could ultimately increase their likelihood of adopting evidence-based teaching practices. Building on social cognitive and cultural perspectives on change, as well as theories of professional development and change in K-12 teachers (Desimone, 2009), we designed and implemented a novel approach to engage faculty members in discussions about teaching. Specifically, we presented faculty members with data on their own students' values, in essence providing them with "new information" that might encourage them to confront their prior beliefs about teaching. We did this during regularly scheduled faculty meetings to promote departmental-level discussion and consensus building. We anticipate that continuing conversations of this type could motivate changes in teaching practices that, in turn, could ultimately impact students' beliefs about cross-disciplinary skills. We plan to assess these downstream outcomes (i.e., changes in teaching practices and student beliefs) in future research.

3 Methods

3.1 Institutional Context

University of Maryland, a research-intensive public university, enrolls about 27,000 undergraduates. Our TLC serves 321 tenure-track and professional-track faculty members from 10 CMNS departments: Astronomy (ASTR), Atmospheric and Oceanic Sciences (AOSC), Biology (BIOL), Cell Biology and Molecular Genetics (CBMG), Chemistry and Biochemistry (CHEM), Computer Science (CMSC), Entomology (ENTM), Geology (GEOL), Mathematics (MATH), and Physics (PHYS). These departments collectively enroll over 6,000 students.

3.2 Faculty Professional Development in Teaching

During the 2016–2017 academic year, we visited regular faculty meetings in the 10 departments to initiate conversations about teaching. We asked the chairs to allow at least 45 min for our visit. In each faculty meeting, we 1) surveyed faculty regarding their educational values, 2) explained the ways in which the TLC could support their teaching endeavors, 3) engaged faculty in a discussion of student educational values, and 4) sought their insight into observed patterns of student values and how those values corresponded to faculty values.

At the beginning of each meeting, faculty were asked to complete a modified version of the Survey of Teaching Beliefs and Practices for Undergraduates (STEP-U) (Marbach-Ad et al., 2019), which focused on 17 cross-disciplinary skills (e.g., scientific writing, problem solving, working in groups). They first rated how much they valued each skill as an outcome of undergraduate education in their discipline on a scale of 1 (not important) to 5 (very important). Using the same scale, they were then asked to predict how much graduating students in their discipline would value each skill. Finally, we asked them to list any skills important to graduates in their discipline that were omitted from the survey. Surveys were anonymous and collected at the end of the meeting for subsequent analysis.

We next summarized the various professional development activities offered to faculty by the TLC (e.g., individual consultations, opportunities to join faculty learning communities, assistance with disseminating innovative teaching practices). These services were summarized on a handout (Appendix 1) given to faculty for future reference.

To stimulate discussion, we distributed a two-page handout summarizing student survey responses (N=2404) collected from University of Maryland students over five years (Marbach-Ad et al., 2019). Student data were presented in tabular form, along with a summary of information gleaned from student interviews and a statistical analysis[1] of demographic and experiential predictors of student values (see example, Appendix 2). One table (Table A1) showed student response rates and demographics (i.e., gender, underrepresented minority group membership, undergraduate research experience, cumulative GPA, career aspirations). A second table (Table A2) consisted of a heat map showing the percentages of students in each CMNS major that indicated a given STEP-U skill was “important” or “very important” to acquire during their undergraduate studies. The heat map format enabled faculty to make quick comparisons of the degree to which their own students valued particular skills relative to other skills and relative to students in other CMNS disciplines.

After giving faculty a few moments to look over the summarized data, we asked them to suggest possible reasons for 1) discrepancies between their students’ values and their own, 2) the possible relationship between student values and classroom experiences, and 3) discrepancies between their students’ values and those of students from other disciplines. Finally, we engaged them in discussions of teaching strategies that could potentially address the observed discrepancies. These discussions were audio recorded for subsequent analysis.

3.3 Analysis of Faculty Data

Surveys administered during the 10 departmental faculty meetings resulted in 184 responses [ASTR (n=13), AOSC (n=11), BIOL (n=16), CBMG (n=25), CHEM (n = 30), CMSC (n=14), ENTM (n=11), GEOL (n=15), MATH (n = 7), PHYS (n=42)]. We analyzed faculty member survey data in a manner similar to student data by calculating proportions of respondents rating the item as “important” or “very important,” then summarizing the results using heat maps. Transcripts of faculty discussions were reviewed independently by two researchers, who recorded major themes, then discussed them until reaching approximately 90% agreement.

4 Findings

We report on the qualitative and quantitative data from the TPD intervention, as well as our own subjective impressions of the process, to inform future discipline-specific TPD efforts. We summarize major themes in Table 1 and describe below the planning process, general impressions of the faculty discussions, the faculty’s specific insights into factors influencing student values, and their suggestions for improving the survey.

Table 1: Summary of Topics Discussed in Each Department

Department	Skills discussed	Faculty insight and reactions to student perspectives	Major discussion points for teaching improvement
ASTR	Scientific writing, working in groups, application to everyday life, dynamic nature of science	Most students are double majors (most often with physics or mathematics). Faculty were disappointed with students' lack of appreciation for scientific writing and how much science applies to everyday life.	**Working in groups** Faculty noted that they had only recently implemented more group work in introductory classes, so the seniors who responded to the survey did not have the benefit of these improvements.
AOSC	Scientific writing, working in groups, communication, quantitative reasoning	Every undergraduate does a research-based senior thesis, which provides unique opportunities for cross-disciplinary skill development. Faculty suggested that AOSC is an applied science and many students go straight into the workplace after graduation, so it is important to incorporate group work in classes. Faculty were concerned that their students were not valuing quantitative reasoning.	**Communication** Faculty suggested this could be developed by encouraging students to go to conferences to present undergraduate research. **Quantitative reasoning** Faculty thought students would benefit from having more assignments that required the application of quantitative reasoning.
BIOL	Scientific writing, memorization, decision-making based on evidence	Many faculty members expressed surprise that students did not value scientific writing.	**Scientific writing** Faculty discussed the need to implement more activities to promote scientific writing and the challenges in doing so.
CBMG	Scientific writing, working in groups, memorization, interdisciplinary nature of science, application to everyday life, communication	Students with different career aspirations have differing values (e.g., pre-medical students have lower appreciation for scientific writing compared to students who are planning to enter graduate school).	**Working in groups** There was a robust discussion of experiences with group work and ways to implement it more effectively. **Memorization** Faculty expressed frustration with how memorization has been devalued in recent years.
CHEM	Scientific writing, working in groups, interdisciplinary nature of science	Faculty underestimated the degree to which students valued many cross-disciplinary skills, and were pleasantly surprised when student values were consistent with faculty values (e.g., scientific writing).	**Scientific writing** Faculty stressed the importance of incorporating writing assignments throughout the curriculum. **Working in groups** Faculty discussed strategies for reducing student resistance (e.g., assigning grades individually, rather than assigning the entire group the same grade).

CMSC	Working in groups	Students do not see themselves as being science majors, so the survey language (geared towards natural sciences) may have seemed inapplicable to their experience. Computer science is an applied science and many students go straight into the workplace after graduation, so it is important to incorporate group work in classes.	**Working in groups** This was mainly incorporated into upper-level courses or done outside of classes (e.g., hackathons).
ENTM	Scientific writing, working in groups	Faculty members discussed lower-level (i.e., first- and second-year) students separately from upper-level students. Students in introductory courses expect professors to provide facts, rather than challenging students to think critically. They perceived that upper-level students were more open to group work. Faculty were frustrated with inadequacies in students' scientific writing skills.	**Scientific writing** Faculty attempted to explain differences between disciplines regarding this skill, e.g. biology standards do not emphasize this skill as explicitly as the American Chemical Society recommendations. **Working in groups** Conversation centered on the importance of working in groups and ways to implement group work more effectively in classes.
GEOL	Scientific writing	Every undergraduate does a research-based senior thesis, which provides unique opportunities for cross-disciplinary skill development.	**Scientific writing**, **Dynamic nature of science**, and **Information literacy** Student appreciation of these skills may arise from GEOL's mandatory senior thesis requirement.
MATH	Working in groups, memorization, application to everyday life, dynamic nature of science	The student body is diverse (many are double majors, they move in and out of the major, there are multiple major tracks), making it challenging for instructors. There are limited opportunities for students to participate in research with mathematics faculty.	**Working in groups** Some faculty expressed frustration and recounted bad experiences, while others offered suggestions for more effective use. **Memorization** Some felt the K-12 trend towards de-emphasizing memorization has hindered student learning of more complex topics.
PHYS	Scientific writing, working in groups, memorization, decision-making based on evidence	Faculty were disappointed that students had relatively little appreciation for working in groups.	**Scientific writing** Faculty believe it is important, but often do not know how best to teach it or who should teach it. **Working in groups** There was consensus that this was important to incorporate in classes.

4.1 Intervention Planning Process

We assumed that every department held regular faculty meetings with high attendance, and anticipated that it would be straightforward to visit during one of these existing meetings. We emailed each chair individually asking for permission to participate in an upcoming faculty meeting. Reflective of how each department has its own norms and values, responses from chairs to our message varied. For example, the chair of the Math department shared that the department did not hold regular meetings of all faculty, in part because a high percentage were adjunct faculty. Instead, the department periodically convened a subset of faculty appropriate to the business at hand. He offered to meet with us along with the department's undergraduate director to discuss our proposed presentation, and afterwards we held a special meeting for faculty members interested in teaching and learning.

Other chairs similarly worked with us to ensure strong participation. For example, the Computer Science chair was immediately supportive of the intervention and offered to provide lunch to help motivate attendance. The Physics chair invited us to a meeting where other important topics were scheduled to be discussed and voted upon, which he thought would encourage faculty member attendance; we did find that this meeting had the largest number of attendees. These experiences emphasize the importance of working collaboratively and flexibly with departments to maximize participation while respecting departmental norms.

4.2 Faculty Insight into Student Values

4.2.1 General Impressions and Major Discussion Points

Faculty meeting discussions were generally enthusiastic and robust, and filled the available time. The discussions were characterized by a great deal of interaction between faculty members, with minimal prompting from the facilitators (see example in Figure 1). Faculty expressed feelings ranging from pride (e.g., Chemistry faculty were proud to see that their students valued scientific writing skills highly) to disappointment (e.g., Physics and Biology faculty members were disappointed with the relatively low percentage of their students who valued scientific writing). Reactions to student values data differed across departments. For instance, most departments were proud that the majority of their students devalued memorization, but Math faculty almost unanimously were disappointed that this was the case. They expressed frustration about how memorization has become de-emphasized in K-12 schooling, leaving college students lacking in the basic knowledge needed to develop more advanced skills.

Several departments had extensive discussions about scientific writing and the potential impact of classroom experiences on student values. Chemistry faculty members explained that most of their courses incorporate writing assignments, and they believed that this encouraged students to value writing skills. Biology and Physics faculty members attributed their students' low appreciation for writing to the fact that writing was rarely taught within courses in the major. Biology faculty members described a strong desire to require more written assignments, but felt that the grading volume would be insurmountable due to large class sizes. They also noted that national disciplinary standards in undergraduate biology emphasize writing to a lesser extent than in chemistry. Physics faculty members reported that they rarely taught writing because they perceived themselves as unskilled in teaching it, viewing it as a task better suited to the English department.

Faculty member 1: I feel that working in groups is something that the students actually hate. I don't think it's good training for a work place, at all. I think it's a completely different thing to work together with my colleagues here than to solve a problem in class or give a group presentation.

TLC Director: It's important to design a group assignment that requires each student to contribute. If you give an assignment that one individual can solve by himself or herself, there is nothing to gain from group [work].

Faculty member 2: There is some research evidence that shows that working in teams, for example, people who are coding in teams do so much better than if they are not in teams.

Faculty member 3: There are different ways to work in groups. It's not only these big, formal problems. It could be something so simple as a think-pair-share activity. It could range from that up until a semester long project.

Faculty member 4: Could you create a website that students could go to where they could learn ways to be an effective group member?

TLC Staff Member: The campus general education group has put together a lot of resources for faculty for forming groups and evaluating groups, and for structuring assignments. There is also a really nice student-centered resource that is all videos, called [Surviving] the zombie apocalypse [at the University of] Minnesota, which was designed to prepare students for being part of a group.

Figure 1: Excerpt of Discussion in Entomology about Group Work Activities

4.2.2 Discussion of Student Demographic Characteristics

Faculty members also discussed the potential influence of individual student attributes on values. Geology and AOSC faculty members explained that their students appreciated skills used in research (e.g., scientific writing, communication) because they all were required to write a senior thesis. Astronomy, Computer Science and Math faculty members noted that their students were often double majors, so their responses were likely impacted by coursework outside the major, even though the prompt asked them to focus only on their major courses. Math faculty members mentioned that there were three main tracks within the major (statistics, theoretical math, and applied math), and speculated that values might differ between tracks. Faculty members also discussed the potential role of career aspirations. For instance, Biology faculty members reported witnessing a lower appreciation for research-related skills among pre-med students, who anticipate doing little future research. Similarly, Computer Science faculty members explained that their graduating students might devalue research skills because students are more likely to immediately enter the workforce rather than attend graduate school.

4.2.3 Suggestions for Survey Modifications

Math and Computer Science faculty speculated that some survey items, particularly those that included the word *science*, may have felt irrelevant to their students, and they suggested the survey items use more inclusive wording. Computer Science faculty members suggested adding an item on computational skills due to their high importance in computer science. Quantitative skills such as programming, statistical analysis, and using mathematical software were mentioned frequently in multiple departments. We used this feedback to subsequently revise and extend the STEP-U.

4.3 Faculty Values and Predictions of Student Values

Several differences between departments in faculty values were evident (Table 2). For instance, in most departments, fewer than half of the faculty members rated memorization as “important” or “very important,” but Math faculty members unanimously found memorization important. All departments devalued working in groups except for Computer Science, where 93% of faculty members rated it as important.

Department	Problem solving	Apply quantitative reasoning	Acquire major scientific concepts	Decision-making based on evidence	Develop creativity and innovation	Understand how science applies to everyday life	Scientific writing	Memorize some basic facts	Remember formulas, structures, and procedures	Work in groups	Understand the inter-disciplinary nature of science
ASTR (N=13)	100%	100%	100%	92%	92%	69%	92%	31%	39%	31%	54%
AOSC (N=11)	100%	100%	100%	100%	90%	73%	100%	36%	40%	73%	82%
BIOL (N=16)	88%	94%	93%	94%	80%	56%	88%	44%	13%	44%	69%
CBMG (N=25)	96%	96%	92%	96%	72%	80%	88%	44%	24%	36%	76%
CHEM (N=30)	100%	97%	93%	97%	65%	67%	87%	53%	30%	40%	77%
CMSC (N=14)	100%	93%	92%	79%	86%	43%	64%	43%	46%	93%	36%
ENTM (N=11)	100%	100%	100%	100%	82%	80%	73%	46%	0%	64%	73%
GEOL (N=15)	100%	100%	86%	93%	87%	47%	86%	40%	43%	40%	60%
MATH (N=7)	100%	100%	50%	100%	71%	83%	86%	100%	71%	43%	57%
PHYS (N=42)	98%	98%	93%	90%	80%	45%	64%	24%	29%	45%	43%

Table 2: Heat Map Showing the Percentage of Faculty Members in Each Department Placing a High Value on Each STEP-U Skill. (web: click on table to enlarge)

Note: Faculty members were asked to rate the importance of each skill for their students to acquire during their undergraduate studies on a scale of 1 to 5 (1 = not important, 2 = slightly important, 3 = fairly important, 4 = important, and 5 = very important). Percentages reflect the proportion of students giving ratings of 4 or 5 on the item. Darker cell colors indicate higher percentages of respondents rating the item as "important" or "very important."

Faculty member predictions of how their students would rate each skill were also quite different from how the students actually responded. Table 3 provides an example juxtaposing faculty values, faculty predictions of student values, and student responses from the Biological Sciences (degree program offered jointly by BIOL, ENTM, and CBMG). The pattern in most other departments was similar, with faculty members largely underestimating the value that students attributed to cross-disciplinary skills. On observing their student results, one Chemistry faculty member said, "I'm kind of impressed that student priorities are similar to my answers and better than what I thought they would answer." This correspondence between student and faculty values may reflect a disciplinary acculturation process, during which student values come to align with faculty values (Marbach-Ad et al., 2019).

Skills	Values of Students	Student Values as Predicted by Faculty	Values of Faculty
Acquire major scientific concepts	92%	72%	92%
Problem-solving	88%	52%	94%
Decision-making based on evidence	87%	59%	98%
Understand the dynamic nature of science	85%	18%	79%
Understand how science applies to everyday life	84%	60%	73%
Develop information literacy	82%	20%	98%
Learn basic sets of laboratory skills	80%	49%	58%
Develop understanding of interdisciplinarity	78%	12%	73%
Develop creativity and innovation	76%	32%	76%
Apply quantitative reasoning	75%	33%	94%
Oral and written communication	72%	45%	92%
Scientific writing	67%	27%	85%
Memorize some basic facts	64%	70%	44%
Remember formulas, structures, and procedures	46%	55%	15%
Work in groups	46%	42%	44%

Table 3: Heat Map Showing the Percentage of Biological Sciences Students (N=1389) and Faculty (N=52) Members Rating Each STEP-U Skill as "important" or "very important" for Undergraduate Students to Acquire. (web: click on table to enlarge)*

Note: We grouped the departments of CBMG, ENTM and BIOL, which collectively sponsor the biological sciences major (BSCI).
Darker cell colors indicate higher percentages of respondents rating the item as "important" or "very important."

5 Implications for Teaching Professional Development

We used student data as a lever to engage faculty members in discussions about teaching by appealing to their identities as researchers (Brownell & Tanner, 2012; Robert & Carlsen, 2017; Savker & Lokere, 2010). This intervention differs from standard TPD interventions in that it gives faculty members the agency to interpret data from their own students and engage in conversation with their peers within the context of their department. We believe that this approach has the potential to inspire faculty commitment to enact change. As conceptualized by social cognitive researchers (Bandura, 1997; Pajares, 1992), thoughts and beliefs have strong influences on behavior. Given that these conversations encouraged faculty members to examine their beliefs and consider beliefs held by fellow faculty members, we anticipate that these conversations may ultimately lead to new departmental teaching norms and changes in teaching behavior. This prediction remains to be tested empirically.

This approach provided access to departmental faculty meetings in a way that facilitated department-wide discussions about teaching. Numerous conversations focusing on improvement of teaching occurred organically in the meetings. These conversations were strengthened by peer-to-peer interaction, whereby faculty members learned about specific student-centered approaches used by their departmental colleagues. The meetings also gave TLC staff new information about the unique needs and perspectives of each department, which will be used to inform future TPD. We were cognizant that, as representatives of the TLC, we might be perceived as outsiders who failed to understand disciplinary and departmental contexts; thus, we focused on facilitating the conditions for faculty members to self-generate knowledge and interpretations about student experiences. As these discussions progressed, we were often asked to suggest resources for effective teaching (e.g., Figure A1).

Our novel approach leverages professional identity within a disciplinary context to promote change in teaching. In our experience, when faculty members are asked to interpret locally-derived data (rather than reviewing data collected and summarized by external researchers), they show engagement, reflect deeply on their own teaching practices, and gain new insight into the student experience. These discussions expose faculty to effective teaching practices being employed by their peers, and we anticipate that this ultimately might inspire some to change their teaching. This strategy is consistent with the "middle out" model of institutional change in teaching (Bradforth et al., 2015) and is widely adaptable across disciplines and institutions.

6 Acknowledgments

This work was supported in part by a Howard Hughes Medical Institution Undergraduate Science Education Program grant to the University of Maryland. This work has been approved by the Institutional Review Board (IRB protocols #375954-8 and 404045-9). We thank the faculty members and students who participated in this study.

7 About the Authors

Gili Marbach-Ad is the Director of the Teaching and Learning Center (TLC) in the College of Computer, Mathematical, and Natural Sciences at the University of Maryland.

Carly Hunt is a research fellow in the Johns Hopkins School of Medicine and former graduate assistant within the College of Computer, Mathematical, and Natural Sciences at the University of Maryland.

Katerina V. Thompson is the Assistant Dean for Science Education Initiatives in the College of Computer, Mathematical, and Natural Sciences at the University of Maryland.

8 References

AAMC-HHMI Scientific Foundation for Future Physicians. (2009). *AAMC/HHMI committee defines scientific competencies for future physicians*. Howard Hughes Medical Institute. http://www.hhmi.org/grants/sffp.html

American Association for the Advancement of Science. (2011). *Vision and change in undergraduate biology education: A call to action*. AAAS. https://live-visionandchange.pantheonsite.io/wp-content/uploads/2013/11/aaas-VISchange-web1113.pdf

American Association for the Advancement of Science. (2015). *Vision and change in undergraduate biology education: Chronicling change, inspiring the future*. AAAS. https://live-visionandchange.pantheonsite.io/wp-content/uploads/2015/07/VISchange2015_webFin.pdf

Andrews, S. E., Keating, J., Corbo, J. C., Gammon, M., Reinholz, D. L., & Finkelstein, N. (this volume). "Transforming teaching evaluation in disciplines: A model and case study of departmental change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 13). Pressbooks.

Andrews, T. C., Conaway, E. P., Zhao, J., & Dolan, E. L. (2016). Colleagues as change agents: How department networks and opinion leaders influence teaching at a single research university. *CBE—Life Sciences Education, 15*(2), ar15. https://doi.org/10.1187/cbe.15-08-0170

Anderson, W. A., Banerjee, U., Drennan, C. L., Elgin, S. C. R., Epstein, I. R., Handelsman, J., Hatfull, G., Losick, R., O'Dowd, D. K., Olivera, B. M., Strobel, S. A., Walker, G. C., & Warner, I. M. (2011). Changing the culture of science education at research universities. *Science, 331*(6014), 152–153. https://doi.org/10.1126/science.1198280

Austin, A. E. (2011). *Promoting evidence-based change in undergraduate science education*. National Academies National Research Council Board on Science Education. http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072578.pdf

Bandura, A. (1997). *Self-efficacy: The exercise of control*. Freeman.

Bradforth, S. E., Miller, E. R., Dichtel, W. R., Leibovich, A. K., Feig, A. L., Martin, D., Bjorkman, K. S., Schultz, Z. D., & Smith, T. L. (2015). University Learning: Improve undergraduate science education. *Nature, 523*(7560), 282–284. https://doi.org/10.1038/523282a

Bok, D. (2006). *Our underachieving colleges: A candid look at how much students learn and why they should be learning more*. Princeton University Press.

Brownell, S. E., & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and… tensions with professional identity? *CBE—Life Sciences Education, 11*(4), 339–346. https://doi.org/10.1187/cbe.12-09-0163

Coppola, B. P., & Krajcik, J. S. (2013). Discipline-centered post-secondary science education research: Understanding university level science learning. *Journal of Research in Science Teaching, 50*(6), 627–638. https://doi.org/10.1002/tea.21099

Coppola, B. P., & Krajcik, J. S. (2014). Discipline-centered post-secondary science education research: Distinctive targets, challenges and opportunities. *Journal of Research in Science Teaching, 51*(6), 679–693. https://doi.org/10.1002/tea.21165

Corbo, J. C., Reinholz, D. L., Dancy, M. H., Deetz, S., & Finkelstein, N. (2016). Framework for transforming departmental culture to support educational innovation. *Physical Review—Physics Education Research, 12*(1), 010113. https://doi.org/10.1103/PhysRevPhysEducRes.12.010113

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational researcher, 38*(3), 181–199. https://doi.org/10.3102/0013189X08331140

Donald, J. G. (1997). *Improving the environment for learning: Academic leaders talk about what works*. Jossey-Bass.

Fairweather, J. (2008). *Linking evidence and promising practices in science, technology, engineering, and mathematics (STEM) undergraduate education*. The National Academies National Research Council Board of Science Education. https://otl.wayne.edu/wider/linking_evidence–fairweather.pdf

Finch, D. J., Hamilton, L. K., Baldwin, R., & Zehner, M. (2013). An exploratory study of factors affecting undergraduate employability. *Education and Training, 55*(7), 681–704. https://doi.org/10.1108/ET-07-2012-0077

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., Gentile, J., Lauffer, S., Steward J., Tilghman, S. M., & Wood, W. B. (2004). Scientific teaching. *Science, 304*(5670), 521–522. http://www.jstor.org/stable/3836701

Hart Research Associates (2015). *Falling short? College learning and career success. Selected findings from online surveys of employers and college students conducted on behalf of the Association of American Colleges & Universities*. Hart Research Associates. https://www.aacu.org/sites/default/files/files/LEAP/2015employerstudentsurvey.pdf

Hart Research Associates. (2018). *Fulfilling the American dream: Liberal education and the future of work. Selected findings from online surveys of business executives and hiring managers conducted on behalf of the Association of American Colleges and Universities*. Hart Research Associates. https://www.aacu.org/sites/default/files/files/LEAP/2018EmployerResearchReport.pdf

Hativa, N. (1995). The department-wide approach to improving faculty instruction in higher-education: Qualitative evaluation. *Research in Higher Education, 36*(4), 377–413. https://doi.org/10.1007/BF02207904

Henderson, C., & Dancy, M. H. (2011, February). *Increasing the impact and diffusion of STEM education innovations*. National Academy of Engineering. http://www.nae.edu/File.aspx?id-36304

Heron, P., McNeil, L., Arion, D., Buell, W., Gates, S. M., Giri, S., McCormack, E., Quinn, H., Williams, Q., & Woolf, L. (2017). *Phys21: Preparing physics students for 21st-century careers*. American Physical Society. https://www.compadre.org/JTUPP/docs/J-Tupp_Report.pdf

Hora, M. T. (2016). *Beyond the skills gap: Preparing college students for life and work*. Harvard Education Press.

Jang, H. (2016). Identifying 21st century STEM competencies using workplace data. *Journal of Science Education and Technology, 25*(2), 284–301. https://doi.org/10.1007/s10956-015-9593-1

Kezar, A. J. (2001). Understanding and facilitating organizational change in the 21st century: Recent research and conceptualizations. *ASHE-ERIC Higher Education Report, 28*(4), 1–162.

Kezar A. (2013). *How colleges change*. Routledge.

Kezar, A. (2014). Higher education change and social networks: A review of research. *The Journal of Higher Education, 85*(1), 91–125. https://doi.org/10.1353/jhe.2014.0003

Marbach-Ad, G., Hunt, C., & Thompson, K. V. (2019). Exploring the values undergraduate students attribute to cross-disciplinary skills needed for the workplace: An analysis of five STEM disciplines. *Journal of Science Education and Technology, 28*(8), 1–18. https://doi.org/10.1007/s10956-019-09778-8

Matusovich, H. M., Paretti, M. C., McNair, L. D., & Hixson, C. (2014). Faculty motivation: A gateway to transforming engineering education. *Journal of Engineering Education, 103*(2), 302–330. https://doi.org/10.1002/jee.20044

National Research Council (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. The National Academies. https://doi.org/10.17226/13362

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of educational research, 62*(3), 307–332. https://doi.org/10.3102/00346543062003307

President's Council of Advisors for Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and* *mathematics*. President's Council of Advisors on Science and Technology. https://files.eric.ed.gov/fulltext/ED541511.pdf

Quardokus, K., & Henderson, C. (2015). Promoting instructional change: Using social network analysis to understand the informal structure of academic departments. *Higher Education, 70*(3), 315–335. https://doi.org/10.1007/s10734-014-9831-0

Robert, J., & Carlsen, W. S. (2017). Teaching and research at a large university: Case studies of science professors. *Journal of Research in Science Teaching, 54*(7), 937–960. https://doi.org/10.1002/tea.21392

Rosenberg, S., Heimler, R., & Morote, E. (2012). Basic employability skills: A triangular design approach. *Education and Training, 54*(1), 7–20. https://doi.org/10.1108/00400911211198869

Savkar, V., & Lokere, J. (2010). *Time to decide: The ambivalence of the world of science toward education*. Nature Education.

Seymour, E. (2001). Tracking the process of change in US undergraduate education in science, mathematics, engineering, and technology. *Science Education, 86*(1), 79–105. https://doi.org/10.1002/sce.1044

Smart, J. C., & Ethington, C. A. (1995). Disciplinary and institutional differences in undergraduate education goals. *New Directions for Teaching and Learning, 64*, 49–57. https://doi.org/10.1002/tl.37219956408

Wieman, C., Perkins, K., & Gilbert, S. (2010). Transforming science education at large research universities: A case study in progress. *Change: The Magazine of Higher Learning, 42*(2), 6–14. https://doi.org/10.1080/00091380903563035

9 Appendices

9.1 The TLC Professional Development Activities

Appendix 1: The TLC Professional Development Activities

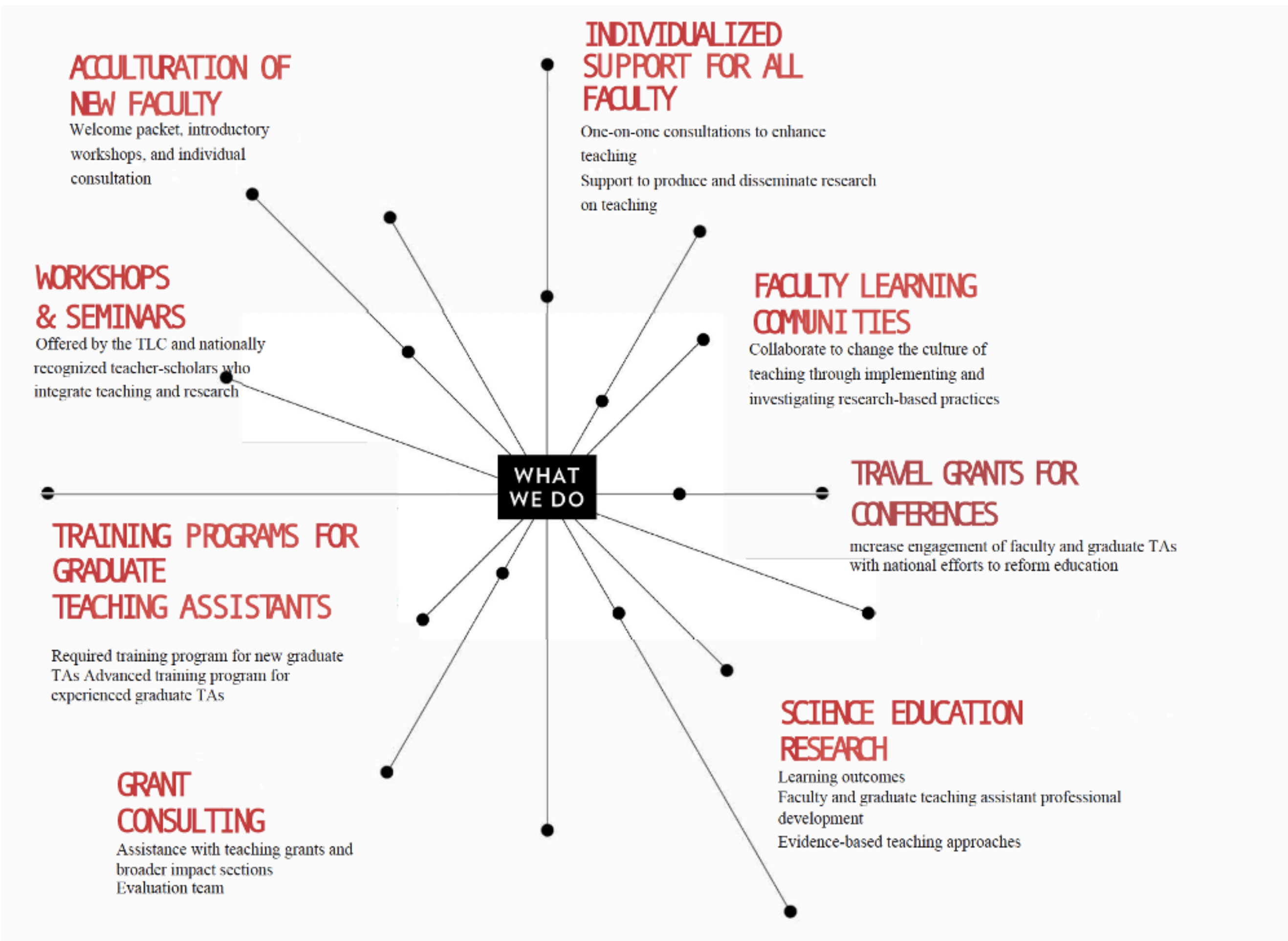


Figure A1: The TLC Professional Development Activities (web: click on image to enlarge)

Appendix 2: Two-Page Handout Distributed During Computer Science Faculty Meeting (for more detail on the origins of these data see Marbach-Ad et al., 2019)

Table A1: Demographic Characteristics of Surveyed Students (2011* through 2015).**

Demographic Characteristic	Computer Science	Mathematics	Biological Sciences	Chemistry	Physics
Nsurvey (Ntotal_graduated)	373 (894)	195 (566)	1389 (2571)	260 (485)	107 (294)
Response Rate	42%	34%	54%	54%	36%
Gender (% Female)	13%	41%	62%	49%	15%
Underrepresented Minority (URM)	9%	7%	13%	12%	8%
Research Experience*	27%	29%	63%	68%	69%
Cumulative GPA	3.2	3.3	3.4	3.4	3.2
Postgraduate Plans**	47%	64%	89%	80%	79%

*Percentage of students with on- or off-campus research experience

**Percentage of students intending to enroll in an advanced degree program in the immediate or near future

*** Samples for Biology and Chemistry include students graduating from 2011 through 2015. Physics, Computer Science and Mathematics samples include students graduating from 2012-2015.

Skills	Computer Science	Math	Biology	Chemistry	Physics
Problem solving	88%	86%	89%	82%	89%
Develop creativity and innovation	74%	66%	75%	73%	81%
Decision-making based on evidence	71%	69%	86%	80%	83%
Apply quantitative reasoning	68%	81%	75%	88%	96%
Acquire major scientific concepts	67%	65%	92%	94%	95%
Develop information literacy	64%	58%	81%	79%	73%
Oral and written communication	56%	55%	72%	72%	60%
Understand how science applies to everyday life	52%	46%	84%	78%	70%
Work in groups	49%	29%	45%	41%	35%
Develop understanding of interdisciplinarity	48%	50%	80%	71%	75%
Understand the dynamic nature of science	39%	35%	85%	84%	82%
Memorize some basic facts	34%	40%	64%	58%	45%
Remember formulas, structures, and procedures	33%	54%	46%	57%	47%
Scientific writing	25%	29%	66%	83%	58%
Learn basic sets of laboratory skills	21%	18%	81%	92%	74%

Table A2. Percentage of students surveyed from 2011-2015 placing a high value (rating 4 or 5 on Likert-type scale) on each skill. (web: click on table to enlarge)

Findings from Student Surveys and Interviews

Problem Solving (Rated as "important" or "very important": **88%**)
Students felt this was the essence of computer science

Develop Creativity and Innovation (Rated as "important" or "very important": **74%**)
Students indicated that this skill was highly important, particularly for solving problems

Decision-making Based on Evidence (Rated as "important" or "very important": **71%**)
Students with prior research experience valued this skill to a greater extent than students who lacked research experience
Underrepresented minority (URM) students valued this skill more highly than non-URM students

Understand How Science Applies to Everyday Life (Rated as "important" or "very important": **52%**; Reported encountering this in some, most, or all major courses: **71%**)
Students intending to pursue advanced degrees placed a higher value on relating course material

to the real world than those not intending to pursue advanced degrees

Real world applications were encountered more frequently in upper-level courses

Work in Groups (Rated as “important” or “very important”: **49%**; Reported encountering this in some, most, or all major courses: **49%**)

Interviewed students thought that this skill would be important for their future careers in the computer science industry

Students reported that they experienced group work primarily in upper-level courses

Understand the Dynamic Nature of Science (Rated as “important” or “very important”: **39%**)

Students with prior research experience valued this skill more highly than students who lacked research experience

Interviewed students expressed that this understanding is very important in computer science, as new algorithms, languages are constantly being developed

Students struggled with figuring out how this item related to their major because it included the word “science”

Memorize Some Basic Facts (Rated as “important” or “very important”: **34%**) and *Acquire Major Scientific Concepts* (Rated as “important” or “very important”: **67%**)

URM students placed a higher value on memorization relative to non-URM students

Students indicated that memorization was of low importance because basic facts can be looked up

Remember Formulas, Structures, and Procedures (Rated as “important” or “very important”: **33%**)

Students with higher GPAs placed a lower value on this skill relative to those with lower GPAs

Students perceived this as important for exams, but not the real-world practice of computer science

Scientific Writing (Rated as “important” or “very important”: **25%**; Reported encountering this in some, most, or all major courses: **32%**)

Students drew distinctions between technical writing and scientific writing. Some felt that scientific writing would be important mainly for students seeking research-oriented careers.

1. Please see Marbach-Ad et al. (2019) for a full description of findings

9. Using a Systems Approach to Change: Examining the AAU Undergraduate STEM Education Initiative

ADRIANNA KEZAR AND EMILY MILLER

1 Introduction

While systems theory is widely known to help foster change, most change efforts in STEM reform do not utilize a systems approach (Austin, 2011; Kegan, & Lahey, 2009). This chapter reports on the Association of American Universities' (AAU) Undergraduate STEM Education Initiative ("Initiative") effort to improve the effectiveness of undergraduate science and mathematics education at research universities and its application of a systems approach to change. While several chapters in this volume speak to parts of the system (departments, colleges, institutions), none focus on how to connect across multiple parts of a system and align them to promote change—the focus of this chapter.

In 2011, AAU launched the Initiative in collaboration with member institutions aimed at influencing the culture of STEM departments at AAU institutions so that faculty are encouraged to and supported in use of teaching practices proven by research to be more effective in engaging students in STEM education and in helping students learn (AAU, 2017b). Over the course of the initiative, AAU member institutions have documented improvement in undergraduate student learning within foundational STEM courses (AAU, n.d.). In addition, the association has identified broader outcomes (e.g. cross-cutting institutional strategies for change) from campuses collaborating and leveraging one another within the network as well as key strategies that worked across multiple levels to create synergy across the system. And the Initiative resulted in other key outcomes such as including language in key legislation—The American Innovation and Competitiveness Act. Thus, outcomes have ranged from transforming departments and improving student outcomes, to new institutional policies and practices, to cross-campus initiatives, to federal legislation—all detailed below.

This chapter documents the three major domains of the system that the Initiative was aimed at influencing 1) the institutional level, 2) the network level, and 3) the national level) in order to comprehensively impact undergraduate STEM reform. This three-domain strategy demonstrates a systems approach in action. Furthermore, the Initiative leveraged the interaction among the three domains and was intentional in attending to the multiple levels and stakeholders within each domain to generate greater synergy within and between each domain. Leveraging more parts of the system leads to greater likelihood of change (Austin, 2011, 2014; Kezar, 2018a). This chapter amplifies the findings about the importance of networks and partnerships noted by other chapters in this volume by Gardner et al., Wojdak et al., and Margherio et al. We also document how networks help facilitate learning to promote change and spread through connecting change agents, similar to other chapter authors.

2 Why Systems Change

Studies from systems theory demonstrate that an organizational entity and social system is made up of an underlying set of structures (e.g. facilities, technology), policies (e.g. promotion and tenure), and processes (e.g. teaching and learning) (Kezar, 2018a; Toma, 2010; Willis et al., 2014). These various underlying aspects are often referred to as the "infrastructure." When these aspects of the system are aligned to support a change initiative, then the transformation is more likely to occur and to be sustained (Toma, 2010). Research demonstrate that transformation efforts that do not modify the underlying structures and processes typically fail, experience challenges or are not sustained (Kezar, 2018a; Smith, 2015; Toma, 2010).

From the beginning, AAU used broader theoretical perspectives about organizational change in academia and systems theory to guide the planning and direction of the Initiative. Ultimately, the association's approach to systemic and sustainable change to undergraduate STEM teaching and learning was grounded in a more nuanced consideration of factors that facilitate, impede, or influence wide-spread transformation in undergraduate education (Miller et al., 2017). The aim was to embed changes into the fabric of the systems—structures, process, and policies—to increase the likelihood that changes will be permanent and result in a cycle of continuous improvement of teaching and learning (Kegan & Lehay, 2009). In Figure 1, we illustrate the various networks that AAU created to help support systemic change. The networks include 1) the eight project sites, 2) the AAU STEM network, 3) the AAU network, 4) departmental networks that connected across AAU and non-AAU institutions, 5) the research university STEM community connected across AAU and non-AAU institutions, 6) a STEM coalition that included members of national organizations, and 7) a network of organizations aimed at improving STEM education.

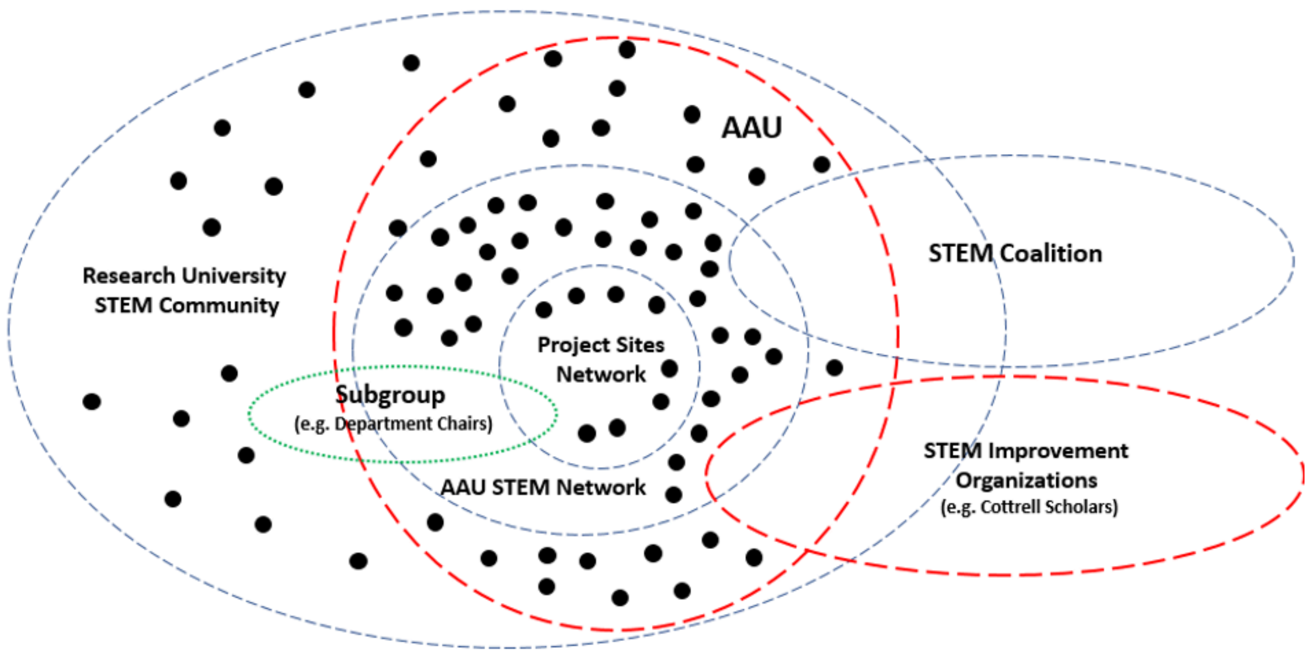


Figure 1: AAU Networks (web: click on image to enlarge)

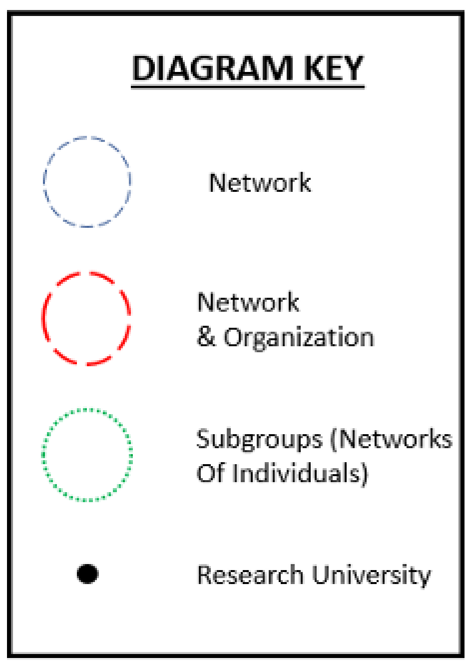


Diagram Key for Figure 1

3 The Institutional Level

AAU leaders recognized that the institutional level was extremely important for creating systemic changes because policy, rewards, incentives, resources, and norms that guide practice all are created and reinforced at the institutional level. In order to shape institutional processes, several key efforts were undertaken including a framework that identifies the key aspects of institutions that could be leveraged for change, funding project sites that would serve as laboratories and models of change, and reporting that would hold institutions accountable for action.

3.1 Institutional Change Framework

AAU created a *Framework for Systemic Change in Undergraduate STEM Teaching and Learning* ("Framework") (AAU, 2013). The Framework recognizes the wider setting in which educational innovations take place—the department, the college, the university, and the national level—and addresses the key institutional elements necessary for sustained improvement to undergraduate STEM education. The three layers of the Framework are: 1. *Pedagogy*—which involves assisting faculty in creating learning goals, assessments, and other practices that support new evidence-based teaching practices; 2. *Infrastructure*—such as workshops from the centers for teaching and learning, and technology and facilities that support new evidence-based teaching practices; and 3. *Cultural change*—support at the institutional level such as changes in promotion and tenure, and commitment to sustaining successful strategies by senior leaders. Given the novelty of working at the institutional level to support new teaching practices, the purpose of the Framework was to provide necessary guidance and expectations for institutions to participate in the Initiative.

3.2 Initiative Project Sites

AAU established a competition to identify a pilot cohort of eight institutions among AAU membership. The request for proposals was ground in the Framework, established a set of institutional-level expectations, and created a context where institutions had to identify the readiness of departments to engage in redesigns of introductory courses. AAU recognized that academic departments are a primary locus for cultural change, and that academic units and colleges are central to improving the quality of undergraduate education. Furthermore, academic departments are powerful and have significant structures of influence. However, AAU choose a strategy of granting institutional rather than departmental awards and established expectations for institution to support departmental activities because institutions are a primary site for sustaining changes.

Departmental and project-based interventions often are not sustained due to lack of support or compatibility with the overall institution (Beach et al., 2012). Tenure and promotion policies, inadequate facilities, missing professional development, and other barriers often shape the uptake (or not) of initiatives (Kezar, 2018a). Hence, making the institution the level of change was an intentional effort to overcome failed change efforts of the past. One way that this initiative differentiated itself from other efforts to improve undergraduate STEM education was that the Initiative emphasized not just individual or departmental change, which has been the focus of many previous STEM projects, but institutional-level change. The idea that change cannot be scaled and sustained unless the overall institution supports the change was relatively novel within this approach when it began in 2013.

Although many of the Initiative interventions are still in process, initial data demonstrates their positive impact. Of the eight initial project sites, all have reported some improvement in student learning outcomes. The magnitude and significance varied according to the different stages of the reform process across the institutions and departments. Dramatic reductions in achievement gaps have been observed on several campuses, especially for women, under-represented minorities, and first-generation students. Reports of decreased DFW (D grades, F grades, and withdrawals from a course) rates are common, as is increased student persistence and success in subsequent courses as measured by grade performance. Project sites also found improved performance on exams designed and sponsored by disciplinary societies to assess knowledge of core disciplinary concepts (i.e., concept inventories). Some campuses also have tracked the effects of instructional interventions on more general psychological factors, such as self-efficacy, metacognition, and student attitudes toward science (AAU, 2017a).

3.3 Project Site Data and Reporting

AAU created a variety of mechanisms to help forward and monitor the work of the project sites. AAU collected survey and metric data to develop baseline information to guide project sites, established a mechanism for measuring improvement in teaching and learning at the department and institutional levels, and helped project sites in measuring their progress (AAU, 2017a). In addition, project sites provided regular annual reflective reports and participated in site visits with AAU professional staff. The aggregate of this information was used by AAU to identify cross-cutting strategies (Coleman, 2019).

One cross-cutting strategy was central to the institutional level—developing productive working partnerships between academic departments and institutional units and structures dedicated to educational effectiveness. Today, AAU observes that many institutions have recognized the interdependence of support units and departments in improving teaching and learning. In this new light, institutions are elevating and reorganizing the traditional teaching center into a full division or more closely aligning it with university leadership, oftentimes to an Associate Provost responsible for teaching innovation or excellence, with a direct reporting line to the Provost. By expanding and more centrally locating these teaching responsibilities at higher levels within the university, the institution can make its expectations for teaching more explicit to academic units; provide the necessary scaffolding for individual faculty members who wish to incorporate evidence-based teaching approaches into their course(s); partner with departments on projects that promote student learning, create inclusive classrooms, and retain highly-qualified students; provide support to assess institutional improvement efforts in teaching and learning; and help to adjust practice and policies at multiple levels of the university. Lastly, these more visible and institution-wide units are better positioned to compete for extramural grant funds to facilitate course transformation, teaching development efforts, and cultural change across the institution.

4 Network Level: The AAU STEM Network

The AAU STEM Network includes all AAU member campuses. Institutions' representation in the network is facilitated by a designated point of contact appointed by the Provost. Many of the points of contacts were successful reformers in STEM education and campus leaders with experience supporting innovations in STEM. Designating point of contacts for the network served to empower individuals with intrinsic motivation and a passion for creating change.

The network level allowed AAU to spread ideas beyond the project sites and engage the broader membership. The goal was to influence all AAU members to be "as excellent in teaching as research."

From a systems approach, AAU created various structures, processes, and messaging that aimed to sustain the network beyond the life of the project sties (Kezar et al., 2019). The goal is for the network to be responsive to emerging challenges in the process of reforming undergraduate STEM education and continuously provide a forum to disseminate model practices and policies.

4.1 Networking Meetings

A strength of AAU is its convening power and ability to generate partnerships and collaborations across a variety of organizations. All convenings are structured to be synergistic with each other and have the intent to leverage more change across the system.

The Initiative holds biannual network meetings where points of contact and other member campus faculty and administrative leaders interact, discuss challenges and strategies for creating change, and contribute and build their knowledge about efforts to improve STEM education. Frequently these forums provide an opportunity to link AAU campuses that are doing similar work or addressing similar challenges. Network meetings also provide space to explore and consider funding opportunities.

A culminating event included 41 AAU member campuses and over 100 faculty members and administrative leaders participating in the STEM Network Conference on January 27–28, 2020. The conference was facilitated in an evidence-based, large introductory science class format. Topics of the sessions included creating inclusive and welcoming classroom environments; using evidence-based teaching strategies; data analysis and analytic tools that are aimed at ensuring introductory STEM courses are equitable; and practices to document, evaluate and reward teaching effectiveness. The event also featured a poster session highlighting the 24-campus mini-grant activities funded by Northrop Grumman. Finally, a dedicated session engaged participants on communicating the value of improvements to undergraduate education to the public that was informed by national survey data AAU is collecting.

AAU also convened teams of department chairs from member campuses in 2015 and 2018. During these workshops, AAU discussed the evidence about improved learning gains and retention in the major witnessed in classes using engaged and structured teaching methods. The chairs then engaged in discussions on topics such as creating inclusive and welcoming classroom environments, using data to inform and assess curricular innovations, introducing practices to evaluate and reward teaching effectiveness, and developing productive partnerships between academic departments and centers for teaching and learning. By engaging STEM department chairs in these critical teaching and learning issues AAU has worked to increase the magnitude and speed of change in the quality and effectiveness of undergraduate STEM education at research universities.

4.2 Messaging and Outreach to Constituent Groups

Another mechanism to support change within the overall AAU network was communication with key constituent groups, including presidents, provosts, and deans. Project sites, for example, presented several times to the AAU Chief Academic Officers. These presentations showcased progress across campuses as a result of a critical cross-cutting strategy and aimed to spur similar action on other campuses.

AAU also created a communications plan that sent regular messages out to AAU network members about STEM education issues ranging from grant opportunities, to new national STEM education reports, to workshops and professional development opportunities, to state and federal policy updates.

4.3 Sharing Best Practices

AAU created an opportunity for AAU STEM Network sites to submit the work they were conducting on undergraduate STEM reform to be put in a sourcebook on the website, to help communicate and educate about existing change efforts. In addition, leaders in undergraduate STEM reform at AAU campuses that were not funded as project sites were brought in as expert speakers for AAU-sponsored meetings and conferences to inform and educate others within the Initiative. AAU published a case studies document in 2016 (*Improving Undergraduate STEM Education at Research Universities: A Collection of Case Studies*) (Dolan et al.) that provided best practices for other AAU campuses as well as campuses nationally that included project sites as well as any AAU campus conducting STEM reform work. Resources and documents that come out of the AAU are noticed and used by leaders on campuses across the country and could reach audiences that STEM reformers typically do not reach (often faculty advocates) and get into the hands of AAU decision makers such as Provosts and Presidents (and beyond). These opportunities to share efforts across all AAU campuses created lasting conversations and connections well beyond the project sites.

5 National Level: Ecosystem for Higher Education STEM Reform

The third level at which the AAU worked is at the national level, shaping dialogue and policy around STEM reform. Change can be much more impactful if the lessons within a set of institutions are shared more broadly, particularly any tools or resources developed, but also the advocacy and ideas around the change more generally. Also, if organizations work collectively to have a shared impact, they are more likely to influence change, as we have seen in collective impact theories of change (Kania & Kramer, 2013). The various groups AAU helped create and empower during the Initiative helped to fuel national STEM reform, foster synergies among organizations and better coordinate their work to have a stronger and lasting impact on STEM reform, increase funding for reform, and generate greater visibility through media about improvements to undergraduate STEM education.

5.1 Partnerships with National STEM Reform Groups

One of AAU's major areas of emphasis to impact the broader STEM-reform level was joining and helping to create partnerships with organizations and associations.

AAU joined and helped to support a coalition of national organizations aimed at improving undergraduate STEM education named "Coalition for Reform of Undergraduate STEM Education" (Coalition or CRUSE). Coalition members include the American Association for the Advancement of Science, the Association of American Colleges and Universities, the Association of Public and Land-Grant Universities, the Association of American Community Colleges, and the National Research Council. As a group, the Coalition convened funders and foundations to discuss important funding priorities and directions related to undergraduate STEM education. This resulted in the development of a major report called *Achieving Systemic Change—A Sourcebook for Advancing and Funding Undergraduate STEM Education* (CRUSE, 2014).

The association also reached out to teaching and learning groups such as the Bayview Alliance, Cottrell Scholars, the Howard Hughes Medical Institute, Professors, the Center for Integration of Research, Teaching and Learning (CIRTL), and the Professional Organizational Development (POD) Network. These partners were frequently invited to meetings of the project teams and network. Correspondingly, project sites and points of contact attended meetings by these groups. AAU staff also took on leadership roles, sat on boards, and assumed positions on steering committees for the National Alliance for Broader Impacts, the National Higher Education and Workforce/Business Forum, and the Accelerating Systemic Change Network (ASCN) as well as many related National

Science Foundation (NSF) project advisory boards. The result was the cross-fertilization of knowledge between the various networks and organizations.

In recognizing that some systems change extended beyond the scope of STEM or AAU member campuses, AAU partnered with the National Academies of Sciences, Engineering, and Medicine (NASEM) Board on Science to co-sponsor and organize the Education Roundtable on Systemic Change in Undergraduate STEM Education, an expert meeting on innovations being advanced to more effectively evaluate teaching. A workshop report titled, *Recognizing and Evaluating Science Teaching in Higher Education: Proceedings of a Workshop—in Brief* (NASEM, 2020) documented the issues around the recognition and evaluation of science teaching in higher education.

In addition, AAU in partnership with NSF hosted a workshop, *Essential Questions and Measures: Assessing Institutional Transformation of Undergraduate STEM Education* (Miller et al., 2019). The objective of the workshop was to identify key improvement indicators at multiple levels to assess the impact of and further leverage projects aimed at developing a culture and practice of evidence-based teaching in undergraduate STEM courses. The workshop engaged 50 leaders, researchers, and evaluators of efforts to transform STEM teaching and learning to think about how best to assess the impact of the institutional transformation track of NSF's Improving Undergraduate STEM Education program and give guidance on how to improve future calls for proposals.

5.2 Federal Policy

In 2016, the America Innovation and Competitiveness Act was approved by Congress late in the session. AAU was successful at including language in the final bill that clarifies that NSF's broader impacts can be achieved through in-class improvements in undergraduate teaching. Specifically, the language makes it clear that the adoption and usage by the NSF awardee of evidence-based and/or active and engaged teaching practices proven to increase persistence and to enhance undergraduate learning and understanding of core STEM concepts in disciplines relating to the PI's NSF-funded research award should be recognized by NSF review panels as an acceptable form of meeting NSF broader impacts criteria.

5.3 Public Relations

AAU also had a robust public relations and media plan.AAU worked to create general media attention through news articles about STEM-reform efforts happening nationally, to place articles in major scientific journals like *CBE—Life Sciences Education* (Dennin et al., 2017) and *Nature* (Bradforth et al., 2015) to directly reach faculty members, and to attend national STEM-reform conferences to promote and direct attention to the Initiative. AAU regularly issued press releases about the progress of the Initiative. These media efforts not only brought attention to the Initiative's reform work in general, but also generated internal validation and legitimacy of the eight project sites, leveraged further local change, and created a buzz among the broader network by making visible the work of reformers.

6 Conclusion: Synergizing the Levels of the System

The Initiative leveraged the interactions between the three levels to try to create and strengthen synergy. For example, speakers were generally brought in from AAU's work at the broader national level to give plenary speeches at their meetings. Additionally, meetings connected project sites and members of the broader AAU network for dialogue and information sharing. The general efforts to create media attention at the national level for the campuses and network also appeared to be an important way to use national attention to leverage local change. Many examples above highlight the synergy they were able to create from various multifaceted strategies.

Systems change is rarely engaged broadly in society nor in higher education in particular. While research consistently shows the importance of a systems approach to change—and specifically large-scale changes—few leaders, institutions, or organizations engage this approach. Working at several levels of a system—institutional, network, and national—is even more unheard of. Being able to document the AAU's intentional use of a systems approach is important to demonstrate how such an approach can be strategically leveraged. AAU learned much from this systems approach (Coleman, 2019), and in an examination of the Initiative learned some additional lessons on how to coordinate a systems approach in even deeper ways (Kezar, 2018b).

Ultimately, this ambitious project, which AAU has continued, sought to increase the importance and value of effective undergraduate STEM teaching in the nation's leading research universities, and continues to promote the implementation of a systemic view of educational reform within academia to improve the quality of undergraduate education.

7 About the Authors

Adrianna Kezar is the Wilbur-Kieffer Endowed Professor, Rossier Dean's Professor in Higher Education Leadership at the University of Southern California.

Emily Miller is the Associate Vice President for Policy at the Association of American Universities.

8 References

Association of American Universities. (n.d.). *Scholarship*. Association of American Universities.

https://www.aau.edu/education-service/undergraduate-education/undergraduate-stem-education-initiative/resources/scholarship

Association of American Universities. (2013). *Framework for systemic change in undergraduate STEM teaching and learning*. Association of American Universities. https://www.aau.edu/sites/default/files/STEM%20Scholarship/AAU_Framework.pdf

Association of American Universities. (2017a). *Essential questions & data sources for continuous improvement of undergraduate STEM teaching and learning*. Association of American Universities. https://www.aau.edu/essential-questions-data-sources-continuous-improvement-undergraduate-stem-teaching-and-learning

Association of American Universities. (2017b). *Progress toward achieving systemic change: A five-year status report on the AAU Undergraduate STEM Education Initiative*. Association of American Universities. https://www.aau.edu/progress-toward-achieving-systemic-change

Austin, A.E. (2014). *Barriers to change in higher education: Taking a systems approach to transforming undergraduate STEM education* [white paper commissioned for Coalition for Reform of Undergraduate STEM Education]. Association of American Colleges and Universities.

Austin, A.E. (2011). *Promoting evidence-based change in undergraduate science education*. National Academies National Research Council Board on Science Education. http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072578.pdf

Beach, A. L., Henderson, C., & Finkelstein, N. (2012). Facilitating change in undergraduate STEM education. *Change: The Magazine of Higher Learning*, *44*(6), 52–59. https://doi.org/10.1080/00091383.2012.728955

Bradforth, S. E., Miller, E. R., Dichtel, W. R., Leibovich, A. K., Feig, A. L., Martin, D., Bjorkman, K. S., Schultz, Z. D., & Smith, T. L. (2015). University Learning: Improve undergraduate science education. *Nature, 523*(7560), 282–284. https://doi.org/10.1038/523282a

Coalition for Reform of Undergraduate STEM Education. (2014). *Achieving systemic change: A source-book for advancing and funding undergraduate STEM education* (C. L. Fry, Ed.). Association of American Colleges and Universities. https://www.aacu.org/sites/default/files/files/publications/E-PKALSourcebook.pdf

Coleman, M. S., Smith, T. L., & Miller, E. R. (2019). Catalysts for achieving sustained improvement in the quality of undergraduate STEM education. *Dædalus, 148*(4), 29–46. https://doi.org/10.1162/daed_a_01759

Dennin, M., Schultz, Z. D., Feig, A., Finkelstein, N., Greenhoot, A. F., Hildreth, M., Leibovich, A. K., Martin, J. D., Moldwin, M. B., O'Dowd, D. K., Posey, L. A., Smith, T. L., & Miller, E. R. (2017). Aligning practice to policies: Changing the culture to recognize and reward teaching at research universities. *CBE—Life Sciences Education*, *16*(4), es5. https://doi.org/10.1187/cbe.17-02-0032

Dolan, E. L., Lepage, G. P., Peacock, S. M., Simmons, E. H, Sweeder, R., & Wieman, C. (2016). *Improving* *undergraduate STEM education at research universities: A collection of case studies*. Association of American Universities. https://www.aau.edu/sites/default/files/STEM%20Scholarship/RCSA2016.pdf

Gardner, G., Ridgway, J., Schussler, E., Miller, K., & Marbach-Ad., G. (this volume). "Research coordination networks to promote cross-institutional change: A case study of graduate student teaching professional development." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 10). Pressbooks.

Kania, J., & Kramer, M. (2013). *Embracing emergence: How collective impact addresses complexity*. Stanford Social Innovation Review. http://rhap.org.za/wp-content/uploads/2018/01/Embracing_Emergence_PDF.pdf

Kegan, R., & Lahey, L. (2009). *Immunity to change: How to overcome it and unlock potential in yourself and your organization*. Harvard Business Press.

Kezar, A. (2018a). *How colleges change: Understanding, leading, and enacting change* (2nd ed.). Routledge.

Kezar, A. (2018b). *Scaling improvement in STEM learning environments: The strategic role of a national organization*. American Association of Universities. https://files.eric.ed.gov/fulltext/ED591360.pdf

Kezar, A., Miller, E., Bernstein-Serra, S., & Holcombe, E. (2019). The promise of a "network of networks" strategy to scale change: Lessons from the AAU STEM Initiative. *Change: The Magazine of Higher Learning*, *51*(2), 47–54. https://doi.org/10.1080/00091383.2019.1569973

Margherio, C., Doten-Snitker, K., Williams, J., Litzler, E., Andrijcic, E., & Mohan, S. (this volume). "Cultivating strategic partnerships to transform STEM education." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 12). Pressbooks.

Miller, E. R., Fairweather, J. S., Slakey, L., Smith, T., & King, T. (2017). Catalyzing institutional transformation: Insights from the AAU STEM Initiative. *Change: The Magazine of Higher Learning*, *49*(5), 36–45. https://doi.org/10.1080/00091383.2017.1366810

Miller, E. R., King, T., Austin, A. E., Smith, K. A., Roberts, J. R., & Pullin, M. J. (2019). *Promoting transformation of undergraduate STEM education: Workshop summary report*. Association of American Universities. https://www.aau.edu/sites/default/files/AAU-Files/STEM-Education-Initiative/Promoting-Transformation-Report.pdf

National Academies of Sciences, Engineering, and Medicine. (2020). *Recognizing and evaluating science teaching in higher education: Proceedings of a workshop—in brief*. The National Academies Press. https://doi.org/10.17226/25685

Smith, D. G. (2015). *Diversity's promise for higher education: Making it work*. Johns Hopkins University Press.

Toma, J. D. (2010). *Strategic management in Higher Education: Building organizational capacity*. Johns Hopkins University Press.

Willis, C. D., Best, A., Riley, B., Herbert, C. P., Millar, J., & Howland, D. (2014). Systems thinking for transformational change in health. *Evidence & Policy: A Journal of Research, Debate and Practice*, *10*(1), 113–126. https://doi.org/10.1332/174426413X662815

Wojdak, J., Phelps-Durr, T., Gough, L., Atuobi, T., DeBoy, C., Moss, P., Sible, J., & Mouchrek, N. (this volume). "Learning together: Four institutions' collective approach to building sustained inclusive excellence programs in STEM." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 11). Pressbooks.

10. Research Coordination Networks to Promote Cross-Institutional Change: A Case Study of Graduate Student Teaching Professional Development

GRANT GARDNER, JUDITH RIDGWAY, ELISABETH SCHUSSLER, KRISTEN MILLER, AND GILI MARBACH-AD

1 Introduction

Academic institutions are complex hierarchical systems where faculty and staff often navigate teaching, research, and service responsibilities between multiple organizational units. Because of this complexity, enacting institutional change can be a challenging endeavor. Even more difficult are change efforts focused on impacting multiple institutions. Different institutions can have different internal structures, policies, processes, and cultures such that change efforts that work at one may not work at them all. As part of a National Science Foundation-funded Research Coordination Network-Undergraduate Biology Education (RCN-UBE) program, our team has been enacting a change project related to graduate student professional development that spans multiple institutions. This chapter highlights our program as a case study into the challenges and opportunities provided by research coordination networks to affect cross-institutional change.

Many institutional change initiatives have focused on encouraging a shift from teacher-centered toward more student-centered pedagogies in faculty members (American Association for the Advancement of Science [AAAS], 2011, 2015; Eddy & Hogan, 2014; Freeman et al., 2014). For example, the Summer Institutes on Scientific Teaching (Pfund et al., 2009) have trained over 2,000 faculty via national, regional, and campus workshops focused on active learning, assessment, and inclusivity. The Promoting Undergraduate Life Science Education network (Brancaccio-Taras et al., 2016) sends regional teams to work with Biology departments to assess their alignment with practices outlined in *Vision and Change in Undergraduate Biology Education* (AAAS, 2011). Despite a national push to support these changes, adoption of student-centered pedagogies has been uneven across instructors and institutions (Stains et al., 2018).

These aforementioned endeavors are impressive but are working with one highly visible group within the academic community (faculty). Our work focuses on “future faculty” and those who develop their teaching, many of whom are less visible members of the academic hierarchy. This chapter describes the RCN-UBE Biology Teaching Assistant Project (BioTAP) and its efforts to impact multiple units of the academic system in order to promote cross-institutional change specific to graduate teaching assistant (GTA) teaching professional development (TPD). We believe that focusing national change efforts on the instructional beliefs and practices of future faculty and on those in the system who train them can have the broadest and most sustainable impact on teaching practices nationwide (Connolly et al., 2018; Ebert-May et al., 2015).

In the following sections, we briefly describe the BioTAP project and the theory of change that guides it. We detail the change context, long-term outcomes, pre-conditions, activities, and assumptions that have guided this work (Reinholz & Andrews, 2020). Because our efforts focus on individuals at multiple institutions, but with a goal for cross-institutional collaboration, our theory of change considers the hierarchical complexity of institutional systems. The broader question we attempt to answer in this chapter is: *how can a research coordination network be leveraged to impact cross-institutional change*? We reflect on what has been successful in reaching our project goals with the hope that this case study helps others attempting to facilitate change across multiple institutions.

2 Change Context—Graduate Teaching Assistant Teaching Professional Development

Graduate teaching assistants are critically-important undergraduate instructors (Sundberg et al., 2005), but minimal focus has been placed on their TPD (Schussler et al., 2015). There are a multitude of reasons for this, including: prioritization of research over teaching in graduate professional development (Anderson et al., 2011), little institutional support for instructional training (Schussler et al., 2015), and a belief that training for teaching is not necessary (Love Stowell et al., 2015). As many graduate students are future faculty, improving their teaching at an early career stage could be one mechanism for impacting nationwide instructional reform (Connolly et al., 2018).

Many of the individuals implementing GTA TPD are intra- or inter-institutionally isolated or have less power to impact the system relative to others: non-tenure track faculty members, graduate students or post-doctoral scholars, and/or laboratory instructional staff. This makes institutional change related to GTA TPD different from other efforts driven by national organizations or relatively more empowered faculty members (for example FIRST; Ebert-May et al., 2015 or CIRTL; Austin et al., 2008). BioTAP was created as a network to connect isolated individuals across institutions to effect cross-institutional change related to GTA TPD.

To foster GTA adoption of student-centered pedagogies, there must be effective GTA TPD; however, the network must acknowledge and address the limited empirical evidence guiding GTA TPD practices. BioTAP's broad goal is to increase the body of empirical research on effective GTA TPD as a means to guide national instructional reform efforts. Our contention is that without these data, it will be difficult to promote institutional change in GTA teaching practices at any institution (Reeves et al., 2016).

The explicit goals of BioTAP are to leverage network stakeholders to: 1) expand and support GTA TPD research and practice collaborations, and 2) synthesize, disseminate, and advocate for research to advance GTA TPD. These goals are dependent on building a vibrant, cohesive, multi-institutional network of individuals focused on enacting evidence-based GTA TPD practices in order to promote instructional change. Achievement of the BioTAP goals would result in the long-term with a network of interacting cross-institutional change agents that is large (many individuals), dense (many connections between individuals), and sustainable.

3 Theory of Change

To guide the network, we developed a theory of change that reflects how our project endeavored to get individual GTA TPD providers at different institutions (inter-institutional) and within institutions (intra-institutional) to work together to effect change in complex systems. We leaned heavily on an article focused on collaborative networks to enact K-12 school reforms (Rincón-Gallardo & Fullan, 2016) because it was about enacting change beyond just a single individual or institution and addressed multiple levels of complex institutional systems. We saw similarities between the authors' approach of empowering teachers to work together for school reform and our desire to empower GTA TPD providers with the tools to reform GTA TPD at their institutions. This allowed us to articulate assumptions and design activities related to getting multiple individual stakeholders to embrace our project goals.

Rincón-Gallardo and Fullan (2016) proposed eight Essential Features of effective networks (Table 1) and emphasized that each network's effectiveness in terms of educational change is tied to how well its components function together in the larger system. Applying this model to our program enabled us to assess strengths and weaknesses that might accelerate or prevent BioTAP from reaching its goals.

To apply their ideas to our project, we compacted their eight Essential Features into four major themes, or "layers," that represented steps that would expand our ideas and impact over time (note that these layers are not academic levels, although the network growth over time inherently expands into new academic areas). This somewhat artificial grouping of layers allowed us to plan activities to enact our theory of change and guided our subsequent evaluation of network growth. Figure 1 shows the modified layers (four themes) used as the BioTAP theory of change, based on Rincón-Gallardo and Fullan's (2016) Essential Features.

Table 1. Comparison of Rincón-Gallardo and Fullan's (2016) Eight Essential Features of a Network with the BioTAP Modification of that Model.

Essential features (Rincón-Gallardo & Fullan, 2016) of effective networks organized from their core to periphery	BioTAP Modification of the essential features, shown using the corresponding layers
1. Focus on ambitious student learning outcomes linked to effective pedagogy.	1. Focus on network outcomes linked to effective network-building and be ambitious to reach stakeholders.
2. Develop strong relationships of trust and internal accountability.	2. Build strong relationships, trust, and both internal and external accountability with stakeholders at multiple organizational units (individual, departmental, college, etc.).
3. Continuously improving practice and systems through cycles of collaborative inquiry. 4. Use deliberate leadership and skilled facilitation within flat power structures. 5. Frequently interact and learn inwards.	3A. Continuously improve networks through cycles of collaborative connecting. 3B. Develop a flat power structure through reduction of the network hierarchy. 3C. Reinforce network ties through frequent interactions.
6. Connect outwards to learn from others. 7. Form new partnership among students, teachers, families, and communities. 8. Secure adequate resources to sustain work.	4A. Connect outwards to build the network and learn from others. 4B. Form new partnerships at different organizational units. 4C. Secure adequate resources to sustain the network.

Note: we clustered the eight features of the model into themes most relevant to the BioTAP network as our ideas and impacts grew over time.

3.1 Pre-Conditions, Activities, and Assumptions

Below we describe our theory of change as well as its alignment with BioTAP project activities. In Section 4, we reflect on the success of our project in terms of the outcomes that would be expected if we successfully adhered to the theory of change. Our ultimate goal was to construct a network in which numerous robust connections between individuals would support cross-institutional change; it should be noted that the evaluation of this outcome could be accomplished through social network analysis; however, describing the project evaluation is not the goal of this chapter.

3.2 Model Layers

Model Layer 1—Focusing on Clear Network Outcomes: The first layer is the development of clear outcomes and consistent communication of project goals and outcomes by the leadership team, in our case the Principal Investigators (PIs) and the steering committee. We held a meeting with the PIs and steering committee early in the project to foster communication, refine the project goals, and create a shared vision. This group served as the core of the developing network and anchored the creation of future network connections. This layer reminds us to articulate both short- and long-term outcomes and develop an ambitious plan to reach and communicate with potential stakeholders. A shared commitment to project goals helps us coordinate efforts and progress toward the outcome of a highly-integrated group of individuals who interact to support high-quality Biology GTA TPD research.

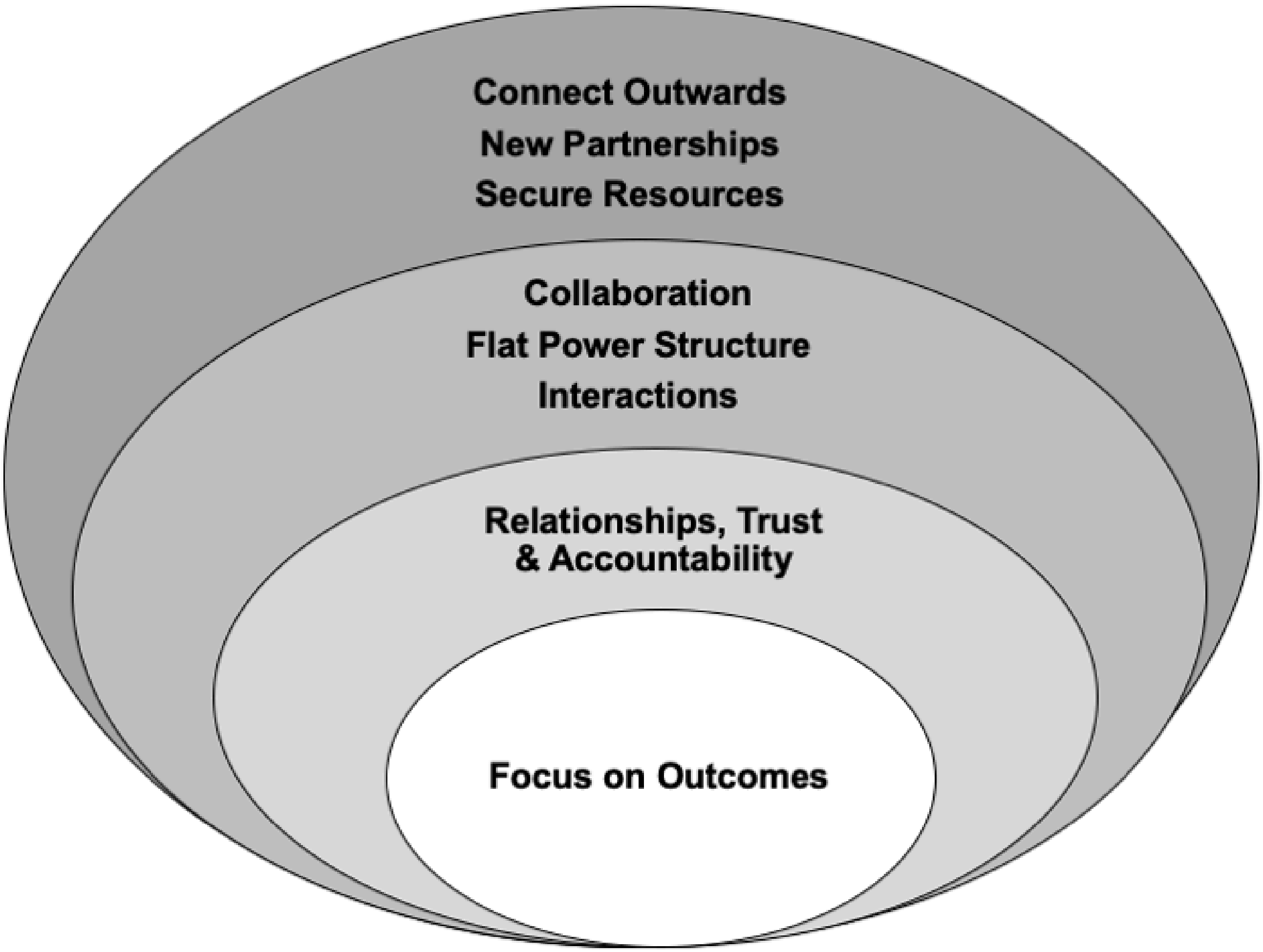


Figure 1. Visualization of the Four Layers Used by BioTAP as Its Theory of Change. The shades of grayscale represent different layers of the model with lighter shades representing Model Layer 1 to darker shades representing Layer 4.

Model Layer 2—Building Network Trust and Accountability: The second layer is to build strong relationships, trust, and internal and external accountability among the network individuals. Establishing trust and accountability among the BioTAP PIs from the beginning was invaluable. We found that we appreciated each other's strengths, opinions, and work ethics, and this led to better initial ideas and products.

Building relationships involved contacting new stakeholders and creating new connections between those stakeholders and our core network. We did this by leveraging our BioTAP listserv and personal connections to reach out to others. Trust and accountability requires bidirectional communication between core members as well as other members of the network, and these connections needed to be robust so they can be sustained over time.

This strengthening of the network connections occurred primarily through the enactment of the BioTAP Scholars program. This program (started in 2017) brings cohorts of individuals from many institutions together to collaboratively develop year-long GTA TPD research projects and enact them with support from the project PIs and their cohort peers. There are currently 66 BioTAP Scholars that include graduate students, postdocs, Teaching and Learning Center members, and tenure- and non-tenure track faculty from 47 institutions (32 are from research institutions and four are international). Many BioTAP Scholars build very strong connections with the PIs and other scholars within their cohort. Recent efforts have focused on connecting members of different cohorts.

To ensure internal and external accountability, we realized that we needed cycles of reflection to improve the program. We spent a year thoughtfully designing the BioTAP Scholars program. It was only after testing our ideas with BioTAP Scholars Cohort 1, reviewing data from our program evaluation, and revising our designs that we felt we were starting to achieve our intended outcomes. Even seemingly small details such as the wording of the BioTAP Scholar application were revised for each cohort. The detail put into the Scholars program and the time spent working closely with Scholars and reviewing our evaluation results built strong relationships and developed trust.

Model Layer 3—Leveraging Collaboration and Flat Leadership Structures in the Network: Our change model involves continuously improving the network through cycles of collaboration between participants, developing a flat power structure through reduction of network hierarchy, and reinforcing connections through frequent interactions (layer 3). The BioTAP community has a culture of frequent interactions and knowledge sharing. Even though the community members are spatially dispersed, we meet regularly through online meetings and virtual conferences. For example, our BioTAP Scholars meet multiple times throughout the year with small groups (“pods”) of their cohort members and two PIs. Pod members share their research progress and receive feedback, with everyone building trust over time that their ideas are valued and equally important to everyone’s progress. Frequently, these discussions lead to new research ideas generated by the pod community and not directed by the PIs.

Through data collected by our external evaluator, we have found that a flat power structure empowers our community, including our steering committee and program participants. For example, our steering committee has education experts and graduate students working together to help mold the BioTAP program. By providing an inclusive environment in which everyone’s voice, regardless of academic hierarchy location or power level, is heard, people of varied experiences can become involved, contribute to improving BioTAP, and ultimately improve GTA TPD. All members of the network can contribute to the advancement of BioTAP with the core acting as facilitators and a goal for the decision-making to become more multi-directional and diffuse over time.

Model Layer 4—Growing and Sustaining the Network: The final layer of our model involves connecting outwards to build the network and learn from others, forming new partnerships, and securing adequate resources to sustain the work. Reaching out of the existing network boundaries to bridge to other groups is important not just for effecting change but also for seeking sustainability resources.

We use the listserv, website, and a yearly virtual conference to link our efforts to departments, universities, and other national organizations. BioTAP's listserv of over 250 members includes BioTAP PIs, steering committee members, BioTAP Scholars, an evaluator, and other interested stakeholders. The BioTAP website (https://biotap.utk.edu) provides resources to support GTA TPD research including research articles, methods guides, and GTA-specific research instruments; this website will be sustained long after funding for the project has ceased. The website also hosts videos produced by nationally-recognized biology education researchers from the University of Georgia sponsored by their institutional CIRTL (Center for the Integration of Research, Teaching and Learning). To date, BioTAP PIs and Scholars have over 15 national presentations and three peer-reviewed publications.

To connect outward, we distribute a letter to BioTAP Scholar supervisors and administrators that includes an explanation of the program as well as a position statement on the value of GTAs as instructors and need for enhanced GTA TPD. We believe that this statement calls attention to the importance of GTA TPD at higher administrative levels. In addition, we have connected with other networks, such as CIRTL, to strengthen the quality of GTA TPD research. The BioTAP community has also hosted two highly-successful virtual conferences. The conferences enable Scholars and others interested in GTA TPD to present their original research to a larger audience and have attracted over 150 attendees from all over the United States and at least three different countries.

Connections to people outside of BioTAP position the network for advocacy on behalf of GTA TPD but rest on the assumption that members have the ability to be advocates within their units. In fact, this may not be the case and presents a significant challenge for any Research Coordination Network whose individuals work in isolation (particularly if these individuals are not powerful or influential within the academic system, such as laboratory coordinators or postdocs). Making connections with institutional advocates who have the ability to make change happen is important to the success of a network comprised of isolated institutional members and a goal for national reform. The administrative letters we send help validate the time and effort of our Scholars and potentially give them a stronger voice in their institutional contexts. These connections also help us seek additional funding and human resources that will support our sustainability and impact on the community.

4 Conclusions

BioTAP seeks to effect cross-institutional change through the power of an RCN-UBE network. Previously, there has been little guidance about how networks such as these can affect institutional change. Building networks involves developing connections between individuals and strengthening those connections over time. We put forward our theory of change for BioTAP as one idea that others may consider as they leverage similar projects. While there is no single "best" potential model to inform a theory of change, the Rincón-Gallardo and Fullan (2016) model has helped us to understand how some elements can differentially help us achieve our outcomes, and which of our assumptions have been erroneous.

We have effectively built a network focused on GTA TPD research, as we envisioned. However, we have faced challenges in enacting collaborative research projects between institutions, mainly because each institution's TPD program(s) is unique in structure. This often means that researchers have different questions they want to explore or that settling on common measurable outcomes is difficult. We now understand that we may not necessarily produce cross-institutional research collaborations from this iteration of the project, but we can foster collaborations between people that build agency for conducting research in some stakeholders who may not currently have that agency.

In the beginning, we envisioned BioTAP Scholars as institutional and cross-institutional change agents able to communicate at multiple academic levels. Some of them did become change agents in their institutions, either through impacts on their own GTA TPD programs or influencing broader institutional practices. However, most are not in a position to be change agents because of their more marginalized status (e.g., graduate students or postdocs) within the hierarchical structure of academia. Nevertheless, with our support, BioTAP Scholars can still be ambassadors for GTA TPD by publishing or presenting their research, or raising awareness at their institutions. In this way, their BioTAP work could be a conduit for change at other institutions, even if they are not effecting change at their own institutions.

We have also found that it is difficult to connect outwards to other organizations to effect change. Every project tends to have their own focus on GTA TPD in their own context, thus it can be hard to find points of overlap in the missions of each group. In the case of GTA TPD, CIRTL, disciplinary societies, and organizations such as the POD Network would have logical overlap in terms of GTA professional development, but need to find a common effort to justify the extra time it would take to collaborate.

In essence, BioTAP is a network of isolated individuals as well as a national change organization. It is comprised of people who individually may have little power at their institutions, but who have the potential to improve the professional development of graduate students. When banded together as a collaborative organization, the group can consolidate efforts and effect change that is scalable to multiple hierarchical academic systems. This may mean common approaches to GTA TPD at multiple institutions or collaborative research projects are necessary to identify improved teaching practices. These changes depend on strong collaborations, focused on common goals, as well as creating connections to other organizations who can support our efforts. Our project has focused on strengthening those connections such that individuals have strong support networks to be able to take more risks and potentially effect change in GTA TPD at multiple levels within their own complex academic contexts.

5 Acknowledgements

BioTAP was funded by a Research Coordination Network grant from the National Science Foundation (DBI 1539903). We gratefully acknowledge all members of the BioTAP network for their commitment to Biology GTA TPD.

6 About the Authors

Grant Gardner is an Associate Professor of Biology and Graduate Research Faculty in the Interdisciplinary Mathematics and Sciences Education Ph.D. program at Middle Tennessee State University.

Judith S. Ridgway is an Assistant Director at the Center for Life Sciences Education at The Ohio State University.

Elisabeth Schussler is a Professor in Ecology and Evolutionary Biology at the University of Tennessee, Knoxville.

Kristen Miller is an Academic Professional and the Director of the Division of Biological Sciences as the University of Georgia.

Gili Marbach-Ad is the director of the Teaching and Learning Center (TLC) in the College of Computer, mathematical, and Natural Sciences at the University of Maryland.

7 References

American Association for the Advancement of Science. (2011). *Vision and change in undergraduate biology education: A call to action*. American Association for the Advancement of Science. https://live-visionandchange.pantheonsite.io/wp-content/uploads/2011/03/Revised-Vision-and-Change-Final-Report.pdf

American Association for the Advancement of Science. (2015). *Vision and change: Chronicling change, inspiring the future*. American Association for the Advancement of Science. https://live-visionandchange.pantheonsite.io/wp-content/uploads/2015/07/VISchange2015_webFin.pdf

Anderson, W. A., Banerjee, U., Drennan, C. L., Elgin, S. C. R., Epstein, I. R., Handelsman, J., Hatfull, G., Losick, R., O'Dowd, D. K., Olivera, B. M., Strobel, S. A., Walker, G. C., & Warner, I. M. (2011). Changing the culture of science education at research universities. *Science*, *331*(6014), 152–153. https://doi.org/10.1126/science.1198280

Austin, A. E., Connolly, M. R., & Colbeck, C. L. (2008). Strategies for preparing integrated faculty: The center for the integration of research, teaching, and learning. *New Directions for Teaching and Learning*, *113*, 69–81. https://doi.org/10.1002/tl.309

Brancaccio-Taras, L., Gull, K. A., & Ratti, C. (2016). The science teaching fellows program: a model for online faculty development of early career scientists interested in teaching. *Journal of Microbiology & Biology Education*, *17*(3), 333–338. https://doi.org/10.1128/jmbe.v17i3.1243

Connolly, M. R., Lee, Y. G., & Savoy, J. N. (2018). The effects of doctoral teaching development on early-career STEM scholars' college teaching self-efficacy. *CBE—Life Sciences Education*, *17*(1), ar14. https://doi.org/10.1187/cbe.17-02-0039

Eddy, S. L., & Hogan, K. A. (2014). Getting under the hood: How and for whom does increasing course structure work? *CBE—Life Sciences Education*, *13*(3), 453–468. https://doi.org/10.1187/cbe.14-03-0050

Ebert-May, D., Derting, T. L., Henkel, T. P., Middlemis Maher, J., Momsen, J. L., Arnold, B., & Passmore, H. A. (2015). Breaking the cycle: Future faculty begin teaching with learner-centered strategies after professional development. *CBE—Life Sciences Education*, *14*(2), ar22. https://doi.org/10.1187/cbe.14-22-0222

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Love Stowell, S. M., Churchill, A. C., Hund, A. K., Kelsey, K. C., Redmond, M. D., Seiter, S. A., & Barger, N. N. (2015). Transforming graduate training in STEM education. *Bulletin of the Ecological Society of America*, *96*(2), 317–323. https://doi.org/10.1890/0012-9623-96.2.317

Pfund, C., Miller, S., Brenner, K., Bruns, P. J., Chang, A., Ebert-May, D., Fagen, A. P., Gentile, J., Gossens, S., Khan, I., Labov, J. B., Pribbenow, C. M., Susman, M., Tong, L., Wright, R. L., Yuan, R. T., Wood, W. B., & Handelsman, J. (2009). Summer institute to improve university science teaching. *Science*, *324*(5926), 470–471. https://doi.org/10.1126/science.1170015

Reeves, T. D., Marbach-Ad, G., Miller, K. R., Ridgway, J., Gardner, G. E., Schussler, E. E., & Wischusen, E. W. (2016). A conceptual framework for graduate teaching assistant professional development evaluation and research. *CBE—Life Sciences Education*, *15*(2), es2. https://doi.org/10.1187/cbe.15-10-0225

Reinholz, D. L., & Andrews, T. C. (2020). Change theory and theory of change: What's the difference anyway? *International Journal of STEM Education, 7*(2), 1–12. https://doi.org/10.1186/s40594-020-0202-3

Rincón-Gallardo, S., & Fullan, M. (2016). Essential features of effective networks in education. *Journal of Professional Capital and Community*, *1*(1), 5–22. https://doi.org/10.1108/JPCC-09-2015-0007

Schussler, E. E., Read, Q., Marbach-Ad, G., Miller, K., & Ferzli, M. (2015). Preparing biology graduate teaching assistants for their roles as instructors: An assessment of institutional approaches. *CBE—Life Sciences Education*, *14*(3), ar31. https://doi.org/10.1187/cbe.14-11-0196

Stains, M., Harshman, J., Barker, M. K., Chasteen, S. V., Cole, R., DeChenne-Peters, S. E., Eagan Jr., M. K., Esson, J. M., Knight, J. K., Laski, F. A., Levis-Fitzgerald, M., Lee, C. J., Lo, S. M., McDonnell, L. M., McKay, T. A., Michelotti, N., Musgrove, A., Palmer, M. S., Plank, K. M., … Young, A. M. (2018). Anatomy of STEM teaching in North American universities. *Science, 359*(6383), 1468–1470. https://doi.org/10.1126/science.aap8892

Sundberg, M. D., Armstrong, J. E., & Wischusen, E. W. (2005). A reappraisal of the status of introductory biology laboratory education in U.S. colleges & universities. *The American Biology Teacher*, *67*(9), 525–529.

11. Learning Together: Four Institutions' Collective Approach to Building Sustained Inclusive Excellence Programs in STEM

JEREMY WOJDAK, TARA PHELPS-DURR, LAURA GOUGH, TRUDYMAE ATUOBI, CYNTHIA DEBOY, PATRICE MOSS, JILL SIBLE, AND NAJLA MOUCHREK

1 Introduction

Inclusive excellence as a concept in higher education unifies aspirations for equitable student success and shifts in institutional culture and practices to better value representational diversity (Clayton-Pederson et al., 2017). Here, Radford University, Towson University, Trinity Washington University, and Virginia Tech, each awarded 2017 Howard Hughes Medical Institute (HHMI) Inclusive Excellence (IE) grants, report on efforts to create inclusive student programs in STEM. Midway through the five-year grant, two themes have emerged: 1) faculty play an essential role as change agents in inclusive excellence and must be empowered to lead and be credited for this work, and 2) convening diverse institutions in learning communities provides peer support and facilitates progress toward inclusion.

2 The Howard Hughes Medical Institute IE Program

Despite major investments supporting equitable outcomes for students who have been underrepresented in STEM (e.g. students of color, first-generation college students, and transfer students), progress has been limited (President's Council of Advisors for Science and Technology, 2012). Even when initiatives such as summer bridge or tutoring programs yield success for individual students, institutions often remain fundamentally unchanged when funding for these programs ends.

HHMI sought a different approach to create sustained advances toward inclusion: "All students, regardless of where they come from and where they are going, deserve a meaningful and positive experience in science through which they will better understand and engage in scientific thinking and discovery. The quality of that experience is the responsibility of the faculty and administrators who play an essential role in defining an institution's culture.

Unfortunately, there exist substantial disparities between students who arrive at college via different pathways. Students who are first in their families to attend college, students who transfer from 2-year to 4-year schools, and students from racial, ethnic, and socioeconomic groups underrepresented in science are significantly less likely to complete the baccalaureate degree" (HHMI, n.d.).

In response to this challenge, HHMI launched the Inclusive Excellence program to *change the institution, not fix the student*, encouraging grantees to reject a deficit mindset regarding students and turn a critical eye toward how institutions themselves needed to change. At the 2017 kick-off meeting, HHMI provided grantee institutions with a sense of mission, some theoretical grounding, and frameworks regarding inclusion and institutional change. However, the approach to inclusive excellence was not prescribed, and institutions were encouraged to "experiment" as they applied their learning to institution-specific goals and contexts. To support this work, HHMI built a network of regional communities of practice, called Peer Implementation Clusters (PICs) and engaged project leadership in professional learning, mentoring, and reflection. Like described in the work of Finkelstein et al. (this volume), this model values cross-institutional research and collaboration, creating a process of collective emerging learning. To date, HHMI has awarded $1M each to 57 institutions over two rounds of funding.

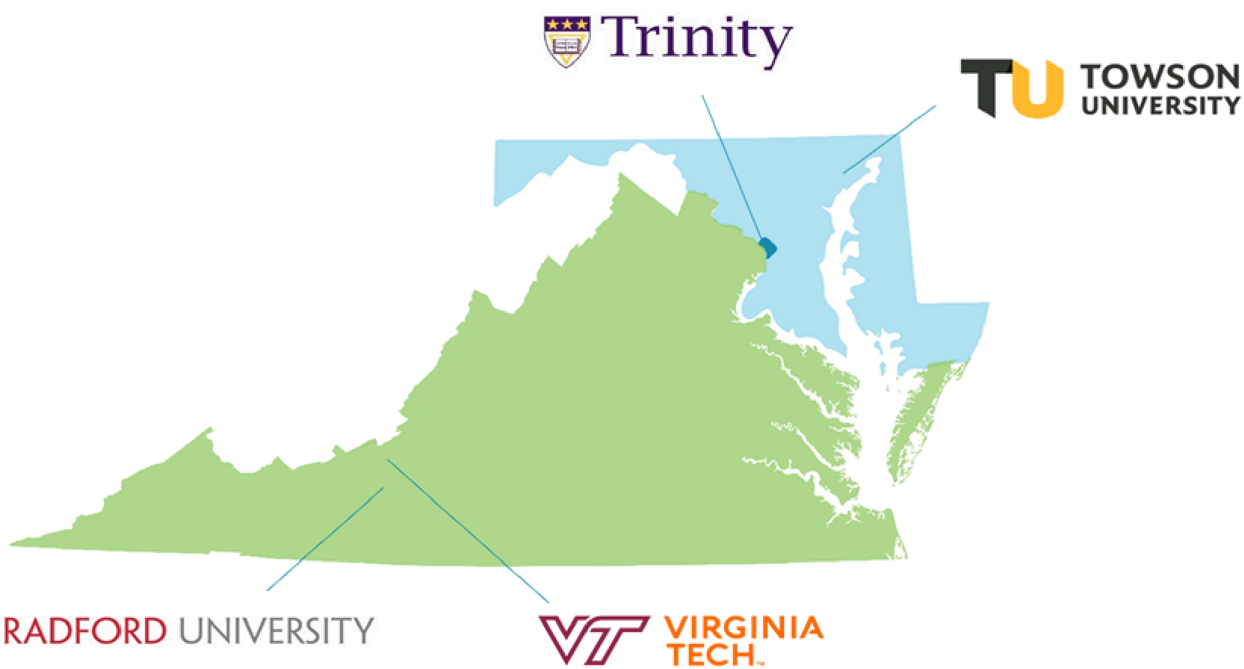


Figure 1. The South Peer Implementation Cluster (PIC institutions located in Maryland, Washington DC, and Virginia. (web: click on image to enlarge)

3 Institutional Profiles and Project Overviews

We constitute the South PIC institutions among the 2017 HHMI Inclusive Excellence awardees

(Figure 1). As we approach midway in the five-year grant period, we reflect upon progress and challenges that must be overcome to emerge as more inclusive institutions. Our South PIC is representative of the diversity of institutions that are part of the HHMI program (Table 1). Collectively, our institutions are public and private faith-based; small, medium, and large; predominantly black and predominantly white; rural and urban.

Table 1. Profiles of South PIC Institutions.

Institution	Radford University	Towson University	Trinity Washington University	Virginia Tech
Location	Radford, VA	Baltimore, MD	Washington, DC	Blacksburg, VA
Undergraduate Enrollment (Fall 2019)	7,967	19,800	1,500	29,300
Institute Type	Four-year, medium, public, primarily residential	Four-year, large, public, primarily residential	Four-year, small, faith-based, primarily nonresidential	Four-year, large, public, primarily residential
Carnegie Classification*	Master's Colleges and Universities: Larger Programs	Doctoral/ Professional Universities	Master's Colleges & Universities: Medium Programs	Doctoral University; Very High Research
Student Demographics**	34% ethnic minority; 60% female; 32% first-gen	45% non-white; 50% transfer; 60% female	90% African American and Latina; 100% female (in Arts and Sciences)	9% underrepresented minority; 9.5% transfer; 16% first-gen
Students Receiving Need -Based Aid***	64%	55%	100%	39%

**The Carnegie Classification of Institutions of Higher Education (n.d.).*
***Rather than adopt common language, we present the demographic categories as used by each institution, reflecting differences in institutional culture and practice.*
****US News and World Reports for Radford, Towson, VT; Trinity self-reported.*

Here, we share an overview of the inclusive excellence activities implemented by our respective universities, highlighting the commonalities that have emerged (Table 2).

Note: PBL: problem-based learning; IE: inclusive excellence; FYE: first-year experience; CURE: course-based undergraduate research experience.

Table 2. Overview of Inclusive Excellence Activities at South PIC Institutions.

Institution	Radford University	Towson University	Trinity Washington University	Virginia Tech
Participating units	Biology, Chemistry, and Physics	Biology, then expanded to Chemistry and Mathematics	Biology, then expanded to Mathematics	Fish and Wildlife, Human Nutrition Food and Exercise, Neuroscience, Chemistry, Biochemistry, Geosciences, Animal and Poultry Science, and Forest Resources & Environmental Conservation
Faculty learning	Faculty trained in PBL and inclusive pedagogy	Faculty meet monthly for a year to learn to teach CUREs and inclusive teaching practices	Faculty learning on understanding bias, culturally competent teaching, increasing student engagement, becoming effective mentors	Faculty cohorts spent a year learning through fall workshops, spring reading groups, a summer institute; departments have additional faculty learning contextualized for their programs.
Faculty incentives	Faculty grants and release time	Faculty stipends and release time		Faculty named scholars; summer salary, IE faculty award
Curricular reform	Faculty implement PBL in their classes	Faculty creating and teaching CUREs; students take CUREs as part of degree	Built flexibility into course sequencing for biology and chemistry; relaxed prerequisites	Varies by department: e.g offering key courses both semesters, piloting PBL-based learning; embedding research in curriculum
Mentoring and student support	Peer mentors host social and academic events	Mentoring and other student supports embedded into class time	Developed Mentor Moments, 1-credit courses at each academic level	Varies by department: e.g. expanding FYE course to second semester to provide additional mentoring; partnering with Student Affairs to support students in recovery
Expanding the network	Teaching postdocs play a critical role	High school teachers engaged in professional learning		Undergraduate fellows initiate their own IE projects

3.1 Radford University

At Radford, we launched the Realizing Inclusive Science Excellence (REALISE) initiative to create a welcoming, inclusive learning environment for all students. The cornerstone of our approach is providing professional learning within a community for faculty to embed project-based learning and inclusive pedagogy into curricula. 21 faculty have participated in REALISE, representing 33%, 62%, and 63% faculty participation in the departments of Biology, Chemistry, and Physics, respectively. Upon completing their professional learning, participants receive one semester half-time reassignment to implement their course redesign, providing the rate-limiting resource for faculty: time. Like the BioTAP initiative described by Gardner et al. (this volume), to seek sustained change through work with future faculty, REALISE engages postdoctoral teaching fellows as essential members of these learning communities. These fellows contribute to curricular reform while developing their own skills to transition into permanent positions as change agents in higher education. REALISE student leaders build community by hosting social (tie-dye, student/faculty mixers, movie nights, fresh fruit Fridays) and academic (CV writing workshops, career exploration day) events. Participation in these activities has steadily increased over the past three semesters, and surveys demonstrate that our students desire more.

3.2 Towson University

At TU, student persistence and retention are lower for transfer students, who comprise half of our student body. With HHMI funding, we created the TU Research Enhancement Program grounded in the creation of course-based undergraduate research experiences (CUREs) to engage more students in authentic research (Auchincloss et al., 2014; Oufiero, 2019), which can increase retention of all students in science, including those from underrepresented groups (e.g., Shaffer et al., 2010; Bangera & Brownell, 2017). In the revised curriculum, students take CUREs in subjects including genetics, cell biology, field ecology, and forensics. As at Radford, professional learning for faculty is the key to our curricular change project. Faculty cohorts of six to eight members engage in monthly professional learning activities for one year to develop their CURE and learn inclusive teaching techniques. These activities have further created additional connections among STEM faculty and diversity and inclusion staff in the Office of the Provost and President. In addition, we have explored student needs and worked to enhance and connect across existing university resources to ensure students can utilize academic and social supports. We are beginning to offer additional supports during classroom time (e.g., mini-discussions or presentations about internships, graduate school, and study skills) to reach thousands of students who are not able to attend activities outside of class. We co-developed a summer workshop for high school teachers modeled on our Molecular Biology Lab CURE. This workshop includes a forum for TU faculty to discuss inclusion and research-based instruction with these teachers. We learn about the challenges they and their students face, and the high school teachers explore implementing authentic research activities in their own classrooms.

3.3 Trinity Washington University

Trinity Washington aims to increase the number of women majoring in the sciences. More than

90% of Trinity's students in the College of Arts and Sciences are African American and Latina. While 94% of science majors taking introductory chemistry in 2013 had graduated by 2018, only 44% graduated as science majors. In response, Trinity faculty developed Trinity ExCEL (Excellence x Confidence Equals Leadership). Similar to TU, we recognized that our students faced extensive commitments outside of school, and thus, initiatives must be embedded within the curriculum. Our program is grounded in faculty professional learning selected from topics that faculty requested: 1) understanding the impact of our own biases, 2) developing strategies for culturally competent teaching, 3) increasing student engagement, and 4) becoming more effective mentors. With such training, we support faculty to promote asset-based learning through student empowerment, and foster student-instructor interactions, thereby creating a framework shown by Lee et al. (2019) to be an effective model to improve minoritized student learning outcomes in STEM. We used training to inform our curriculum redesign, which included relaxing prerequisites and the prescribed order of courses to increase flexibility for students who may otherwise fall off-cycle. We also included 1-credit mentoring courses to help students become self-regulated learners as described by Sebesta et al. (2017). Mentor courses increase faculty and peer mentorship and focus on: 1) student belonging and self-efficacy, 2) communication in academia, 3) obtaining experiential learning, and 4) post-baccalaureate careers. Furthermore, pillars shown to support student success including mentorship, student mindset, and student learning techniques (Lisberg & Woods, 2018) have been incorporated into our revised curriculum.

3.4 Virginia Tech

At Virginia Tech, our Inclusive Excellence project engages multiple science departments, supported by university-level administration, as a strategy for sustainable change at a large, decentralized institution. While our retention (>90% first-to-second year) and graduation (>85% 6-year graduation) rates are high for students in our science programs, disaggregated data revealed disparities for students from identities that are marginalized in STEM (underrepresented minorities, transfer, and first generation). Moreover, students from these identities reported that the Virginia Tech tagline, "This is home," did not apply for them. Each year, faculty members are recruited from up to three departments to participate in a year of professional learning in inclusive pedagogy. They learn theoretical foundations (e.g., stereotype threat, implicit bias), and based on faculty request, also learn practical and discipline-specific approaches to improve their teaching and mentoring. Faculty participate in guided reflection about their learning. As in the work described by MarbachAd et al. (this volume), participating departments consider disaggregated data and focus group reports for their own students to reveal disparities for marginalized populations. Like MarbachAd et al., we recognized the quite different contexts across departments and predicted a one-size-fits-all approach would not work for building sustained change. Thus, we distribute the majority of our Inclusive Excellence funding as mini-grants, giving departments agency to implement projects of their own design. These projects emerge from ideas that department faculty develop collaboratively and are contextualized to each department's needs and culture. To date, eight departments and 45 faculty from three science colleges have been involved.

4 Emergent Theme: The Critical Role of Faculty in Building Inclusive Excellence

As the reports from our institutions demonstrate, our various “experiments” share common themes (Table 2), the most central of which is faculty learning and subsequent expectations for faculty to implement pedagogical and curricular reforms that promote inclusion. This work is challenging logistically, intellectually, and emotionally, and frequently, is in addition to a full faculty workload. Across the South PIC, faculty are willing to commit to this work for extended periods of time. While professional learning has taken many forms (workshops, summer institutes, guest speakers, reading groups), a common theme has been faculty communities that meet regularly for months to years and engage in reflection, a practice recognized to promote sustained changes in STEM teaching (Henderson et al., 2011). Peer support has been critical within our institutions to help faculty remain engaged in these projects and develop changes in mindset and habits. Faculty who started as participants now serve as leaders among their peers, presenting at departmental and South PIC meetings. While each of our inclusive excellence teams contains administrative leadership, these administrators serve primarily in advocacy and support roles, recognizing faculty as the primary change agents.

The content for faculty learning has largely fallen into two categories: 1) learning about diversity and inclusion (e.g. implicit bias, stereotype threat), and 2) pedagogical training. The former has been led by national and campus experts. The latter has frequently fallen into the “good pedagogy” category based on the prediction that more learner-centered approaches will reduce achievement gaps for the populations of students that are the focus of this project, as supported by a number of studies (e.g. Beichner et al., 2007; Eddy & Hogan, 2014). However, in some fields, these pedagogical approaches have exacerbated achievement gaps (e.g., Johnson et al., 2019; Setren et al., 2019), highlighting the importance of a more comprehensive approach to professional learning. Beyond more generalized training in “active learning” approaches, much of our faculty learning has been focused directly on inclusive pedagogy (e.g., writing inclusive syllabi, adopting inclusive language) to apply lessons learned from the diversity and inclusion awareness training. One important question that will be addressed by our Inclusive Excellence projects is whether the pairing of faculty learning in diversity and inclusion with pedagogical training provides an effective strategy for reducing success gaps in our classrooms. Other important aspects, echoing the work of Margherio et al. (this volume), are the creation of strategic partnerships leading to shared vision and mutual learning.

As we consider what it will take to sustain our work beyond the lifetime of the grants, we must consider the essential role that we have defined for faculty who must make difficult decisions about how to spend their time in ways that align with institutional priorities. We appreciate the empathy and respect for faculty put forth by The Every Learner Everywhere project in the New Learning Compact, and have adopted their stance and some of their language (e.g., “professional learning” instead of “faculty development”) in our inclusive excellence work (Bass et al., 2019). Given that few arrive at faculty positions with expertise in pedagogy or inclusion, faculty learning must be recognized as part of faculty workload (Neumann, 2005). Our faculty stress that time needs to be devoted to course development and redesign, practice, reflection, and peer support. The particular situations may differ among faculty, ranging from part-time instructors who should be paid for time spent on professional learning, to assistant professors with high expectations for research accomplishments to earn tenure. However, the take-home message is consistent: if inclusive excellence initiatives are to expand beyond the early adopters and be sustained beyond the lifetime of a grant, the work must be recognized and rewarded, including counting towards tenure and promotion. Otherwise, our work risks contributing to workload disparity issues that tend to negatively impact women and faculty of color (O'Meara et al., 2018). While we share our success to date, collectively we have seen participation in some of our more time-consuming faculty learning initiatives begin to decline. Reflecting on our work in the context of the systems approach to change described by Kezar and Miller (this volume), we find that our institutions have made good progress in providing the pedagogical tools and infrastructure to advance inclusive excellence, but risk failing at long-term cultural change if we cannot impact changes in policy regarding faculty recognition and rewards for this work.

5 Learning Together: The Value of our Peer Implementation Cluster

The organization of Inclusive Excellence grantees into PICs was one strategy HHMI employed to facilitate sharing and learning across the grantee institutions. The clusters were organized geographically so that institutions could convene at least once a year. The South PIC typifies the diversity of these clusters (Table 1). Institutional leaders from each PIC were first introduced to each other by HHMI during the kickoff meeting in the summer of 2017. During this introduction, we shared our initial challenges, goals, and strategies. Despite differences not only among our institutional profiles but also in our planned approaches to inclusive excellence, we recognized the potential to learn from each other.

The nature of South PIC interactions has evolved substantially over the past two and a half years. In the first year, each institution was focused on launching its own program, and the PIC meetings were limited to formal monthly virtual meetings to plan a spring 2018 South PIC gathering to be hosted by Trinity Washington University. This event, held in May 2018, brought together ~35 individuals across the four institutions for two days of professional learning led by national experts, HHMI, and Trinity Washington faculty. During year 1, Radford and Virginia Tech, co-located in rural Southwest Virginia, extended reciprocal invitations to share professional learning events including visits by national and local experts from each institution. Towson and Trinity Washington shared strategies for assessment and facilitating student mentorship. Additionally, Towson's Vice President of Inclusion and Institutional Equity and Coordinator of Diversity Training facilitated professional learning for Trinity faculty. An Inclusive Pedagogy Faculty Mentoring Network (sponsored by the QUBES: Quantitative Undergraduate Biology Education and Synthesis project) with participation from all four institutions met every other week in the fall of 2018 to discuss readings on a range of topics. In April of 2019, faculty from each institution partnered to offer a workshop on inclusive excellence as part of the ASCN Transforming Institutions Conference, providing the basis for this collaborative report. The South PIC convened at Virginia Tech in June 2019 for its annual meeting, which was combined with Virginia Tech's two-day Summer Institute professional learning event for over 200 faculty. Towson hosted a virtual South PIC meeting in May 2020 with a focus on the impact of COVID-19 on the work of inclusive excellence. 70 colleagues from the South PIC institutions as well as Bowie State, Community College of Baltimore County, and Baltimore City Community College attended.

Beyond these formal interactions, the South PIC has become a community of support, particularly for program leaders as we strive to institutionalize projects at our respective universities. As many of our participating faculty have begun attending conferences focused on inclusion in STEM and professional learning, we seek out one another at national meetings and invite each other to give presentations at organized symposia. South PIC program directors chat regularly to share mentorship in matters ranging from how to approach the reflection-based annual reports to how to best support faculty who are overwhelmed during the COVID-19 crisis. We have helped one another identify program evaluators and workshop facilitators. We have pointed to examples of strong support from university leadership at one another's institutions as we seek to influence change at our own. This building of professional relationships of mutual support and trust has developed organically without a formal, common framework as described by Finkelstein et al. (this volume) for their teaching evaluation project. In contrast to the AAU STEM network (Kezar & Miller, this volume) and other STEM change initiatives, the Inclusive Excellence PICs do not bring together like institutions. The groupings based solely on geography provide an element of the larger experiment that HHMI has undertaken, and we recognize the foresight of HHMI that modeled the principles of inclusive excellence by bringing together institutions with diverse profiles to learn together toward a common goal. Our annual PIC meetings provide us with an opportunity to introduce more faculty from each institution to inclusive excellence work and to the group, developing additional networking opportunities across campuses.

6 Institutionalizing Inclusive Excellence

Each of our programs has reported progress toward sustaining their inclusive excellence programs. Science departments beyond those involved when the grants were awarded have joined our projects. We have partnered with university-level administration to expand professional learning programs in diversity, equity, and inclusion to campus-wide initiatives. Presidents, provosts, and in some cases, Boards of Visitors/Trustees have been present to learn and then advocate for our projects on all four campuses. Our faculty have become involved in student-life issues ranging from food insecurity to substance use disorders. Perhaps the most visible result of this work in Spring 2020 has been how participating departments have responded to the sudden move to on-line teaching and learning due to the COVID-19 pandemic. Faculty who had been engaged in professional learning about issues of equity and inclusion have approached on-line learning through these lenses. They considered access to learning for all students, participating in webinars and discussions with colleagues to consider these issues. The flexibility required to learn how to teach inclusively has been an asset for us as we navigated this new environment. The leadership of the South PIC shared ideas and resources throughout the spring semester, leveraging our network to provide lessons learned and moral support. Our 2020 South PIC meeting was devoted to discussing how we will continue our inclusive excellence work as our universities continue to evolve in response to the pandemic. Learning together has taken on a heightened significance as we simultaneously navigate uncharted and age-old challenges to inclusion. We look forward to sharing future results of our individual and collective project evaluations.

7 Acknowledgements

We thank the Howard Hughes Medical for Institute Inclusive Excellence grants to Radford University, Towson University, Trinity Washington University, and Virginia Tech. We thank ASCN for the opportunity to present at the 2019 Transforming Institutions Conference and submit this chapter.

8 About the Authors

Jeremy Wojdak is a Professor of Biology in the Artis College of Science and Technology at Radford University.

Tara Phelps-Durr is a Professor of Biology in the Artis College of Science and Technology at Radford University.

Laura Gough is Professor and Chair of the Department of Biological Sciences at Towson University.

Trudymae Atuobi is the Student Success Program Coordinator and Adjunct Professor of Biology at Towson University.

Cynthia DeBoy is a Clare Boothe Luce Associate Professor of Biology in the College of Arts and Sciences at Trinity Washington University.

Patrice E. Moss is a Clare Boothe Luce Associate Professor and Chair of the Biology Program at Trinity Washington University.

Jill Sible is the Associate Vice Provost for Undergraduate Education and a Professor in Biological Sciences at Virginia Tech.

Najla Mouchrek is the Program Director for Interfaith Leadership and Holistic Development at Virginia Tech.

9 References

Auchincloss, L. C., Laursen, S. L., Branchaw, J. L., Eagan, K., Graham, M., Hanauer, D. I., Lawrie, G., McLinn, C. M., Pelaez, N., Rowland, S., Towns, M., Trautmann, N. M., Varma-Nelson, P., Weston, T. J., & Dolan, E. L. (2014). Assessment of course-based undergraduate research experiences: A meeting report. *CBE—Life Sciences Education*, *13*(1), 29–40. https://doi.org/10.1187/cbe.14-01-0004

Bangera, G., & Brownell, S. E. (2014). Course-based undergraduate research experiences can make scientific research more inclusive. *CBE—Life Sciences Education*, *13*(4), 602–606. https://doi.org/10.1187/cbe.14-06-0099

Bass, R., Eynon, B., & Gambino, L.M. (2019). *The new learning compact: A framework for professional learning and educational change*. Every Learner Everywhere. https://www.everylearnereverywhere.org/wp-content/uploads/NewLearningCompact.pdf

Beichner, R. J., Saul, J. M., Abbott, D. S., Morse, J. J., Deardorff, D. L., Allain, R. J., Bonham, S. W., Dancy, M. H., and Risley, J. S. (2007). The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) project. *Research-Based Reform of University Introductory Physics, 1*(1), 2–39. http://www.per-central.org/document/ServeFile.cfm?ID=4517

The Carnegie Classifications of Institutions of Higher Education. (n.d.). *About Carnegie Classification*. http://carnegieclassifications.iu.edu/

Clayton-Pedersen, A. R., O'Neill, N., & McTighe Musil, C. (2017). *Making excellence inclusive: A framework for embedding diversity and inclusion into colleges and universities' academic excellence mission*. Association of American Colleges & Universities. https://www.aacu.org/sites/default/files/files/mei/MakingExcellenceInclusive2017.pdf

Eddy, S.L., and Hogan, K.A. (2014). Getting under the hood: How and for whom does increasing course structure work? *CBE—Life Sciences Education, 13*(3), 453–468. https://doi.rg/10.1187/cbe.14-03-0050

Finkelstein, N., Greenhoot, A. F., Weaver, G., & Austin, A. E. (this volume). "A department-level cultural change project: Transforming the evaluation of teaching." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 14). Pressbooks.

Gardner, G., Ridgway, J., Schussler, E., Miller, K., & Marbach-Ad., G. (this volume). "Research coordination networks to promote cross-institutional change: A case study of graduate student teaching professional development." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 10). Pressbooks.

Henderson, C., Beach, A., & Finkelstein, N. (2011) Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*, 952–984. https://doi.org/10.1002/tea.20439

Howard Hughes Medical Institute. (n.d.). *Inclusive Excellence*. Howard Hughes Medical Institute. https://www.hhmi.org/science-education/programs/inclusive-excellence

Johnson, E., Andrews-Larson, C., Keene, K., Melhuish, K., Keller, R., & Fortune, N. (2019). Inquiry does not guarantee equity. *Proceedings of the annual conference on research in undergraduate mathematics education*. The Special Interest Group of the Mathematics Association of America (SIGMAA) for Research in Undergraduate Mathematics Education. http://sigmaa.maa.org/rume/crume2019/Papers/37.pdf

Kezar, A., & Miller, E. R. (this volume). "Using a systems approach to change: Examining the AAU Undergraduate STEM Education Initiative." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 9). Pressbooks.

Lee, J. Y., Khalil, D., & Boykin, A. W. (2019) Enhancing STEM teaching and learning at HBCUs: A focus on student learning outcomes. *Student Services, 167*, 23–36. https://doi.org/10.1002/ss.20318

Lisberg, A., & Woods, B. (2018). Mentorship, mindset and learning strategies. *Journal of STEM Education, 19*(3), 14–19. https://www.jstem.org/jstem/index.php/JSTEM/article/view/2280/1964

Marbach-Ad., G., Hunt, C., & Thompson, K. V. (this volume). "Using data on student values and experiences to engage faculty members in discussions on improving teaching." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 8). Pressbooks.

Margherio, C., Doten-Snitker, K., Williams, J., Litzler, E., Andrijcic, E., & Mohan, S. (this volume). "Cultivating strategic partnerships to transform STEM education." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 12). Pressbooks.

Neumann, A. (2005). Observations: Taking seriously the topic of learning in studies of faculty work and careers. In E. G. Creamer & L. R. Lattuca (Eds.), Advancing faculty learning through interdisciplinary collaboration [Special issue]. *New Directions for Teaching and Learning, 102*, 63–83. https://doi.org/10.1002/tl.197

O'Meara, K., Jaeger, A., Misra, J., Lennartz, C., & Kuvaeva, A. (2018). Undoing disparities in faculty workloads: A randomized trial experiment. *PloS One*, *13*(12), e0207316. https://doi.org/10.1371/journal.pone.0207316

Oufiero, C. E. (2019) The organismal form and function lab-course: A new CURE for a lack of authentic research experiences in organismal biology. *Integrative Organismal Biology, 1*(1), obz021. https://doi.org/10.1093/iob/obz021

President's Council of Advisors for Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and* *mathematics*. President's Council of Advisors on Science and Technology. https://files.eric.ed.gov/fulltext/ED541511.pdf

Sebesta, A. J., & Bray Speth, E. (2017). How should I study for the exam? Self-regulated learning strategies and achievement in introductory biology. *CBE—Life Sciences Education*, *16*(2), ar30. https://doi.org/10.1187/cbe.16-09-0269

Setren, E., Greenberg, K., Moore, O., & Yankovich, M. (2019). *Effects of the flipped classroom: Evidence from a randomized trial*. Annenberg Institute at Brown University. https://edworkingpapers.org/sites/default/files/ai19-113.pdf

Shaffer, C. D., Alvarez, C., Bailey, C., Barnard, D., Bhalla, S., Chandrasekaran, C., Chandrasekaran, V., Chung, H.-M., Dorer, D. R., Du, C., Eckdahl, T. T., Poet, J. L., Frohlich, D., Goodman, A. L., Gosser, Y., Hauser, C., Hoopes, L. L. M., Johnson, D., Jones, C. J., … Elgin, S. C. R. (2010). The genomics education partnership: Successful integration of research into laboratory classes at a diverse group of undergraduate institutions. *CBE—Life Sciences Education, 9*(1), 55–69. https://doi.org/10.1187/cbe.09-11-0087

12. Cultivating Strategic Partnerships to Transform STEM Education

CARA MARGHERIO, KERICE DOTEN-SNITKER, JULIA WILLIAMS, ELIZABETH LITZLER, EVA ANDRIJCIC, AND SRIRAM MOHAN

1 Cultivating Strategic Partnerships to Transform STEM Education

Educational transformation requires more than an innovative idea in order to succeed. The scope and scale of systemic change points to the essential need for strategic partnerships across disciplines and departments. Strategic partnerships are relationships among parties having joint rights and responsibilities as they work together to achieve common goals that could not be achieved by either party working alone (Barnett et al., 2010; Hoffman-Johnson, 2007). These relationships can be valuable tools for creating effective, sustainable change within higher education, providing a variety of benefits such as reducing costs through shared resources (Amey, 2010; Barnett et al., 2010; Worrall, 2007); improving the professional development of students (Buys & Bursnall, 2007); and expanding the impact of successful programs (Estrada et al., 2016). Despite the growing interest in forming strategic partnerships, the majority of these partnerships break down and fail (Eddy, 2010; Farrell & Seifert, 2007; Klein, 2017; Reed et al., 2007). In order to realize the benefits of successful strategic partnerships, we must first improve our understanding of how strategic partnerships develop. The process of forming a strategic partnership sets the objectives and expectations of the relationship, which in turn impact the likelihood of success and sustainability of the relationship.

While the process of partnership formation is iterative and not necessarily linear (Buys & Bursnall, 2007), prior research on strategic partnerships has worked to delineate stages through which these relationships develop. As strategic partnerships form, they first move through initiation and clarification stages (Sargent & Waters, 2004). In the initiation stage, motivations for collaborating may be instrumental (e.g., complementary skill sets, access to data) and/or intrinsic (e.g., enjoyment of working with each other) (Sargent & Waters, 2004). Potential partners are often identified through existing social networks and past working relationships (Buys & Bursnall, 2007; Hudson, 2016). During the clarification stage, decisions are made about the size, scope, and duration of the partnership (Sargent & Waters, 2004) and roles for individuals and groups become clearly defined (Buys & Bursnall, 2007). At this time, the members of a strategic partnership must develop clear goals to move the relationship forward (Sargent & Waters, 2004).

The analysis presented here emerges from our participatory action research with the National Science Foundation (NSF) Revolutionizing Engineering Departments (RED) teams investigating the process of creating change within STEM higher education. The RED funding mechanism is designed to support awardees in creating systemic change in engineering and computer science higher education, with the goal of improving undergraduate educational outcomes and creating more inclusive environments for students and faculty. The currently funded projects range in scope from one department to an entire college. These projects are reconstructing their educational environments, from dismantling the traditional course structure to reformulating assessments of student achievements to diffusing social justice throughout the curriculum.

In 2015 NSF funded the first cohort of six RED teams; the second cohort of seven teams was funded in 2016, a third cohort of six teams was funded in 2017, and a fourth cohort of two teams was funded in 2019. Each of the RED grants is for five years. The RED funding mechanism requires the teams to be multidisciplinary; in addition to instructional faculty, each team must include at least one education researcher, social scientist, and administrator. While faculty form the core of each team, the teams also include academic services staff, administrative staff, postdoctoral fellows, and graduate and undergraduate students. As shown in Table 1, the projects vary in disciplinary scope. Many of the teams are focused on a single-discipline department, yet some include multidisciplinary departments, multiple engineering departments, or even entire colleges of engineering.

With the initial funding of the RED grants came the opportunity to study the process of change within academia. As RED Participatory Action Research (REDPAR), we facilitate the consortium of RED teams and conduct research on the change process occurring within each of the RED schools. As demands for change in STEM education in the United States grow, projects like RED provide useful models for transformation. As the RED teams work to create and sustain systemic change, they have built a variety of strategic partnerships to help them achieve their goals. Here we examine how the RED teams have experienced the initiation and clarification stages of strategic partnership formation. These findings are part of the larger, on-going REDPAR project.

Table 1: NSF RED Grant Recipients, 2015–2019

Institution	Unit	Discipline
2015		
Arizona State University Polytechnic	College	General Engineering
Colorado State University Fort Collins	Department	Electrical and Computer Engineering
Oregon State University	College	Chemical, Biological, and Environmental Engineering
Purdue University	Department	Mechanical Engineering
University of North Carolina at Charlotte	College	Computing and Informatics
University of San Diego	College	General Engineering
2016		
Boise State University	Department	Computer Science
Iowa State University	Department	Electrical and Computer Engineering
Rowan University	Department	Civil and Environmental Engineering
University of Illinois at Urbana-Champaign	Department	Bioengineering
University of New Mexico	Department	Chemical and Biological Engineering
University of Texas El Paso	Department	Computer Science
Virginia Polytechnic Institute and State University	Department	Electrical and Computer Engineering
2017		
Clemson University	Department	Civil Engineering
East Carolina University	Department	Computer Science
Georgia Institute of Technology	Department	Biomedical Engineering
North Carolina A&T State University	Department	Chemical, Biological and Bioengineering
Seattle University	Department	Mechanical Engineering
Texas A&M University College Station	Department	Aerospace Engineering
2019		
Embry-Riddle Aeronautical University	Department	Electrical, Computer, Software, and Systems Engineering
University of Connecticut	Department	Civil and Environmental Engineering

2 Methods

The data consist of focus group discussions as well as observations of monthly calls of the consortium of RED teams. The semi-structured focus group discussions are conducted via phone and/or video conference call with each team at two time points: within the first six months of their grant ("baseline") and approximately 28–30 months after their grant was awarded ("midpoint"). This analysis includes data from the first three cohorts of RED teams' baseline focus group discussions along with the first and second cohorts' midpoint focus groups. REDPAR team members Margherio, Doten-Snitker, and Litzler facilitated the 18 baseline focus groups and 11 midpoint focus groups; each focus group consisted of members from one RED team. The focus groups ranged in size from two to 11 participants, with an average of five participants. Baseline focus groups were designed to gather information on the initial stages of the change projects, including team formation, the proposal creation process, and relevant prior experiences. The midpoint focus groups were designed to gather information on implementation, adaptation, context, and the skills involved in academic change-making. Focus groups are especially useful for this research as they allow team members to respond to and build on each other's comments (Lofland & Lofland, 2006), revealing individual and collective reasoning and motivations as the teams converse (Ansay et al., 2004; Morgan, 1996).

Each month, REDPAR team members Williams, Andrijcic, and Mohan facilitate a video conference call for the consortium of RED teams. Each call lasts for one hour and covers topics such as change project management, using social media as a resource for change, and communicating your impact. REDPAR team members Margherio, Doten-Snitker, and Litzler observe and transcribe each monthly call. This analysis includes 21 call transcriptions, representing all of the monthly calls in the first two years of the RED grant program.

We entered all of the data into the NVivo qualitative data management software program. Utilizing an abductive approach (Timmermans & Tavory, 2012), we made iterative moves between data coding and theory building, paying particular attention to any unexpected findings. Margherio and Doten-Snitker led the coding process and engaged in making iterative moves with existing research models and discussing the research findings as they evolved. We developed the initial coding scheme after reviewing six first-year focus group transcripts and eight call transcripts, as well as studies of academic change by Kezar (2011, 2014) and Kezar and Eckel (2002). During the coding process, we updated and revised the coding scheme with emergent codes; each transcript was read three times and coded on the second and third passes. Throughout the analysis, we wrote analytic memos to explicate the coding categories, identify patterns and themes, and investigate the implicit meanings and underlying assumptions within the data (Charmaz, 2001).

3 Results

In the initial stages of strategic partnership formation, we find that the teams have been focused on identifying potential partners, motivating partnerships, and building shared vision. The teams described having developed a broad range of partnerships in order to further their work. Seven teams were working with professional associations or networks, such as using professional organizations as a venue to push dialogue about change to other institutions. Six teams were deepening connections with industry, while seven teams mentioned relationships with their campus centers for teaching and learning. Other partners included: campus administration and support offices, campus initiatives, a non-profit organization, a state legislature, and local high schools. Some of these relationships were extensions of prior strategic partnerships, some were initiated during the proposal writing process, and some began after the grant was funded.

3.1 Identifying Potential Partners

RED teams have voiced a variety of instrumental motivations for building strategic partnerships as a part of their projects, including: finding allies for their projects, attracting resources, supplementing skill sets, and navigating bureaucracy. In order to connect to potential partners, RED team members have leveraged their individual social capital, building relationships through their pre-existing connections and relying on prior working relationships. For example, to partner with a faculty development program for improving campus diversity and inclusion, one team relied on "really good personal ties and investments from that group." Two teams' PIs were already involved in consortiums, one national and one state-level, whose missions complemented the teams' goals; their connections in these consortiums helped them find institutions and individuals who wanted to amplify and support the teams' work.

A few new partners were identified by looking at the local environment beyond teams' personal connections, in order to meet specific goals for their projects. For example, one team hosted a "speed networking event" on campus to build connections and identify potential partners. Another team worked to forge a new partnership with their campus teaching center. In their baseline focus group, one of their team's members said, "My impression is that they are very eager to help, but most of their experiences are not in Engineering. I think they consider that as a challenge and an opportunity for them to learn from us." In a later conversation, this same team reflected back on the beginnings of this partnership and stated, "When we approached them and told them what we were planning, they got extremely excited." Thinking beyond conventional partners helped teams reach out to groups who were eager to collaborate but may have been overlooked or ignored in the past.

RED teams have continued to build strategic partnerships as their projects have progressed. After seeing how many of their students struggled with writing, one team reached out to an English professor. A team member explained:

> After seeing [our students struggle], we decided that, of course, the conventional answer would be to point fingers at the English Department and say, “Wow, you take so many English classes, what about it?” or “What happened?” We met and talked to the professor in charge of the rhetoric program … He looked at what we do and he essentially told us we weren’t quite doing things the right way, and there were better ways to teach writing than what we were doing … That is what has been evolving over the last year [as we learn] how to do that properly, and ultimately that has resulted in institutionalizing the change. We have revised our curriculum.

When RED teams encountered challenges, such as students struggling with writing, rather than placing blame they saw an opportunity for seeking a strategic partnership to meet their change project’s needs.

3.2 Motivating Partnerships

Teams had opportunities, resources, and collaborative products they could offer to motivate partnership (Doten-Snitker et al., 2020). The value to partners might be through specific features of the change project, the organizational capital of the department or institution, or even factors entirely external to the project. Several teams experienced particular success through connecting to institutional initiatives. One of these teams was partnering with a campus-wide effort on communication skills; this team and the new partner attended each other’s workshops. “We are trying to embed what we are doing into the bigger picture, so that the system will align with our hopes and aspirations,” expressed a team member.

When crossing disciplinary and organizational boundaries, partners’ motivations were sometimes outside of what teams imagined the rewards to be. For example, one RED team noted: “We had someone from Art who is a sculptor; when she saw the size of our machine shop, [she said,] ‘Maybe I have a real excuse to talk to you people.’” Showing potential partners how the partnership aligned with their interests or commitments facilitated partnership formation.

RED teams have worked to establish supportive frameworks for their strategic partnerships by aligning goals and activities, building on their partner’s strengths, and creating mutually beneficial relationships. One team discovered that highly-involved staff members were champions of their projects because they “see these types of projects as more aligned with their job.” RED teams realized the need to embed respect into the structure of the partnership. For example, in describing a cross-disciplinary collaboration, one team member explained, “you don’t want to relegate the other discipline to some sort of service role, it needed to be of substance (i.e., not just grading papers).”

3.3 Building Shared Vision

In many of the partnerships, RED teams invited partners into a visioning process that reflects the ideas of the partners, not just that of the original team. Teams empowered their partners through formational communication, inviting stakeholders to contribute to the change process through offering alternative or additional ideas for goals or how to implement the change (Doten-Snitker et al., 2020). For example, one team described this process as follows:

> We invited our advisory board to participate in [a] brainstorming process with us—what are their perceptions for needs for change. And that was immensely beneficial. We repeated that in year two refining our ideas based on their comments.

Three other teams reported similar processes with their industrial advisory boards. A member of one of these teams remarked that a great benefit of their relationship with their board was "the advisory board seeing how they could contribute to the project now and over time." The other team developed a new project component through the leadership of the board, meeting needs in professional training that the board identified and using the board's capacities to develop and implement the new component.

A few of the teams worked to build shared vision from the beginning. For example, one team incorporated a potential strategic partner into the proposal writing process, while another team gathered commitments from potential partners in industry prior to submitting their grant application. Two teams brought up potential partnerships where they had mutual interest but had not yet decided with their partners what they should focus on. One team member explained, "I just got an email today, and they are excited about moving forward on this … We are brainstorming." In these nascent relationships, teams were engaging with potential partners in developing shared vision from the very first conversations about working together.

Yet RED teams also learned that sharing vision with strategic partners is an ongoing process, and continued effort must be put toward communication among strategic partners. One PI advised, "Don't think that everyone is going to interpret the milestones the same way … After the kickoff, we were still trying to clarify what the whole thing even was. It takes time to work through those things." Another team described a recent experience where their RED team and their strategic partner arrived at a meeting with different assumptions about the goals of the meeting. Communication, and cross-disciplinary communication in particular, was seen as a critical skill in building strategic partnerships.

4 Discussion

Our findings highlight the need to engage in an expansive search to identify potential partners and to leverage social capital to form these relationships. While initial efforts to build strategic partnerships may start with prior working relationships, it is important to look beyond one's immediate social network for potential partners, in order to meet the needs of your change project. By leveraging social capital (Eddy, 2010), it is possible to access a greater range of potential partners.

This research has indicated that RED teams are considering their projects and products from the perspective of the partner (Barnett et al., 2010) to motivate partnerships, including the partners' interests and needs as well as what they stand to gain from the collaboration. This is especially important in appealing to groups or individuals outside of one's social networks, who may have less intrinsic motivation to partner. While at times RED teams stumbled upon their potential partners' motivations, humble inquiry (Schein, 2013) offers an intentional method of learning about others' motivations, values, and goals. In addition, sharing one's own needs and interests early will help build trust in the relationship (Barnett et al., 2010).

We find that communication is important at every step within the initial stages of forming strategic partnerships, from identifying partners to motivating partnerships to building shared vision. These findings support prior research on the value of communication showing that partners must discuss and resolve disparate interests when initiating a partnership to minimize misunderstandings (Buys & Bursnall, 2007). Further, communication is a key component of building trust and mutual respect; these interpersonal processes are vital to being able to give constructive feedback within a strategic partnership (Sargent & Waters, 2004). Motivations for the partnership are likely to change over time (Amey, 2010), and partners need to continue to engage in conversation about their commitment as the relationship and joint project evolves.

This analysis has focused on the initiation and clarification stages of strategic partnership formation, identifying successful practices for building collaborative relationships in these early stages. These lessons extend to implementing and sustaining strategic partnerships as well. While the dynamics of the collaboration will shift over time (Barnett et al., 2010), partners must continue to communicate about workload balances, rewards and recognition for their work, and overall project goals. Open and regular communication is necessary to ensure equitable input, mutual benefits, and a continued shared vision (Buys & Bursnall, 2007; Hudson, 2016). Key to this work is the recognition that all partners need to engage in developing a shared vision for the project. Through shared vision building and democratic decision-making, these strategic partnerships may provide a framework to sustain changes for the long-term.

5 About the Authors

Cara Margherio is the Assistant Director of the Center for Evaluation & Research for STEM Equity at the University of Washington.

Kerice Doten-Snitker was a Graduate Research Assistant in the Center for Evaluation and Research for STEM Equity (CERSE) at the University of Washington and will be a Postdoctoral Scholar in the Department of Social Sciences and a Junior Researcher in Sociology in the Carlos III-Juan March Institute at Universidad Carlos III de Madrid.

Julia M. Williams is Professor of English in the Department of Humanities, Social Sciences, and the Arts at Rose-Hulman Institute of Technology.

Elizabeth Litzler is Director of the Center for Evaluation & Research for STEM Equity at the University of Washington and Affiliate Assistant Professor in Sociology at the University of Washington.

Eva Andrijcic is an Associate Professor of Engineering Management at Rose-Hulman Institute of Technology.

Sriram Mohan is a Professor of Computer Science and Software Engineering at Rose-Hulman Institute of Technology.

6 References

Amey, M. J. (2010). Leading partnerships: Competencies for collaboration. *New Directions for Community Colleges* (149), 13–23. https://doi.org/10.1002/cc.391

Ansay, S. J., Perkins, D. F., & Nelson, C. J. (2004). Interpreting outcomes: Using focus groups in evaluation research. *Family Relations, 53*(3), 310–316. https://doi.org/10.1111/j.0022-2445.2004.0007.x

Barnett, B. G., Hall, G. E., Berg, J. H., & Camarena, M. M. (2010). A typology of partnerships for promoting innovation. *Journal of School Leadership*, *20*(1), 10–36. https://doi.org/10.1177/105268469900900602

Buys, N., & Bursnall, S. (2007). Establishing university–community partnerships: Processes and benefits. *Journal of Higher Education Policy and Management*, *29*(1), 73–86. https://doi.org/10.1080/13600800601175797

Charmaz, K. (2001). Grounded theory. In R. M. Emerson (Ed.), *Contemporary field research: Perspectives and formulations* (pp. 335–352). Waveland Press.

Doten-Snitker, K., Margherio, C., Litzler, E., Ingram, E., & Williams, J. (2020). Developing a shared vision for change: Moving toward inclusive empowerment. *Research in Higher Education*, 1–24. https://doi.org/10.1007/s11162-020-09594-9

Eddy, P. L. (2010). *Partnerships and collaboration in higher education: AEHE (Vol. 2).* John Wiley & Sons.

Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Tobinson, T. J., Summers, M. F., Werner-Washburne, M., & Zavala, M.-E. (2016). Improving underrepresented minority student persistence in STEM. *CBE—Life Sciences Education*, *15*(3), es5. https://doi.org/10.1187/cbe.16-01-0038

Farrell, P. L., & Seifert, K. A. (2007). Lessons learned from a dual-enrollment partnership. *New Directions for Community Colleges* (139), 69–77. https://doi.org/10.1002/cc.294

Hoffman-Johnson, G. (2007). Seamless transition in the twenty-first century: Partnering to survive and thrive. *New Directions for Community Colleges* (139), 17–27. https://doi.org/10.1002/cc.289

Hudson, R. (2016). *Creating university/K–12 partnerships for the enhancement of educational leadership preparation and increasing student achievement: Sustainability factors, barriers, and benefits* [Doctoral dissertation, Auburn University]. Auburn University Electronic Theses and Dissertations. https://etd.auburn.edu/handle/10415/5166

Kezar, A. (2011). *Understanding and facilitating organizational change in the 21st century: Recent research and conceptualizations*. John Wiley & Sons.

Kezar, A. (2014). *How colleges change: Understanding, leading, and enacting change*. Routledge.

Kezar, A., & Eckel, P. (2002). Examining the institutional transformation process: The importance of sensemaking, interrelated strategies, and balance. *Research in Higher Education*, *43*(3), 295–328. https://doi.org/10.1023/A:1014889001242

Klein, C. (2017). Negotiating cultural boundaries through collaboration: The roles of motivation, advocacy and process. *Innovative Higher Education*, *42*(3), 253–267. https://doi.org/10.1007/s10755-016-9382-7

Lofland, J., & Lofland, L. H. (1995*). Analyzing social settings: A guide to qualitative observation and analysis*. Wadsworth.

Morgan, D. L. (1996). Focus groups. *Annual Review of Sociology*, *22*(1), 129–152. https://doi.org/10.1146/annurev.soc.22.1.129

Reed, G. G., Cooper, J. E., & Young, L. (2007). A partnership in flux: The demise of a program. *New Directions for Community Colleges* (139), 79–90. https://doi.org/10.1002/cc.295

Sargent, L. D., & Waters, L. E. (2004). Careers and academic research collaborations: An inductive process framework for understanding successful collaborations. *Journal of Vocational Behavior*, *64*(2), 308–319. https://doi.org/10.116/j.jvb.2002.11.001

Schein, E. H. (2013). *Humble inquiry: The gentle art of asking instead of telling*. Berrett-Koehler Publishers.

Timmermans, S., & Tavory, I. (2012). Theory construction in qualitative research: From grounded theory to abductive analysis. *Sociological Theory*, *30*(3), 167–186. https://doi.org/10.1177/0735275112457914

Worrall, L. (2007). Asking the community: A case study of community partner perspectives. *Michigan Journal of Community Service Learning*, *14*(1), 5–17.

13. Transforming Teaching Evaluation in Disciplines: A Model and Case Study of Departmental Change

SARAH E. ANDREWS, JESSICA KEATING, JOEL C. CORBO, MARK GAMMON, DANIEL L. REINHOLZ, AND NOAH FINKELSTEIN

Current teaching evaluation systems for merit, reappointment, tenure, and promotion decisions in higher education, particularly at research institutions, often poorly measure teaching effectiveness (Bradforth et al., 2015) and lack systematic processes for reflection and formative development of teaching quality. These systems typically over-rely on end-of-semester student evaluations (SETs), which have been shown to be susceptible to bias (Huston, 2006; Li & Benton, 2017; MacNell et al., 2015; Youmans & Jee, 2007). They can also be inconsistent within and across departments for a given institution, making it particularly difficult to track change over time. In response to these concerns and national calls for improvement to teaching quality (e.g., National Academies of Sciences, Engineering, and Medicine [NASEM], 2018; President's Council of Advisors on Science and Technology, 2012; Seymour & Hewitt, 1997), the Teaching Quality Framework Initiative (TQF) is creating a process and tools for systemic transformation of departmental evaluation of teaching at the University of Colorado Boulder (CU-B).

As part of the multi-institutional TEval project (Finkelstein et al., this volume), the TQF is grounded in the scholarship of higher education (e.g., Bernstein, 2002; Bernstein et al., 2010; Glassick et al., 1997), institutional and organizational change in academic contexts (e.g., Corbo et al., 2016; Elrod & Kezar, 2017; Kezar, 2013; Reinholz et al., 2017; see also Kezar & Miller, this volume), and scholarly approaches to teaching and learning (e.g., Beach et al., 2016; Boyer, 1990; Fairweather, 2002). We focus on evaluation of teaching as this can directly impact long-term objectives of institutions of higher education, including increased valuation of teaching, externalization of departmental and institutional expectations about teaching and learning, improved instruction and student outcomes, a systematic approach to broadening diversity and inclusion, and a shift in culture toward a scholarly approach to teaching. TQF objectives span across multiple scales and include, but are not limited to: 1) aligning and sharing resources, processes, and values across departments, 2) identifying evidence-based measures of teaching quality and adapting to department needs, 3) adopting these quality measures campus-wide, 4) helping departments and the university establish guidelines for what teaching excellence means for merit, reappointment, tenure, and promotion (contextualized to department), 5) enhancing the visibility and value of teaching campus-wide, 6) supporting a national movement to value educational practices, and 7) influencing policy and value-setters (e.g., the Association of American Universities [AAU]).

In this chapter, we briefly present the overall framework for change and the structure of TQF activities, explore the departmental layer of change in detail by presenting a three-phase process (cultivating interest, forming departmental teams, facilitating regular departmental team meetings), and then describe a case study of one department that has engaged in all three phases. The TQF Initiative currently (May 2020) supports 19 units (11 STEM, eight non-STEM) across three colleges (Arts & Sciences, Engineering & Applied Sciences, and Business) at CU-B: eight in Phase 1, three in Phase 2, and eight in Phase 3. We complement the three-phase process (where departmental level change happens) with regular stakeholder meetings, outreach to key administrative officials, and the sharing of resources and ideas across departments to create campus-wide change. We anticipate the tools and approaches that we describe in this chapter will be of interest and use to multiple stakeholders, particularly policy makers, education researchers, and change agents.

1 TQF Framework model

The TQF Initiative framework model for improved teaching evaluation is based on several components: a rubric grounded in scholarship around higher education, teaching and learning, and teaching evaluation; the use of multiple measures from multiple voices (the faculty member being evaluated, their peers, and students); explicit attention to formative as well as summative assessment practices; the alignment of the rubric with the multiple measures/voices, and the use of the rubric in summative evaluations for merit, reappointment, tenure, and promotion (Figure 1). The TQF assessment rubric was developed from foundational scholarship (Boyer, 1990; Glassick et al., 1997) and work at the University of Kansas (Greenhoot et al., 2017). An early structure was based around six components of scholarly activity relevant to teaching (adapted from Glassick et al., 1997), but based on feedback from early TQF participants these were revised to the current seven dimensions of teaching effectiveness: 1) goals, content, and alignment, 2) preparation for teaching, 3) methods and teaching practices, 4) presentation and student interaction, 5) student outcomes, 6) mentorship and advising, and 7) reflection, development, and teaching service/scholarship. The full TQF assessment rubric can be found at: https://www.colorado.edu/teaching-quality-framework/TQF_Assessment_Rubric.

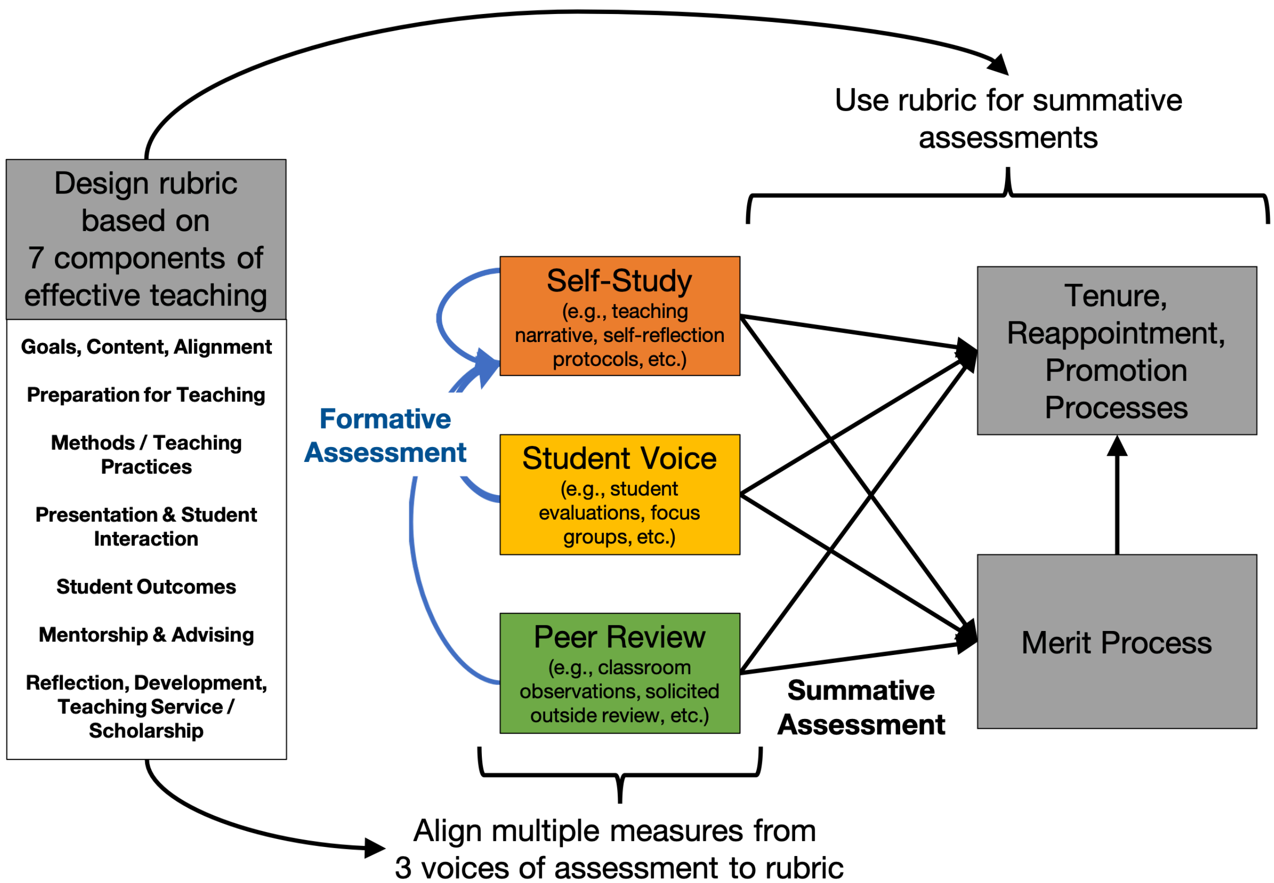


Figure 1. The Teaching Quality Framework (TQF) Initiative Framework Model for Improved Evaluation. Multiple measures from multiple voices are used to collect data that align with a rubric that is grounded in scholarship. These measures are used for formative/developmental purposes and as a scoring metric for summative assessment processes. (web: click on image to enlarge)

2 Structure of TQF activities

The TQF central team serves as a hub of resources, scholarship, and personnel, in communication and collaboration with individual academic units and administrators (Figure 2). TQF central members are broadly trained in STEM education, disciplinary-based education research, social psychology, information technology, higher education, and/or institutional/organizational change. In particular, facilitators are postdoctoral level research associates who are hired for their experience and skills in facilitation, project management, qualitative research, and program assessment. These skills are also developed on the job via training, shadowing, and co-facilitating with experienced facilitators (see Chasteen et al., 2015 and Reinholz et al., 2017 for similar examples of postdoctoral level researchers as facilitators).

At the center of the change process is support of departments through a three-phase departmental level process (encompassed by the dashed blue lines in Figure 2) that culminates in Departmental

Action Team (DAT) working groups (hereafter, TQF departmental teams). This new type of approach to faculty and departmental development uses externally-facilitated faculty teams to support sustainable departmental change by shifting departmental structures and culture (Corbo et al., 2016; Reinholz et al., 2017; also see Ngai et al. [this volume] for more on the DAT model and theory of change). TQF departmental teams are described further in Figure 3 and Sections 3 and 4 below. Regular campus meetings (one per semester) and annual national meetings with other institutions in the TEval project serve multiple purposes, including bringing together stakeholders from multiple levels (e.g., faculty, staff, and administrators), voicing support from administrators, and showcasing successes and new resources (e.g., the TQF FAQ and departmentally-defined measures). Sharing of resources in particular provides a means of facilitating common structures and language across departments, campus-wide, and cross-institutionally. Additionally, these meetings, along with cross-departmental meetings of faculty from Phase 3 departmental teams, help to build community and maintain engagement in the project by providing regular opportunities for stakeholders to converse with others working towards a common goal (improved teaching evaluation), and who are often grappling with similar challenges. It is not uncommon to hear from participants that they value knowing that they are not alone in the process. Finally, regular strategic meetings between TQF central and key administrative/institutional level stakeholders help sanction and garner support for the project and coordinate efforts campus wide (Margherio et al. [this volume] also describes example processes for building shared vision).

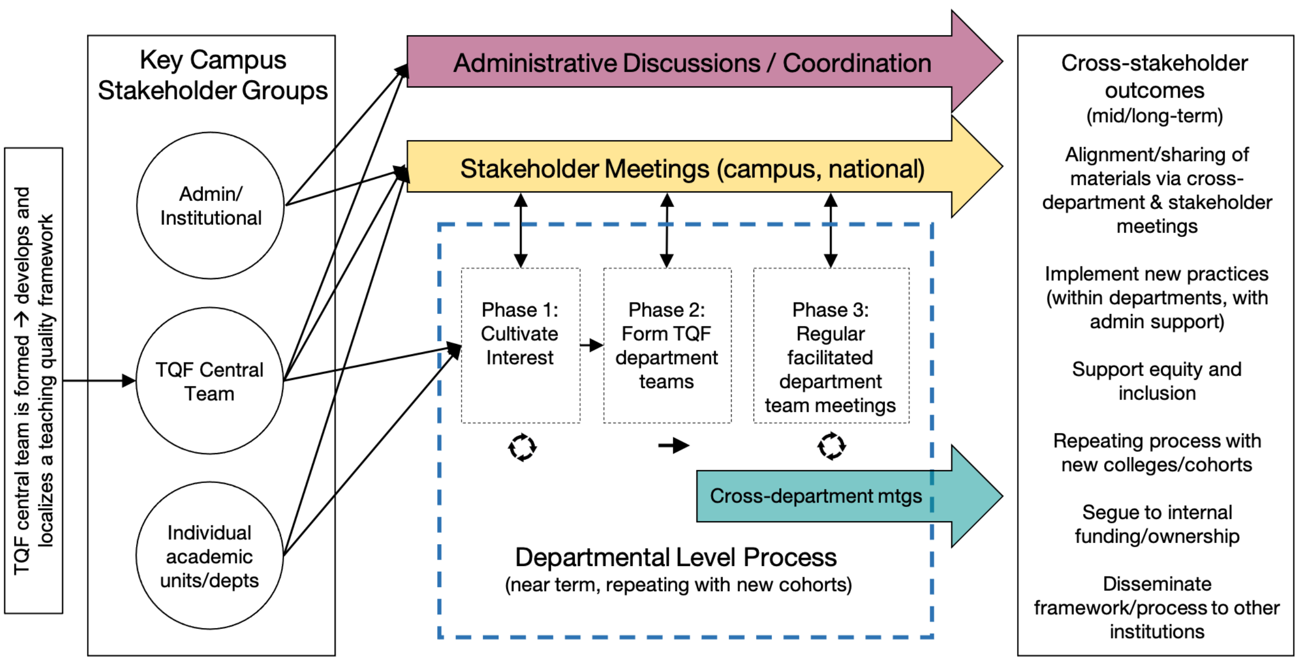


Figure 2. The Teaching Quality Framework (TQF) Initiative Structure of Activities. Key stakeholder groups (left) engage with each other via campus and national meetings (yellow arrow, central middle), with additional strategic meetings between TQF central and key administrative/institutional level stakeholders (pink arrow, central top). A dashed blue line encompasses the TQF three-phase departmental level process (center bottom box, expanded in Figure 3) and cross-departmental meetings (green arrow, center bottom) allow Phase 3 participants to share information. A short list of non-exhaustive expected outcomes of the project are included in the right-most panel. (web: click on image to enlarge)

3 TQF Three-Phase Departmental Process Model

The TQF initiative focuses on departments as the key unit of sustained change (see Marbach-Ad et al. [this volume] for another example of a departmental-level approach to change and theoretical background on departments as a key unit of change). The TQF three-phase departmental process includes: 1) cultivating interest, 2) forming departmentally based change teams, and finally 3) facilitating the working teams to design and enact the change.

3.1 Phase 1: Cultivating interest

In Phase 1 (Figure 3, left panel), departments express interest, which is cultivated via one-on-one meetings with TQF central members and attendance at regular campus-wide stakeholder discussions. Cultivating interest also involves awareness raising within a department, building on prior educational change efforts, and responding to external pressures and internal concerns (expanded upon in Table 1). Units may stay in Phase 1 for extended periods depending on: a) unit-level interest/support for active engagement (e.g., see characteristics that define department readiness for change, after Elrod & Kezar, 2017, in Table 2) and b) TQF central resources (e.g., time, personnel).

Table 1: Approaches for Cultivating Interest in Transforming Teaching Evaluation and the TQF Initiative.

Mode of Cultivating Interest	Description/Examples
Direct discussions with leadership	One-on-one meetings between TQF central member(s) and campus/department leadership to raise awareness of the project, discuss how TQF efforts may connect with campus/department efforts/goals, and address questions they may have related to the TQF Initiative.
Awareness raising via stakeholder meetings	Once per semester, TQF central organizes meetings for faculty from Phase 1, 2, and 3 units, key administrators, and other stakeholders such as students and representatives from units with overlapping goals (e.g., the Boulder Faculty Assembly, Office of Information Technology, Center for Teaching and Learning, Institutional Research, etc.). Typical meetings include TQF updates on the local and national status of the project (e.g., showcasing successes), guided discussions around a theme (e.g., student evaluations of teaching), and share-outs from Phase 3 units on tools and processes they have developed.
Awareness raising within a department	The TQF PI and/or a postdoctoral research associate give a brief presentation, typically during a faculty meeting. The presentation includes an overview of the framework (e.g., Figure 1), status/progress of the project as a whole and examples from other departments, and an explanation of what would be involved if they opt-in to forming a departmental team (e.g., a simplified explanation of Phases 2 and 3 from Figure 3). Faculty are then given the opportunity to ask questions, express concerns, share about related work they are doing in the department, etc.
Building on prior educational change efforts	In some cases, there are existing efforts within a department that overlap with or align with teaching evaluation in some way (e.g., efforts to create department-wide learning goals, implement evidence-based teaching practices, form teaching circles of peers who observe each other and meet collectively to discuss/share feedback, etc.). In such cases, the TQF central team works to show how TQF department teams could work with and build upon those efforts, rather than replace those efforts (e.g., build recognition for using departmental learning goals and/or evidence-based practices into departmental evaluation of teaching).
Responding to external pressures and internal concerns	External pressures such as accreditation or internal concerns such as dissatisfaction with one or more aspects of their current teaching evaluation practices (e.g., over-reliance on student evaluations of teaching, a lack of transparency in the annual merit evaluation process, perceived lack of value for quality teaching, etc.), can lead to a desire to improve departmental teaching evaluation practices. However, many departments lack knowledge on how to approach making such changes. TQF can respond to these concerns by providing a facilitator with a depth of expertise on teaching evaluation and institutional change, by brokering connections with key administrators, and by connecting them to other departments engaged in the work.

Table 2: Characteristics that Define Departmental Readiness for Change (after Elrod & Kezar, 2017) and Increased Engagement with the Teaching Quality Framework Initiative.

Characteristics Defining Readiness
Awareness of a need (by individual or groups of faculty and/or department leadership) within their department for improved evaluation of teaching
Interest and motivation as expressed by faculty and/or department chair
Consensus or critical mass (some significant proportion, yet to be defined, of the department must be aware of the need for change and be motivated enough to support the formation of a team and be open to making changes to their evaluation systems)
Commitment from department leadership (e.g., the chair, associate chair, and/or relevant committees)
Bandwidth and resources for enacting change (e.g., 3–6 department members are able to form a team and have time to meet regularly enough to drive progress, approximately twice per month)
Department culture that functions well in terms of internal communication and pathways toward change and sustaining the change efforts after TQF involvement

3.2 Phase 2: Forming a TQF departmental team

During Phase 2 (Figure 3, center panel), the TQF central team and departmental leadership coordinate to define timelines, processes, and members for the TQF departmental team using an opt-in model: departments choose to participate and determine who participates and how participants will be rewarded. While the formation of a team is typically left to the department to determine, TQF central members share and encourage the design of ideal characteristics of a team (Table 3). Methods by which TQF departmental teams have formed and/or team members have been recruited are included in Table 4. Incentives for participation are also determined primarily by the department; TQF central members share a few options on how they might provide incentive for participation (e.g., pay, service credit, or course release) and then let departments take the lead. Phase 2 can occur over a short time period (e.g., weeks) or may extend over longer periods depending primarily on the length of time it takes departments to recruit team members and determine incentive structures.

Table 3: Guidelines for Characteristics Considered When Recruiting TQF Departmental Team Members.

Characteristics	Additional Explanation/Notes
Ensure representation from different voices within the department	What this means may vary by department, but some examples include representation across ranks (instructor, tenure-track, tenured), demographic variability (e.g., gender, race/ethnicity, time in department), and representation from people who teach different course types (e.g., lower division versus graduate, online versus in-class or hybrid, language learning versus culture, lecture versus lab, etc.).
Secure one or more department members who are well placed with power and status within the department	People who may be initially skeptical of changing teaching evaluation practices but who could be brought on board can be quite powerful in terms of helping to change minds in the department. However, people who are immovably skeptical and uncompromising can inhibit efforts and should be avoided.
Where possible, select members who are well placed within department structures that are related to teaching evaluation	Examples include associate chairs, chairs, personnel committee members, peer evaluation committee members, etc.
Include several people who are enthusiastic and care deeply about teaching	The team should not be made up exclusively by such people, as in some departments there can be stigma associated with a heavy focus on teaching and they may experience trouble getting recommendations from the team accepted in the broader department. Ideal candidates are those who both care deeply about teaching/pedagogy and who are well respected in the department.
The team should be made up of people who are comfortable working with each other	Examples include department members who have a reputation as team players and/or who have a history of working well together (e.g., have worked on other committees successfully), etc.

Table 4: Examples of Methods Used to Form TQF Departmental Teams and/or Recruit Team Members.

Methods Used by Departments to Form TQF Departmental Teams
Formation out of existing committees or structures (e.g., a Faculty Learning Community [FLC] or an Undergraduate Studies Committee)
A department-wide call for volunteers, taking whoever was interested (attending to characteristics in Table 2 where possible)
Assignment to the team by the department chair
Individual recruiting by the department lead (i.e., the person coordinating with TQF central)
Some combination of the above (e.g., a department-wide call followed by assignment by a chair or recruiting additional members to an existing committee or structure)

3.3 Phase 3: Regular Facilitated TQF Departmental Team Meetings

In Phase 3 (Figure 3, right panel), TQF departmental teams engage in regular, facilitated meetings to align their teaching evaluation practices with the TQF framework. They typically begin by reviewing the framework (e.g., Figure 1 and the TQF assessment rubric) to ensure they understand the context and goals they are working toward. Facilitators use probing questions to help faculty externalize their current teaching evaluation practices (e.g., “Can you describe how your department currently determines annual merit? Is this process written down? How often does it change?”), and areas of common concern (e.g., “Is there a particular part of the merit process that causes tension in your department?”). Having them share about common teaching practices in their department and the extent to which they are already engaging in and encouraging the use of evidence-based practices can help faculty start to externalize department values around teaching. As teams select an aspect of their teaching evaluation system to improve and begin working on adapting existing tools and processes, they continue to explicate their values around teaching as they make decisions on the structure and content of these tools/processes. For example, many teams start by focusing on peer observation with the goal of developing a structured protocol for observations. As faculty review existing protocols and make choices about which one(s) they prefer and adapt the content to their discipline, they continuously engage in conversations about teaching practices in their department and the degree to which they believe they could achieve department buy-in to the content and form of the protocol and procedures for its use. Once a team has completed a draft of a particular tool/process, they typically move towards departmental implementation of the tool/process outside of team meetings (touching base in meetings as needed to facilitate implementation) and move on to a new tool/process during team meetings. In other words, they typically take a piecemeal, iterative approach rather than developing a completely revised system before seeking departmental approval. The processes for gaining approval for departmental implementation vary somewhat by department and are still being studied, but in general involve: 1) sharing the tool/process with representatives from relevant committees and other key members of the department (as defined by the team members), 2) revisions as needed, 3) sharing the revised tool/process department wide for more extensive review and feedback (e.g., via sending an email to the entire department and/or discussing in a department-wide meeting), 4) additional revisions as needed, and 5) a departmental vote on whether to adopt the new tool/process.

The TQF Initiative has supported three cohorts engaged in Phase 3. The two units in Cohort 2 (one STEM, one non-STEM) are special cases in that they have engaged in the process but have had only minimal facilitation by the TQF central team; they are closer to a consultation model that we have not finished defining and are thus out of the scope of this chapter. The other six Phase 3 departments are split evenly between Cohort 1 (all STEM) and Cohort 3 (all non-STEM). While Cohorts 1 and 3 are separated in time (Cohort 1 started in Fall 2017/Spring 2018 and Cohort 3 started in Fall 2018/Spring 2019), the defining characteristics of the cohorts are similarity in structure, process, activities engaged in, and resources available to the TQF departmental team when it commenced. Cohort 1 spent more time early on reviewing the TQF framework, externalizing current practices, and creating common understanding of effective teaching practices, and thus spent a significant amount of time on more abstract discussions. As a result, they made less early progress toward achieving concrete goals (e.g., revisions to their current teaching evaluation practices). The TQF facilitators started to make progress toward such goals when they assembled a wide array of peer observation protocols and showed the TQF departmental teams the landscape of possibilities for such data sources.

The TQF departmental teams entering Cohort 3 benefitted from starting later in the Initiative, as the TQF departmental team process was modified based on facilitator experiences with Cohort 1. In particular, TQF facilitators modified their approach to move more quickly to working on concrete goals by, for example, identifying an aspect of their current teaching evaluation that they believed could be improved, identifying the range of possible tools already available, selecting the one that best fit their needs, and modifying as needed. Other aspects of the Phase 3 cycle, such as reviewing the framework and creating a common understanding of teaching excellence were touched upon early but were then revisited as needed throughout; working on a specific tool/process placed these more abstract conversations in a concrete context and so their discussions could be more productive and efficient. Cohort 1 is now following a similar process to Cohort 3 (e.g., working on concrete goals and cycling back to the framework or other aspects as needed).

All eight of the Phase 3 departments/units have developed new or revised tools and processes for teaching evaluation, including protocols for peer observation, self-reflection, student rating systems, and classroom interviews. Many of these tools and processes are now publicly available on the TQF website (TQF Initiative, n.d.).

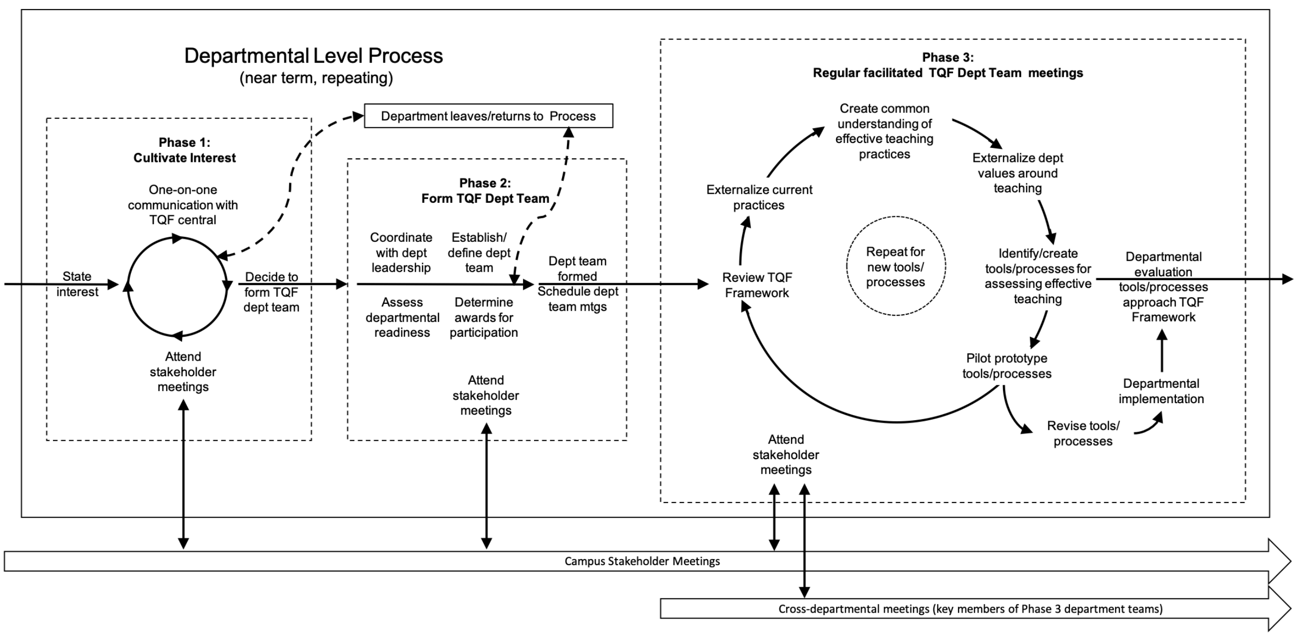


Figure 3. The TQF Three-Phase Departmental Level Change Process. Departments that have expressed interest in engaging with the TQF Initiative begin in Phase 1 (left panel), where interest is cultivated. During Phase 2 (center panel), the TQF central team and departmental leadership coordinate to define timelines, processes, and members for TQF departmental teams. In Phase 3 (right panel), TQF departmental teams engage in regular facilitated meetings to align their teaching evaluation practices with the TQF framework. These facilitated TQF department team meetings are complemented with regular stakeholder and cross-departmental meetings (bottom arrows). (web: click on image to enlarge)

4 A Case Study of the TQF Three-Phase Departmental Process: The Juniper Department

The Juniper department (fictitious name) is a humanities department in the College of Arts & Sciences at CU-B.

4.1.1 Juniper Department Phase 1

In October 2017, a faculty member contacted the TQF central team: she was on the department's committee responsible for reviewing materials for annual merit and had been tasked with proposing an alternative teaching evaluation method for their merit process. Between this first contact and April 2018, she, along with the two other members of the committee, one of whom was the department chair, met with TQF team member Keating several times, and at the end of April, they held a listening session during one of their department-wide meetings. Through these meetings, it became clear that the Juniper department was ready for change. They had consensus that their current system of teaching evaluation for merit was problematic and were particularly dissatisfied with the heavy weight given to the omnibus questions on the SETs (e.g., "rate your instructor overall" and "rate the course overall"), particularly due to concerns about bias. But they lacked the expertise and time to survey the landscape of research and come up with alternatives to their system. In the spring, TQF central did not have the capacity to take on an additional departmental team, but it was decided that they could begin in Fall 2018.

4.1.2 Juniper Department Phase 2

Phase 2 occurred during the summer of 2018. The three people who initially approached TQF in Phase 1 became the first Juniper TQF departmental team members (one was assigned the role of team lead, i.e., the person coordinating with TQF central) and an additional two faculty were recruited via a department-wide call for volunteers. The five members of the Juniper team included three instructors, one associate professor, and one full professor (who is also the department chair), four of whom were women and one of whom was a man. Incentives for participation were determined internally by the department and are unknown at this time but at minimum were counted as a service assignment. In late August 2018, a member of the Juniper team attended the Fall 2018 stakeholders' meeting and the Juniper team and TQF central scheduled meetings for the coming term.

4.1.3 Juniper Department Phase 3

The Juniper Department began regular TQF facilitated team meetings (approximately two per month) in the fall of 2018. They were part of Cohort 3 and benefited from TQFs experiences working with Cohort 1 (as described in section 3.3 above). Two TQF facilitators (postdoctoral-level scholars Andrews and Keating) intentionally focused the departmental team as quickly as possible on beginning the work of revising specific tools and processes. In the first meeting, they were re-introduced to the TQF project and framework model (Figure 1) and engaged in a facilitated discussion around their current teaching evaluation practices and potential areas they felt most needed addressing. By the second meeting, they were already reviewing the landscape of peer-observation protocols and beginning the work of selecting a protocol that best fit their needs (the UTeach Observation Protocol [UTOP]; Walkington & Marder, 2014; Wasserman & Walkington, 2014) and modifying it to reflect their discipline and teaching values. By the end of their first semester of facilitated meetings, they were able to bring a peer-observation protocol and procedures for their use to their department as a whole, and in early Spring 2019, the Juniper department voted to implement these in Fall 2019.

Also in Spring 2019, the first several Juniper team meetings delved back into the framework and discussions around their current merit system. In particular, they reviewed their system with an eye toward alignment with the framework. They then spent several meetings alternating between working on a guide for incorporating self-reflection into their merit system, and a teaching evaluation rubric (based on the TQF assessment rubric) to evaluate multiple measures from multiple voices (self-reflection, peer observation, SETs, and course materials) for annual merit. Members of the Juniper team also attended the TQF stakeholders' meeting and the inaugural cross-departmental team meeting (one to two members from each Phase 3 department team) in the spring of 2019.

In late spring 2019, the Juniper team members brought their self-reflection guide and merit evaluation plan to the rest of the department for a vote, which was successful: the new system, which includes revised tools and approaches for peer review, self-reflection, and student ratings, was used in Spring 2020 to evaluate materials from the 2019 calendar year. Currently (May 2020), the Juniper department is still engaged with TQF with plans to connect as needed to aid implementation of their new tools and processes and to consider ways they may help their faculty prepare materials for the new system.

5 Ongoing Efforts and Future Steps

The TQF continues to gain momentum as a fourth cohort of five departments within a single college will be entering Phase 3 starting in Fall 2020. Cohort 4 will be similar to Cohort 3 in most aspects but will include structures (e.g., college-level cross-department team meetings) to foster collaboration and facilitate alignment of teaching evaluation structures within the single college. Other departments (e.g., the Juniper department described above) are reaching a point where they are transitioning from the TQF facilitated departmental teams of Phase 3 to a consulting model (in the process of being defined, but generally, TQF central will provide support as needed) with different needs/goals. We are reaching a point where TQF central resources are being outpaced by the increased level of interest in engaging with the process and so are: 1) developing a toolkit that can be used by interested departments in the absence of a TQF facilitator (but with consultation), and 2) exploring mechanisms to institutionalize the project. We are also actively connecting with other units of the TEval coalition (University of Massachusetts Amherst and the University of Kansas), and the BayView Alliance, NSEC, and NASEM efforts in teaching evaluations.

6 Acknowledgements

We are grateful to a department team member participant from the “Juniper” Department for their review of this paper. Comments from four anonymous reviewers also greatly improved this paper. We are also grateful for the support of the NSF (grant DUE-1725959), the TEval coalition, the Bayview Alliance, the AAU, CU-B College of Arts and Sciences, College of Engineering & Applied Science, and Leeds School of Business. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of any of these funders.

7 About the Authors

Sarah Andrews is a Research Associate in the Center for STEM Learning at the University of Colorado Boulder.

Jessica Keating is an Assessment Analyst in the Office of Data Analytics (ODA) and collaborator/ former postdoctoral researcher for the Teaching Quality Framework (TQF/TEval) at the University of Colorado Boulder.

Joel C. Corbo is a Senior Research Associate in the Center for STEM Learning at the University of Colorado Boulder.

Mark Gammon is a sociologist and Learning Development & Design Manager in the Office of Information Technology at the University of Colorado Boulder.

Daniel Reinholz is an Assistant Professor in the Department of Mathematics and Statistics at San Diego State University.

Noah Finkelstein is a Professor in the Department of Physics and co-Director of the Center for STEM Learning at the University of Colorado Boulder.

7 References

Beach, A. L., Sorcinelli, M. D., Austin, A. E., & Rivard, J. K. (2016). *Faculty development in the age of evidence: Current practices, future imperatives*. Stylus Publishing, LLC.

Bernstein, D. (2002). Representing the intellectual work in teaching through peer-reviewed course portfolios. In S. F. Davis & W. Buskist (Eds.), *The teaching of psychology: Essays in honor of Wilbert J. McKeachie and Charles L. Brewer* (pp. 215–229). Lawrence Erlbaum Associates. http://hdl.handle.net/1808/7987

Bernstein, D. J., Addison, W., Altman, C., Hollister, D., Komarraju, M., Prieto, L., Rocheleau, C., & Shore, C. M. (2010). Toward a scientist-educator model of teaching psychology. In D. F. Halpern (Ed.), *Undergraduate education in psychology: A blueprint for the future of the discipline* (pp. 29–45). American Psychological Association. https://doi.org/10.1037/12063-002

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. The Carnegie

Foundation for the Advancement of Teaching.

Bradforth, S. E., Miller, E. R., Dichtel, W. R., Leibovich, A. K., Feig, A. L., Martin, J. D., Bjorkman, K. S., Schultz, Z. D., & Smith, T. L. (2015). University learning: Improve undergraduate science education. *Nature, 532*(7560), 282–284. https://doi.org/10.1038/523282a

Chasteen, S. V., Perkins, K. K., Code, W. J., & Wieman, C. E. (2015). The Science Education Initiative: An Experiment in Scaling Up Educational Improvements in a Research University. In G. C. Weaver, W. D. Burgess, A. L. Childress, & L. Slakey (Eds), *Transforming institutions: Undergraduate STEM education for the 21st Century* (pp. 125–139). Perdue University Press. https://www.researchgate.net/publication/296705160_The_Science_Education_Initiative_An_Experiment_in_Scaling_Up_Educational_Improvements_in_a_Research_University

Corbo, J. C., Reinholz, D. L., Dancy, M. H., Deetz, S., & Finkelstein, N. (2016). Sustainable change: A framework for transforming departmental culture to support educational innovation. *Physical Review Special Topics: Physics Education Research 12*, 010113. https://doi.org/10.1103/PhysRevPhysEducRes.12.010113

Elrod, S., & Kezar, A. (2017). Increasing Student Success in STEM: Summary of A Guide to Systemic Institutional Change. *Change: The Magazine of Higher Learning, 49*(4), 26–34. https://doi.org/10.1080/00091383.2017.1357097

Fairweather, J. (2002). The ultimate faculty evaluation: Promotion and tenure decisions. *New Directions for Institutional Research, 114*, 97–108. https://doi.org/10.1002/ir.50

Finkelstein, N., Greenhoot, A. F., Weaver, G., & Austin, A. E. (this volume). A department-level cultural change project: Transforming the evaluation of teaching. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 14). Pressbooks.

Greenhoot, A. F., Ward, D., & Bernstein, D. (2017). *Benchmarks for teaching effectiveness rubric*. The University of Kansas Center for Teaching Excellence. https://cte.ku.edu/rubric-department-evaluation-faculty-teaching

Glassick, C. E., Huber, M. T., & Maeroff, G. I. (1997). *Scholarship assessed: Evaluation of the professoriate. Special Report*. Jossey Bass Inc.

Huston, T. A. (2006). Race and gender bias in higher education: Could faculty course evaluations impede further progress toward parity? *Seattle Journal for Social Justice, 4*(2), article 34. https://digitalcommons.law.seattleu.edu/sjsj/vol4/iss2/34

Kezar, A. (2013). *How colleges change: Understanding, leading, and enacting change*. Routledge

Kezar, A., & Miller, E. R. (this volume). "Using a systems approach to change: Examining the AAU Undergraduate STEM Education Initiative." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 9). Pressbooks.

Li, D., & Benton, S. L. (2017). The effects of instructor gender and discipline group on student ratings of instruction. *IDEA Research Report #10*. The IDEA Center. https://www.ideaedu.org/Portals/0/Uploads/Documents/Research%20Reports/Research_Report_10.pdf

MacNell, L, Driscoll, A., & Hunt, A. N. (2015). What's in a name: Exposing gender bias in student ratings of teaching. *Innovative Higher Education, 40*(4), 291–303. https://doi.org/10.1007/s10755-014-9313-4

Marbach-Ad., G., Hunt, C., & Thompson, K. V. (this volume). "Using data on student values and experiences to engage faculty members in discussions on improving teaching." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 8). Pressbooks.

Margherio, C., Doten-Snitker, K., Williams, J., Litzler, E., Andrijcic, E., & Mohan, S. (this volume). "Cultivating strategic partnerships to transform STEM education." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 12). Pressbooks.

National Academies of Sciences, Engineering, and Medicine (2018). *Indicators for monitoring undergraduate STEM education*. The National Academies Press. https://doi.org/10.17226/24943

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. President's Council of Advisors on Science and Technology. https://files.eric.ed.gov/fulltext/ED541511.pdf

Reinholz, D. L., Corbo, J. C., Dancy, M., & Finkelstein, N. (2017). Departmental Action Teams: Supporting faculty learning through departmental change. *Learning Communities Journal, 9*, 5–32. https://www.researchgate.net/publication/327634179_Departmental_Action_Teams_Supporting_Faculty_Learning_Through_Departmental_Change

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Westview Press.

Teaching Quality Framework Initiative. (n.d.). *Teaching Quality Framework Initiative*. University of Colorado Boulder. https://www.colorado.edu/teaching-quality-framework/tools-for-teaching-evaluation

Walkington, C., & Marder, M. (2014). Classroom observation and value-added models give complementary information about quality of mathematics teaching. In T. Kane, K. Kerr, & R. Pianta (Eds.), *Designing teacher evaluation systems: New guidance from the Measuring Effective Teaching project* (pp. 234–277). John Wiley & Sons. https://doi.org/10.1002/9781119210856.ch8

Wasserman, N., & Walkington, C. (2014). Exploring links between beginning UTeachers' beliefs and observed classroom practices. *Teacher Education & Practice, 27*(2/3), 376–401. https://www.tc.columbia.edu/faculty/nhw2108/faculty-profile/files/TEP27(2_3)_Wasserman.pdf

Youmans, R. J., & Jee, B. D. (2007). Fudging the numbers: Distributing chocolate influences student evaluations of an undergraduate course. *Teaching of Psychology, 34*(4), 245–247. https://doi.org/10.1080/00986280701700318

14. A Department-Level Cultural Change Project: Transforming the Evaluation of Teaching

NOAH FINKELSTEIN, ANDREA FOLLMER GREENHOOT, GABRIELA WEAVER, AND ANN E. AUSTIN

1 Introduction

Promoting widespread use of evidence-based educational practices (EBEPs) is an important and continuing challenge across higher education institutions. Increasing the use of EBEPs requires explicit support and reward for faculty who embrace these practices, through methods of evaluating teaching that align with research on teaching and learning and that recognize the many facets of teaching. However, few universities employ such approaches to evaluation, usually relying instead on student surveys about their experiences, which focus on a narrow range of teaching practices and have been criticized for bias and other limitations (Stroebe, 2016; Uttl, 2016). Changing the processes for evaluating teaching can contribute to efforts to encourage the use of more effective teaching practices and support greater institutional commitment to high-quality teaching. A key to such cultural change is to focus on the department, given these are the primary units for faculty evaluation at most universities and the units in which faculty see themselves as having the greatest influence (Tagg, 2012, and each of the chapters in this section).

This chapter describes a coordinated approach to fostering change in teaching evaluation processes at the department level, with a focus on strategies that support departmental engagement in change. We draw on our experiences in a multi-institutional project, TEval, that is being carried out at a cluster of three public, research-intensive universities (TEval, n.d.). The TEval approach centers around department-level adaptation and use of a research-based framework that helps departments define and document the elements of teaching effectiveness. A central unit supports departments' adaptation, implementation, reflection and improvement of the system, and fosters communication and collaboration with other stakeholders and university leaders.

The cluster of three universities collaborating in this project constitute a networked improvement community (NIC) (Bryk et al., 2015), engaged together in an action research paradigm. Organizations that collaborate in taking an NIC approach share a clearly defined goal, develop a common understanding of the problem, test innovative approaches to handling the problem across diverse contexts, engage in rapid iteration, adaptation, and adjustment within each context, compare experiences and results, and learn from consideration of overall patterns and findings. Informed by principles of the NIC model, the three universities involved in the TEval project share a commitment to developing more holistic approaches to teaching evaluation that align with evidence-based teaching practices. They are each implementing a common rubric, while adapting the form and use of the rubric to their local institutional contexts, and tracking and comparing results to produce new insights and discoveries. Leaders and faculty participants from each campus regularly share experiences and results with colleagues from the other campuses at cross-campus knowledge exchanges. A cross-institutional case study is examining the process of transformation within and across the three campuses, focusing on what approaches work most effectively under what circumstances.

The primary purpose of this chapter is to introduce an NIC-based approach to transforming teaching evaluation. Since institution-level change is a time-consuming process, the departments involved in the project overall are still relatively early in implementation of the plans they have developed. Thus, in this chapter, we describe the common framework and related evaluation rubric (Section 2), as well as outline a set of common processes and commitments for helping departments contextualize and implement the framework (Section 3). Next, we provide brief descriptions of how these processes are being implemented at three campuses, allowing attention to different contexts as consistent with the principles of NICs (Section 4). Our on-going cross-institutional research and periodic Knowledge Exchanges that bring together leaders from across the institutions are enabling us to compare processes and begin to identify emerging lessons. In the final section, we offer some emerging (but still developing) observations based on the common and distinct approaches to promoting departmentally-based improvement of teaching evaluation taken by the participating universities (Section 5).

2 Our Common Framework

The evaluation approaches being advanced are based in a common framework that draws on 25 years of work on scholarly teaching and its evaluation (Bernstein & Huber, 2006; Glassick et al., 1997; Hutchings, 1995, 1996; Lyde et al., 2016) and related work on the peer review of teaching (see Bernstein, 2008). The framework for our approach provides a richer, more complete view of teaching practice and the evidence that speaks to it than most commonly used measures (Dennin et al., 2017; National Academies of Sciences, Engineering, and Medicine [NASEM], 2020a). The framework specifies that multiple dimensions of teaching activities should be evaluated, to capture the teaching endeavor in its totality, including aspects that take place outside of the classroom and that go beyond the teaching of individual courses. Table 1 shows the dimensions of the framework that are currently being enacted across the change effort. The seven dimensions are designed to span the full array of teaching activities (inside and out of the classroom) with equity and inclusivity as a theme running across all of the dimensions.

Table 1: Framework for Supporting a Scholarly Approach to Teaching Evaluation.

Teaching Dimension*	Description/Guiding Questions
Goals, content, and alignment	What are students expected to learn from the courses taught? Are course goals articulated and appropriate? Is content aligned with the curriculum? Are topics appropriately challenging and related to current issues in the field? Are the materials high quality and aligned with course goals? Does content represent diverse perspectives?
Teaching practices	How is in-class and out-of-class time used? What assignments, assessments, and learning activities are implemented to help students learn? to: Are effective and inclusive methods being used to support learning in all students? Do in and out of class activities provide opportunities for practice and feedback on important skills and concepts? Are students engaged in the learning process? Are assessments and assignments varied, enabling students to demonstrate knowledge through multiple means?
Achievement of learning outcomes	What impact do these courses have on learners? What evidence shows the level of student understanding and how does it inform the instructor's teaching? Are standards for evaluating students connected to program or other expectations? Are there efforts to support learning in all students and reduce inequities? Does learning support success in other contexts (e.g., later courses)?
Class climate	What sort of climate for learning does the faculty member create? What are the students' views of their learning experience and how has this informed the faculty member's teaching? Is the classroom climate respectful, inclusive, and cooperative? Does it encourage student motivation, efficacy, and ownership? Does the instructor model inclusive language and behavior?
Reflection and iterative growth	How has the faculty member's teaching changed over time? How has this been informed by evidence of student learning and student feedback? Have improvements in student learning or improved equity been shown, based on past course modifications?
Mentoring and advising	How effectively has the faculty member worked individually with undergraduate or graduate students? How does the quality and time commitment to mentoring fit with disciplinary and departmental expectations?
Involvement in teaching service, scholarship, or community	In what ways has the faculty member contributed to the broader teaching community, both on and off campus? Is the instructor involved in teaching-related committees, curriculum or assessment activities? Does the faculty member share practices or teaching results with colleagues?

**Note: These dimensions are drawn from the Benchmarks for Teaching Effectiveness Framework (Follmer Greenhoot, Ward, Bernstein, Patterson, & Colyott, 2020).*

The framework also specifies that multiple lenses (sources and types of data) should be used, including faculty self-report (e.g., course materials, evidence of students learning and reflections on it), peer/outside reviews (e.g., class visits, review of course materials), and student voices (e.g., student surveys, alumni letters, focus groups). Information from these sources, moreover, should be triangulated to provide convergent evidence on multiple categories of teaching activities. Each campus has operationalized this framework as a rubric, with guiding questions for each dimension and descriptions of different quality tiers of each one (ranging from novice to professional). These descriptions of different levels of performance provide scaffolding and feedback to improve teaching while also structuring the evaluation process.

The framework is designed to bring greater attention to the full range of activities that comprise teaching, to promote more serious consideration of multiple sources of information that speak to teaching effectiveness, to bring greater structure, consistency and validity to teaching evaluation, and to promote processes that support teaching improvement as well as evaluation. The framework is designed to be a starting point for department-level conversations.

3 Processes and Commitments to Change

As noted, the three campuses are enacting common processes, commitments and theories of change to support departments in using the framework to design and implement new approaches for teaching evaluation. A central unit on each campus guides departments through the cycle shown in Figure 1, to contextualize the framework (the rubric language and possible evidence for each dimension) to local disciplinary culture, implement it, and refine it based on results and lessons learned. For example, specific approaches for what counts as and how to measure student learning are likely different in history and physics, and these units are supported in identifying appropriate data sources, measures and processes. Further, the relative weighting of each dimension of effective teaching may vary by discipline. For example, some disciplinary units may value mentoring and advising more than others. All departments are asked to use information gathered from the self-report, peer review, and students, but also are encouraged to identify the combination of evidence and artifacts from these sources most appropriate for them. This approach provides the university with a common approach and language around teaching evaluation while preserving disciplinary identity and specificity.

In facilitating departmentally-based work, we draw from models of change that employ a bottom-up and top-down approach meeting a middle-out approach for change (Reinholz et al., 2015). In the *bottom-up approach*, departmental working groups of individual faculty are supported by the centralized transformation effort to identify specific tools and processes that address the benchmarks for teaching effectiveness described in section one. Recognizing the critical role of *top-down support*, the campus-based change initiative connects the departmentally-based work with institutional leadership and its processes and priorities for teaching evaluation. For example, in the UMass description below, the departmentally based work is aligned with goals and priorities of both the faculty union and the Office of the Provost. At Colorado and Kansas, the department work supports the faculty governance's calls to move away from student rating systems (e.g., Boulder Faculty Assembly [BFA], 2018) while fulfilling the Regents mandate for a student rating system. Applying a *middle-out* approach, each campus has its locus of action in department-wide discussion and adoption of the improved tools and processes developed by in-house working groups. Furthermore, the projects support cross-departmental sharing of the specific tools, approaches, challenges and solutions for improving teaching evaluations.

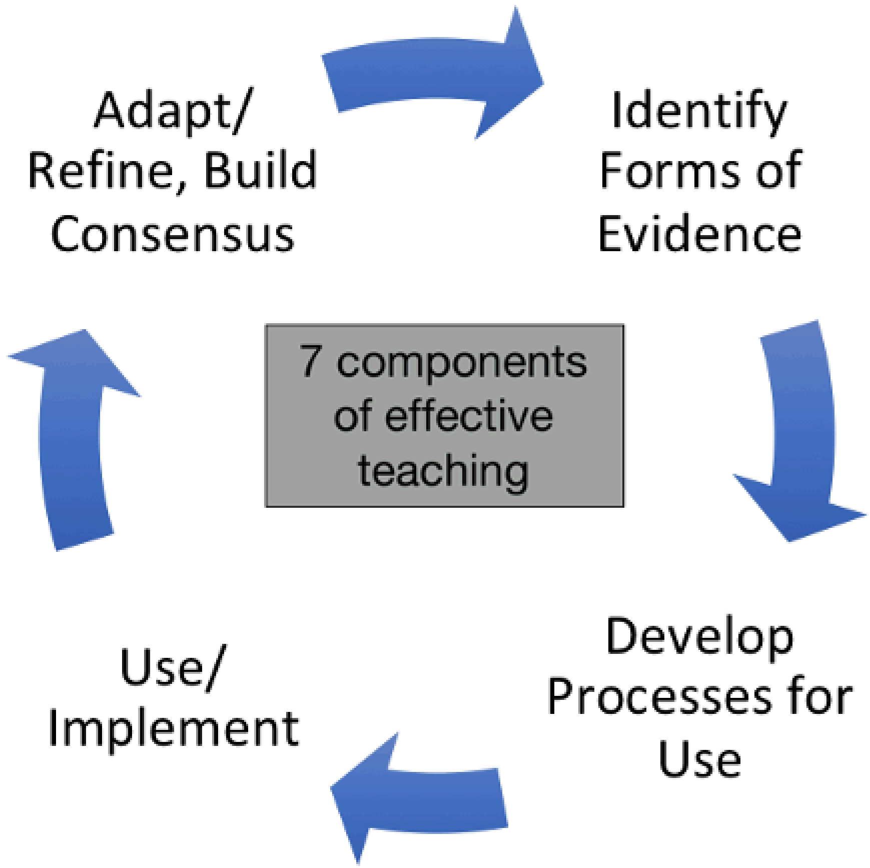


Figure 1. The Cycle of Department-Driven Adaptation, Use, and Refinement of the Rubric (web: click on image to enlarge)

The project holds core commitments to change, which support campus-wide and cross-campus cohesion. The commitments of this project include the following principles:

- *Voluntary engagement*—all units are welcomed but not required to participate in change
- *Scholarly approaches*—wherever possible, disciplines draw from evidence-based tools and processes and appropriate theories of change (ASCN, 2020 and chapters in this section).
- *Disciplinary-definition*—departments define their specific approaches.
- *Common-structure*—while locally enacted, a common framework applies to all units.
- *Balancing formative and summative approaches*—teaching evaluation should serve to improve education *and* to provide final evaluation of effectiveness.
- *Continuous improvement*—both the instructors and departments are continually refining teaching practices and evaluation of teaching.
- *Learner-facing and Inclusive*—ultimately, all units should support students, with particular attention to diversity, equity, and inclusion.

4 Implementation at Three Sites

4.1 University of Colorado Boulder

The University of Colorado Boulder (CU-B) approach, the Teaching Quality Framework Initiative (TQF, n.d.), presented in more detail in a case study (Andrews et al., this volume) was seeded by the Association of American Universities (AAU)'s STEM Education Initiative. The project includes three categories of stakeholders. TQF-central (a team of individuals housed in the Center for STEM Learning) manages the overall project, supports departmental engagement and contextualization of the framework, builds campus-wide community across all stakeholders, and coordinates with the administrative and institutional stakeholders to ensure campus wide support and alignment. Departments are facilitated using a Departmental Action Team (Corbo et al., 2016) approach, to contextualize the framework to local disciplinary culture, to establish processes for enacting evaluation, and to link these to departmental policies and structures. Campus-wide and administrative stakeholders include the associate provosts, deans, the faculty assembly, institutional research, information technology, the student council, and other campus groups committed to enhancing educational practice and faculty evaluation.

Departments engaged in three phases for enacting change. Phase 1 identifies department-wide interest, and includes departmental representatives in the campus-wide stakeholder meetings. Phase 2 identifies a working group of faculty, associated processes, and reward structures for the group. Phase 3 is a roughly year-long process where the departmental working team engages in facilitated discussions to identify appropriate forms of data, improved rating systems, observation protocols, etc. The working group also defines the processes and policies for enacting the new teaching evaluation system and where it applies (i.e. in annual merit and/or comprehensive review and tenure). For an example of departmentally based approaches to using the rubric, see materials in Teaching Quality Framework Initiative (n.d.).

Each semester, there are opportunities to share materials and approaches across disciplinary units. Additionally, once or twice per semester, a campus-wide stakeholder group gathers to align the disciplinary-based efforts with each other to campus priorities and resources. As of May 2020, 19 units were involved across three colleges: Arts and Sciences (A&S), Engineering, and Business. Eight departments have participated in the phase 3 process, creating new tools and processes for evaluating teaching in their units. The TQF initiative also partners with the Boulder Faculty Assembly to address calls for improved teaching evaluation (BFA, 2018), and the Office of Institutional Research piloting a new student evaluation of teaching (SET) rating system and new models for representing and using these SET data. Each of the colleges (A&S, Engineering, and Business) has provided support to fund staff at TQF-Central to enact change in their units, and have or are developing statements of commitment to enhanced teaching evaluation that align with the TQF approach.

4.2 University of Kansas

The University of Kansas (KU) effort, Benchmarks for Teaching Effectiveness, is led out of KU's Center for Teaching Excellence (CTE). University policy already requires multiple sources of information for teaching evaluation, therefore the primary focus of the KU project is on developing structures, procedures, and expectations that support more meaningful implementation of the policies. The effort began in 2015 when the CTE developed the Benchmarks rubric (Greenhoot et al., 2020) in response to growing faculty dissatisfaction with teaching evaluation practices, along with widening faculty participation in educational transformation. The Benchmarks rubric was built on a model of teaching as inquiry (e.g., Bernstein, 2008) that had guided CTE programs for years; the rubric translated those ideals into transparent expectations about effective teaching and was refined through broad input from stakeholders, including department chairs, CTE department ambassadors, and departments that piloted it for peer review of teaching.

As the hub of KU's TEval implementation, the CTE supports departments in carrying out the iterative process illustrated in Figure 1, while also collaborating with university leadership and governance structures to move towards institutionalization of a transformed approach. To ensure readiness and broad engagement, departments are selected through a competitive proposal process that prioritizes clear support from the department chair and broad faculty participation. Departments identify a project leader and a team of three or more faculty members to carry out the work. The CTE supports department-level work through a) mini-grant funds, b) monthly consultations with a CTE faculty leader, c) examples, templates, tools, and other resources (see materials in TEval, n.d.), and d) convening a cross-department working group that meets about twice a semester to share strategies, results, and lessons. Department teams produce a report each semester, and present their work at campus events/workshops. The goal is to provide accountability, generate artifacts for analysis by the PIs, give visibility to the work, and create models for other departments.

To date, 12 STEM and non-STEM departments in three cohorts have adapted and used the rubric and built consensus around it. Although all departments are working towards use of the rubric for promotion and tenure (P&T) evaluations, they vary in their starting points. Some have already implemented it in the P&T context (for department-level evaluation, or peer- or self-reviews that become part of the P&T package), whereas others are first using it in lower-stakes or formative settings, such as mentoring of pre-tenure faculty or peer-review "triads."

The CTE has also worked with administrators to align new requirements, recommendations, and infrastructure (e.g., requirements for the timing and quality of peer reviews, an online system for annual evaluation of contingent faculty and teaching professors) with the ideals embedded in the Benchmarks framework, and advocate the Benchmarks rubric as a tool for completing required processes. Additionally, participants and leaders in the Benchmarks initiative are serving on steering committees charged by the Provost Office and Faculty Governance to reconsider P&T guidelines on teaching and appropriate uses of student ratings.

4.3 University of Massachusetts, Amherst

The TEval project at the University of Massachusetts, Amherst (UMass) is a collaboration between the Office of Academic Planning and Assessment (OAPA) and the educational initiatives area of the Office of the Provost. The effort resulted from a task force review of external research about and processes for teaching evaluation, resulting in an internal white paper with recommendations for the UMass community. That task force was co-led by the directors of the OAPA and the UMass Center for Teaching Excellence and Faculty Development (TEFD), and its work preceded the funding of TEval by the National Science Foundation (NSF). The team recommended expanding campus approaches to teaching beyond student evaluations and that a model based on the KU Benchmarks work be adapted and implemented at UMass.

The TEval partnership with KU and CU-B allowed UMass to leverage the work that its task force had done and take action on recommended next steps with the funding provided by NSF. Each year of the first three years of TEval, the UMass leadership team selected departments from among those applying to participate in adapting and implementing a form of the Benchmarks rubric. The applications submitted for participation needed to demonstrate the department's commitment to expanding their approach to teaching evaluation, describe how the effort would be a department-wide one, and be co-led by the Head or Chair in addition to one or more faculty members. By supplementing NSF funding with funding from the Office of the Provost, departments from both STEM and non-STEM disciplines have been included in each of the three cohorts. To date, nine departments (four non-STEM, five STEM), representing four Colleges (Public Health and Health Sciences; Information and Computer Sciences; Humanities and Fine Arts; Natural Sciences) are involved.

One or two members from each participating department attend bi-weekly cross-departmental meetings with the project leadership team. These meetings allow for exchange of information between the leadership team and the participating departments, as well as among faculty from different departments. Importantly, these regular meetings serve to establish a learning community among those engaged in the process of transforming their departmental approach to the evaluation of teaching. The leadership team also meets with each participating department individually at least once per semester. If a department requests them, additional support or meetings are also arranged. Departments that began the project as part of the first cohort are still involved, which has allowed a natural peer-mentoring dynamic to emerge, while the multidisciplinary nature of the group cross-fertilizes ideas among participants.

The engagement of upper-level administration in the UMass effort has proven vital in maintaining forward momentum for the work. The initial task force was launched with support of the Provost, and the NSF-supported work has been reported at regular intervals to that office. In addition, leaders of the faculty union at UMass have been informed of the efforts from the time the task force white paper emerged. Engagement of these two groups has recently resulted in new wording being negotiated for the faculty contracts, which requires multiple sources of information being considered for teaching evaluation. While faculty have expressed a desire for evaluation methods beyond just student surveys, the effort required to integrate new approaches into the normal operations of departments involves time and work that many participants had not anticipated. Their dedication to date has been buoyed by the knowledge that the work may result in a template for campus-wide change, and that it is being supported by both the faculty union and the administration. Similarly, those changes would likely not be embraced if they were dictated from above rather than nurtured from within.

5 Lessons Learned and Next Steps

In addition to guiding the work within and across each of the three participating institutions, we are also conducting cross-institutional research to learn from our cases about initiating and advancing institution-level efforts to reform approaches to teaching evaluation. We are using site visits, interviews, focus groups, document review, and conversations among institutional leaders at the Knowledge Exchanges as strategies for engaging in the cross-institutional comparisons and reflections that are elements in how NICs learn. At this point in our project, we can offer some emerging observations and lessons, but much remains to be learned as the departments more fully implement and adapt their use of the rubric. The three institutions engaged in the project have some distinctive contextual differences; for example, institutional leadership for the project is located in different places at each institution, and one has a faculty union. Also, each department involved has chosen its own approach to using the rubric. Some, for example, have decided to begin with careful consideration of the elements of the rubric and adaptation of each element to specific disciplinary needs, while others have been willing to accept the dimensions of the rubric with little change. Use of the rubric is a relatively slow process in most cases, with small groups of faculty choosing to experiment by applying it to specific faculty processes as starting points for attracting broader attention, interest, and buy-in from their colleagues.

Starting points for applying the rubric typically fall in one of the following areas: as a guide for mentoring early career colleagues; as a framework for classroom observations and peer reviews and discussions about teaching; as a framework for a required or optional self-reflection statement in an annual review or promotion packet; or as a guide for discussion topics in graduate student professional development. Departments' choices of starting points seem to relate to the interests of the faculty leaders and their perceptions of where they may get the most traction for testing and demonstrating the usefulness and relevance of the rubric to their departmental context.

We have seen a set of common challenges or barriers across the participating institutions and departments. These include a sense of uncertainty as to where to start; that is, interest in using the rubric is sometimes greater than strategic knowledge of how to begin a change effort. For many faculty members, the time they perceive that will be needed to experiment with or apply the rubric in various ways is a major barrier, thwarting progress. In other cases, some faculty with strong teaching orientations invest time but find that they struggle to get attention and commitment to use of the rubric from more senior colleagues or the departmental chair. Now two years into the project, we also have seen examples of loss of momentum when supportive department chairs or highly invested faculty colleagues depart. Probably the strongest, as well as most frequent, challenge is lack of wide commitment and buy-in across a department.

We also are using the NIC approach to compare the implementation of innovations across contexts to begin to deduce a set of strategies that facilitate change toward transformation in teaching evaluation. We highlight a few of these strategies here, while noting that transformational organizational change in higher education requires patience. The process of developing, testing, and implementing strategies for using the rubric and transforming departmental cultures is getting a foothold but still in the developmental stages in most of the departments. Some of the important strategies to initiate change around teaching evaluation include assessing relevant features of the institutional landscape and then developing and articulating a narrative about how thoughtful teaching evaluation relates to institutional priorities and history. Another strategy includes finding ways to attract and sustain the interest of recognized leaders within the department as well as finding champions at the departmental, college, or institutional levels. Identifying allies whose own interests and goals align with the project of reforming teaching evaluation can also be useful. As the departments continue their work of refining the rubric for their situations and finding ways to implement and integrate it into their collective and individual work, we will continue to observe and analyze the processes they follow and issues they confront.

Interest in new approaches to teaching evaluation is growing across the U.S. (and beyond). The project has its roots in the Bay View Alliance (n.d.), and, as the initiative continues, the team is connecting its work with national initiatives focused on teaching evaluation that are emerging at the National Academies' Roundtable on Systemic Reform on STEM Undergraduate Education (NASEM, 2020b) and the AAU (AAU, n.d.). The TEval website (TEval, n.d.) provides up-to-date information on these developments.

6 Acknowledgements

This material is based upon work supported, in part, by the NSF, Award numbers: DRL 1725946, 1726087, 1725959, and 1725956. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.

TEval is a multi-institution initiative of the Bay View Alliance, an international network of research universities exploring strategies to support and sustain the widespread adoption of instructional methods that lead to better student learning.

7 About the Authors

Noah Finkelstein is a Professor in the Department of Physics and co-Director of the Center for STEM Learning at the University of Colorado Boulder.

Andrea Follmer Greenhoot is Professor of Psychology, Director of the Center for Teaching Excellence, and Gautt Teaching Scholar at the University of Kansas.

Gabriela Weaver is a Professor of Chemistry at the University of Massachusetts, Amherst.

Ann E. Austin is the Associate Dean for Research in the Department of Educational Administration at the University of Michigan.

8 References

Association of American Universities (n.d.). *Undergraduate STEM Education Initiative*. Association of American Universities. https://www.aau.edu/education-community-impact/undergraduate-education/undergraduate-stem-education-initiative-3

Andrews, S. E., Keating, J., Corbo, J. C., Gammon, M., Reinholz, D. L., & Finkelstein, N. (this volume). "Transforming teaching evaluation in disciplines: A model and case study of departmental change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 13). Pressbooks.

Accelerating Systemic Change Network (n.d.). *Working Group 1: Guiding Theories*. Accelerating Systemic Change Network. https://ascnhighered.org/ASCN/guiding_theories.html

Boulder Faculty Assembly. (2018). *Best practices—Moving beyond the FCQ*. University of Colorado Boulder, College of Media, Communication, and Information. https://www.colorado.edu/cmci/sites/default/files/attached-files/beyond_the_fcq_best_practices_draft_10.24.18.pdf

Bernstein, D. (2008). Peer review and evaluation of the intellectual work of teaching. *Change: The Magazine of Higher Learning, 40*(2), 48–51. http://doi.org/10.3200/CHNG.40.2.48-51

Bernstein, D., & Huber, M. T. (2006). *What is good teaching? Raising the bar through Scholarship Assessed* [presentation]. International Society for the Scholarship of Teaching and Learning, Washington, D.C.

Bryk, A., Gomez, L. M., Grunow, A., & LeMahieu, P. (2015). *Learning to improve: How America's schools can get better at getting better*. Harvard Education Press.

Bay View Alliance (n.d.). *Evaluating teaching: Transforming the evaluation of teaching*. Bay View Alliance. https://bayviewalliance.org/projects/evaluating-teaching/

Corbo, J. C., Reinholz, D.L., Dancy, M.H, Deetz, S. and Finkelstein, N. (2016). Sustainable change: A framework for transforming departmental culture to support educational innovation. *Physical Review Special Topics—Physics Education Research 12*, 010113. https://doi.org/10.1103/PhysRevPhysEducRes.12.010113

Dennin, M., Schultz, Z. D., Feig, A., Finkelstein, N., Greenhoot, A. F., Hildreth, M., Leibovich, A. K., Martin, J. D., Moldwin, M. B., O'Dowd, D. K., Posey, L. A., Smith, T. L., & Miller, E. R. (2017). Aligning practice to policies: Changing the culture to recognize and reward teaching at research universities. *CBE—Life Sciences Education*, *16*(4), es5. https://doi.org/10.1187/cbe.17-02-0032

Greenhoot, A. F., Ward, D., Bernstein, D., Patterson, M., & Colyott, K. (2020). *Benchmarks for teaching effectiveness rubric*. The University of Kansas Center for Teaching Excellence. https://cte.ku.edu/rubric-department-evaluation-faculty-teaching

Gardner, G., Ridway, J., Schussler, E., Miller, K., & Marbach-Ad, G. (this volume). "Research coordination networks to promote cross-institutional change: A case study of graduate student teaching professional development." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 10). Pressbooks.

Glassick, C. E., Huber, M. T., & Maeroff, G. I. (1997). *Scholarship assessed: Evaluation of the professoriate. Special Report*. Jossey Bass Inc.

Hutchings, P. (Ed.). (1995). *From idea to prototype: The peer review of teaching*. Stylus.

Hutchings, P. (Ed.). (1996). *Making teaching community property: A menu for peer collaboration and peer review*. Stylus.

Kezar, A., & Miller, E. R. (this volume). "Using a systems approach to change: Examining the AAU Undergraduate STEM Education Initiative." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 9). Pressbooks.

Lyde, A.R., Grieshaber, D.C., & Byrns, G. (2016). Faculty teaching performance: Perceptions of a multi-source method for evaluation (MME). *Journal of the Scholarship of Teaching and Learning, 16*(3), 82–94. https://doi.org/10.14434/josotl.v16i3.18145

Marbach-Ad., G., Hunt, C., & Thompson, K. V. (this volume). "Using data on student values and experiences to engage faculty members in discussions on improving teaching." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 8). Pressbooks.

Margherio, C., Doten-Snitker, K., Williams, J., Litzler, E., Andrijcic, E., & Mohan, S. (this volume). "Cultivating strategic partnerships to transform STEM education." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 12). Pressbooks.

National Academies of Sciences, Engineering, and Medicine. (2020a). *Recognizing and evaluating science teaching in higher education: Proceedings of a workshop—in brief.* The National Academies Press. https://doi.org/10.17226/25685

National Academies of Sciences, Engineering, and Medicine (2020b). *Roundtable on systemic change in undergraduate STEM education*. The National Academies of Sciences, Engineering, and Medicine. https://sites.nationalacademies.org/DBASSE/BOSE/systemic_change_in_Undergrad_STEM_Education/index.htm

Reinholz, D. L., Corbo, J. C., Dancy, M. H., Deetz, S., and Finkelstein, N. (2015). Towards a Model of Systemic Change in University STEM Education. In G. C. Weaver, W. D. Burgess, A. L. Childress, and L. Slakey (Eds.), *Transforming institutions: 21st century undergraduate STEM education* (pp. 115–124). Purdue University Press

Stroebe, W. (2016). Why good teaching evaluations may reward bad teaching: On grade inflation and other unintended consequences of student evaluations. *Perspectives on Psychological Science*, *11*(6), 800–816. https://doi.org/10.1177/1745691616650284

Tagg, J. (2012). Why does the faculty resist change? *Change: The Magazine of Higher Learning, 44*(1), 6–15. https://doi.org/10.1080/00091383.2012.635987

TEval. (n.d.). Transforming higher education—Multidimensional evaluation of teaching. TEval.net. https://teval.net

Teaching Quality Framework Initiative. (n.d.). Teaching Quality Framework Initiative. University of Colorado Boulder. https://www.colorado.edu/teaching-quality-framework/

Uttl, B., White, C. A., & Gonzalez, D. W. (2016). Meta-analysis of faculty's teaching effectiveness: Student evaluation of teaching ratings and student learning are not related. *Studies in Educational Evaluation, 54*, 22–42. https://doi.org/10.1016/j.stueduc.2016.08.007

Wojdak, J., Phelps-Durr, T., Gough, L., Atuobi, T., DeBoy, C., Moss, P., Sible, J., & Mouchrek, N. (this volume). "Learning together: Four institutions' collective approach to building sustained inclusive excellence programs in STEM." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 11). Pressbooks.

SECTION III

CHANGE LEADERS

Introduction: Change Leaders

SCOTT SIMKINS, LINDA SLAKEY, AND LORNE WHITEHEAD

The papers here take a broad view of *who leads change*. The interventions studied portray the whole range of scale from individual classrooms to consortia of institutions, and of maturity, from early tests of models to summaries of lessons learned in work going back more than a decade. Further, the formal role within the institution of the change agents presented ranges from individual instructor, through formal leadership roles including teaching center director, department head, dean, provost, and president, and for the first time in the *Transforming Institutions* series, studies of significant roles for students as change agents. A subtext in several places is that not all change agents are aware that they are in a role that may have that effect. Collectively, the chapters expand our sense of what have come to be called top-down, bottom-up, or middle-out approaches to bringing about sustainable systemic change.

The first two chapters focus on models that see students as partners and agents in bringing about change. Cook-Sather and colleagues at Haverford College present a compelling account of pedagogical partnerships engaging students for the purpose of improving equity and inclusion efforts in STEM. At the micro-level, two approaches were explored—one in which the partnership pairs were initiated by faculty members, and the other in which students took the initiative. Also explored was a "meso-level" partnership involving a center director and a student partner, and a "macro-level" partnership involving a group of faculty collaborating with one another and students on designing a co-curricular course. The implicit definition of leadership in this model is one of mutual support among partners. For all partners, this can lead to a sense of agency and an increased confidence in the possibility of change. The authors report positive accounts from everyone involved. Overall, students both benefitted from and contributed to this equity work by supporting faculty engagement in these efforts and taking up and initiating partnership approaches for change.

Like Cook-Sather et al., Callahan and colleagues sought to engage student leaders in conversations about pedagogy that have traditionally not included them. The population titled "student leaders" included students in the roles of learning assistants, education research assistants, and serving on departmental committees. The authors review Henderson et al.'s (2010) four change strategies of disseminating curriculum and pedagogy, developing reflective practitioners, enacting policies to influence change, and developing a shared vision. They engaged student leaders to stimulate new conversations focused on improving teaching and learning at multiple levels to support success and retention in STEM for a broader diversity of students. A key observation was that faculty looked to student leaders for information about their students' needs and received it as advice to consider. Their overall recommendation is to bolster recognition of student leaders as experts of the student experience and incorporation of their ideas into STEM improvement efforts.

Viewing students as change agents, and engaging them as partners in this work, has been a topic of interest in the scholarship of teaching and learning community for some time. Healey (2020) maintains a bibliography of this literature that includes an acknowledgment of the substantial contributions of Cook-Sather. The new examples presented here illustrate how student leaders can move from work with single courses or professors to broader efforts within an institution. What students have to say has particular resonance for some faculty members in terms of bringing about pedagogical change, thus this approach has untapped potential.

The next three chapters approach institutional change using faculty learning communities (see Cox & Richlin [2004] for a history and overview of this model.) Dillon and colleagues describe an example of leadership exerted by individual faculty committed to structural change, acting within a learning community framework. They report on a 3-year pilot program funded by the National Science Foundation, the purpose of which was to study an implementation of the CACAO change model (Change, Adopters, Change Agents, and Organization). A key approach was for faculty members to select a specific aspect of teaching to be observed by peers, which reduces the time commitment for the observers and provides a greater sense of control for those observed. The work evolved through careful implementation stages, and the authors report two particularly encouraging outcomes—very good feedback from a survey of faculty participants, and a very significant level of faculty participation.

Nelson and colleagues evaluated a particular model of discipline-based faculty learning community, called SIMPLE, across a group of five departments. The acronym summarizes a commitment to achieving Sustainable change, the encouragement and valuing of making Incremental changes, the use of Mentoring within the group, working on the specific needs of the People in the group, and attending to the Learning Environment. In initiating the study, obtaining funding for it, and providing training to the internal leaders of the learning communities, the authors themselves have modeled acting as change agents within their institution. Their study gives substantial attention to the importance of engaging early adopters of active learning strategies who are opinion leaders within their departments to be the internal leaders of the learning communities.

Klein and colleagues studied the use of cross-course faculty learning communities within departments as a way to bring about both broad and lasting cultural change. The study particularly calls attention to ways that faculty working within such a venture can leverage factors in their environment to increase their effectiveness in engaging colleagues and at the same time use their work to catalyze broader institutional change. For example, the orientation meeting for the team included leaders at several institutional levels: a vice-provost, dean, and department head. They involved very highly respected colleagues in the leadership teams for the learning communities and took care to frame the work in ways that aligned with departmental cultural norms. This study viewed the leader of a learning community as the key change agent, but as with the work of Nelson et al., the authors themselves were leading institutional change, and involved other campus level leaders as well.

Halasek and colleagues describe an ambitious, top-down project actively led by the president and provost of a public research university with an undergraduate enrollment of over 45,000 students, designed to offer substantial teaching enrichment instruction to every instructor of an undergraduate course. Like Callahan et al., the authors use the model of Henderson et al. (2010) as a framework for analysis of their observations, and they also view the actions of the two high-level leaders through the lens of Kotter's (2012) model for organizational change. While they find that the president's thinking and actions map well onto Kotter's framework, they note the need to also make effective use of pressures and circumstances that lie outside the initial linear process for the proposed initiative. They find that a model of interacting gears serves well to analyze how the leaders navigate a complex set of issues.

The chapters summarized above all describe work relatively close to its initial implementation phases. The final two chapters offer reflections on the use of Discipline-Based Education Specialists (DBES) to bring about department-level change. This model, also called the embedded expert model, has been in place for over a decade at two universities, and for more than five years at several others. A focus in both these chapters is on the specialist as a key agent of change within departments, but the model also requires departmental leadership and guidance from the department head or other senior faculty member, and coordinating leadership across the program. Higher-level leaders willing to invest resources in the DBES positions are also needed, so change is supported at several levels if not actively led by them.

The chapter by Chasteen and colleagues at the University of Colorado Boulder and the University of British Columbia is a compelling summary of their free, online, open-licensed Science Education Initiative Handbook (Chasteen & Code, 2018) and its practical advice concerning DBES. Unlike the models in previous chapters, the DBES typically use postdoctoral fellows or others with direct training in teaching and learning within the discipline to catalyze teaching change within a specific department. The authors concisely cover key ideas concerning the required high-level training and interpersonal skills, and summarize practical tips based on careful, sound observations over many courses over many years. Topics include the persuasive use of data, boosting visibility of teaching improvement efforts, using evidence-based reasoning, and ensuring that support is available, especially for junior-ranking DBES.

Greenhoot and colleagues are each the leader of a central unit that coordinated the embedded expert model across departments on their campus. They present three key leadership questions that should be addressed in order for these resource-intensive programs to yield a good return on investment: how to deploy the financial resources, how to engage departments and faculty in the work, and how to plan for long-term sustainability once the initial investment period is over. After reviewing tactics used to good effect on each of their campuses, they offer a set of guiding principles which echo themes that emerge in other papers in the section. In particular, they point out the usefulness of leveraging other factors on campus, and attending to the factors that make pedagogic change feel both possible and rewarding for faculty.

Returning to the question we first raised, of whether individual project leaders see themselves as change agents on a larger scale, we see cases here in which micro-level, faculty-led approaches point toward sustainable and systemic change at the institution. This is a common entry point for faculty who are interested in institutional (or at least departmental) change. We look forward to further studies that specifically examine steps leaders can take in order to lift projects that impact only a few colleagues toward ones that produce sustainable systemic change, as well as examples of how project leaders can develop broad, self-sustaining models of pedagogical change leader development that will promote permanent institutional change.

The papers in this section illustrate a variety of approaches to leading change that could be adopted by different kinds of institutions in different kinds of settings. These approaches, taken together, are inclusive, rather than exclusive, and the institutions involved in these projects reflect that. If sustainable systemic changes in higher education pedagogy are going to become widespread, and thus provide opportunities for greater participation in STEM disciplines (and beyond) for all students, institutions of all types must be part of that process. The examples here show how those interested in leading change at a wide variety of institutions can join that process. We look forward to even more examples in the future from community colleges and minority-serving institutions, who are historically underrepresented in systemic change efforts, yet provide important roles in U.S. higher education.

In closing, we note that as this volume goes to press, the higher education community has an increased awareness of the need to foreground equity and inclusivity in all our work to lead change. This trend was already evident, but it takes on additional importance across the STEM education reform community at this moment of sharply heightened awareness of the toxic effects of racism and the importance of social justice in society. The statement of purpose of the Sloan Equity and Inclusion in STEM Introductory Courses [SEISMIC] (2020) initiative, a coalition of universities that use data analytics as a principal tool to assess and guide pedagogic change, captures the motivating force of this concern in a way that is useful for change agents at all levels:

> [W]e aim to motivate changes to long-established practice with something more than the possibility of marginal improvements in learning. By focusing on equity and inclusion as our central metric for success, we harness a higher level of collective passion from the students, faculty, staff, and administrators who participate.

We look forward to seeing the progress change agents in higher education will make in this area in the years ahead.

References

Callahan, K. M., Williams, K., & Reese, S. (this volume). "Student leaders as agents of change." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 16). Pressbooks.

Chasteen, S. V. & Code, W. J. (2018). *The Science Education Initiative handbook*. Pressbooks. https://pressbooks.bccampus.ca/seihandbook/

Chasteen, S., Code, W., & Sherman, S. B. (this volume). "Practical advice for partnering with and coaching faculty as an embedded educational expert." In K. White, A. Beach, N. Finkelstein, C.

Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 21). Pressbooks.

Cook-Sather, A., White, H., Aramburu, T., Samuels, C., & Wynkoop, P. (this volume). “Moving toward greater equity and inclusion in STEM through pedagogical partnership.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 15). Pressbooks.

Cox, M. D., & Richlin, L. (Eds.). (2004). Building faculty learning communities [Special issue]. *New Directions for Teaching and Learning, 97*. https://onlinelibrary.wiley.com/toc/15360768/2004/2004/97

Greenhoot, A. F., Aslan, C., Chasteen, S., Code, W., & Sherman, S. B. (this volume). “Variations on embedded expert models: Implementing change initiatives that support departments from within.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 22). Pressbooks.

Halasek, K., Heckler, A., & Rhodes-DiSalvo, M. (this volume). “Transforming the teaching of thousands: Promoting evidence-based practices at scale.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 20). Pressbooks.

Healey, M. (2020) *Students as partners and change agents: A selected bibliography*. Michealey.co.uk. https://www.mickhealey.co.uk/download/students-as-change-agents-bibliography-2

Henderson, C., Finkelstein, N. & Beach, A. (2010). Beyond dissemination in college science teaching: An introduction to four core change strategies. *Journal of college science teaching, 39*(5), 18–25. https://www.jstor.org/stable/42993814

Klein, C., Lester, J., & Nelson, J. (this volume). “Leveraging organizational structure and culture to catalyze pedagogical change in higher education.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 19). Pressbooks.

Kotter, J. (2012). *Leading Change*. Harvard Business Review Press.

Nelson, J. K., & Hjalmarson, M. A. (this volume). “Discipline-based teaching development groups: The SIMPLE framework for change from within.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 18). Pressbooks.

Salomone, S., Dillon, H., Prestholdt, T., Peterson, V., James, C., & Anctil, E. (this volume). “Making teachers matter more: REFLECT at the University of Portland.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 17). Pressbooks.

Sloan Equity and Inclusion in STEM Introductory Courses. (2020). *SEISMIC overview*. SEISMICproject.org. https://www.seismicproject.org/about/overview/

15. Moving toward Greater Equity and Inclusion in STEM through Pedagogical Partnership

ALISON COOK-SATHER, HELEN WHITE, TOMÁS ARAMBURU, CAMILLE SAMUELS, AND PAUL WYNKOOP

1 Introduction

Traditional equity and inclusion efforts concentrate on helping students navigate and succeed within existing institutional norms and practices. Pedagogical partnerships have the potential both to support students in such navigation and to position them to draw on their experiences, identities, and knowledge to challenge and change those norms and practices (de Bie et al., 2019). By "pedagogical partnership," we mean "a collaborative, reciprocal process" through which participants "contribute equally, although not necessarily in the same ways, to curricular or pedagogical conceptualization, decision making, implementation, investigation, or analysis" (Cook-Sather et al., 2014, pp. 6–7). Pedagogical partnerships can inspire deepened engagement, raised awareness, and enhanced experiences of teaching and learning for student and faculty partners (Cook-Sather et al., 2014; Mercer-Mapstone et al., 2017). Particularly relevant to this discussion, they can also contribute to the creation of more culturally responsive and inclusive practices (Cook-Sather, 2019; Cook-Sather & Agu, 2013; Cook-Sather & Des-Ogugua, 2018) through recognizing historically underrepresented and under-served students in particular as "holders and creators of knowledge" (Delgado Bernal, 2002, p. 106) and through making equity and inclusion the focus of all partnership work.

This paper offers four examples of how student-faculty partners lead change toward more equitable and inclusive practices in STEM through pedagogical partnership at Haverford College. A selective, liberal arts college in the mid-Atlantic region of the United States, Haverford enrolls 1,353 students, 42.5% students of color and 14% international students, and supports 50% of students with some form of financial aid. Self-described as highly rigorous, the college has recently recognized that its "rigor-first" approach privileges some students over others, particularly in STEM. In Astronomy, Physics, Mathematics, and Computer Science (but not Biology or Chemistry), numbers of both underrepresented students and female-identifying students decrease between the first and second semesters and into the second year. Furthermore, students perceive introductory science classes as "weed-out" courses, and underrepresented students interested in STEM are advised by peers to avoid introductory science courses because of the negative classroom culture and insufficient support structures.

Since 2007, Haverford has co-sponsored with Bryn Mawr College the Students as Learners and Teachers (SaLT) program through which more than 290 faculty and 195 students have participated in over 400 pedagogical partnerships. The signature program of the Teaching and Learning Institute at Bryn Mawr and Haverford Colleges, SaLT has focused since its advent on developing more inclusive and equitable classroom practices (Cook-Sather, 2018), both through positioning underrepresented students as educational developers (Cook-Sather et al., 2019a) and through making equity and inclusion an implicit or explicit focus of all partnership work (Cook-Sather et al., 2019b).

Supported originally by over $1 million in funding from The Andrew W. Mellon Foundation and subsequently by the Provosts' Offices at Bryn Mawr and Haverford Colleges, the SaLT program supports faculty at any stage in their careers (Cook-Sather, 2016). The student consultants who piloted the program were five students of color, and in each subsequent semester between 50% and 75% of the 195 SaLT student consultants have identified as belonging to one or more of the following equity-seeking groups: African American, Asian American, Latinx, female, first-generation college student, low income, disabled, and/or queer (Cook-Sather, 2019). SaLT supports or informs all the examples we discuss here.

The "we" of this paper is an intentional combination of faculty and students at Haverford College:

- Alison Cook-Sather is a faculty member in the Bryn Mawr/Haverford Education Program and director of SaLT.
- Helen White is a faculty member in the Chemistry and Environmental Studies Departments and director of the Integrated Natural Science Center.
- Tomás Aramburu, class of 2019, majored in chemistry, minored in creative writing, completed a concentration in biochemistry, and was a teaching assistant in the Chemistry Department.
- Camille Samuels, class of 2021, has been a student in White's courses, and
- Paul Wynkoop, class of 2020, majored in psychology and completed a minor in neuroscience and worked as a SaLT student consultant for three years.

Elaborating on the description of some of the SaLT program work Cook-Sather shared at the ASCN Transforming Institutions Conference (Takayama et al., 2017), we describe four efforts, each at a different stage of maturation, to make pedagogical practices in STEM more equitable and inclusive: two at the micro level, one at the meso level, and one at the macro level. The longest-standing micro-level example has been researched and reported on in numerous publications, some of which are cited here. The other three follow from or build on that example and are in the very preliminary stages of being researched. Figure 1 presents these four examples.

IIn contrast to the successful top-down model of change Halasek et al. (this volume) discuss, this paper offers an example of how change can be effected moving from the micro through the meso to the macros levels.

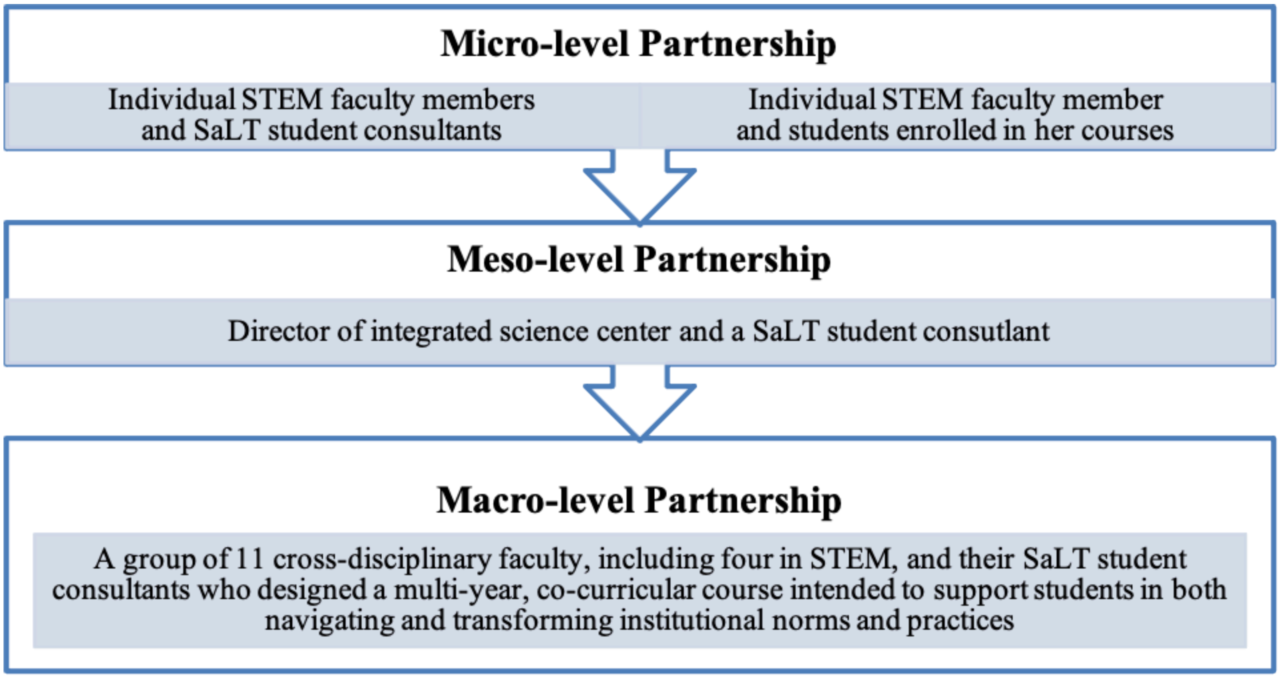


Figure 1: Micro-, Meso-, and Macro-Level Pedagogical Partnerships (click on image to enlarge)

2 Micro-level Example 1: Faculty Working with SaLT Student Consultants

Of the 290 faculty who have participated in the SaLT program since its advent, 85 have been in a STEM field. Each of them worked in a micro-level pedagogical partnership—a semester-long, one-on-one collaboration or a summer-long collaboration with an undergraduate student positioned as a pedagogical partner—and some continued their partnership work for multiple semesters. All student-faculty pairs receive guidelines for how to develop partnerships (see Cook-Sather et al. [2019b] for the guidelines), although each partnership is unique.

Almost all initial partnerships pay an undergraduate student not enrolled in a faculty member's course by the hour for the following: observing one session of that course per week, taking detailed observation notes on pedagogical approaches or challenges upon which the faculty partner wants to focus, and then meeting weekly with the faculty partner to discuss what is already contributing to the creation of an equitable and effective learning environment and what might be revised better to meet the needs of a diversity of students. Rather than receiving training prior to embarking on this work, student partners meet weekly in small groups with Cook-Sather and other student partners to develop the language, confidence, and capacity to work in such intellectually and emotionally demanding roles. (See Cook-Sather et al. [2019b] for details regarding how to develop such pedagogical partnership.) This approach shares many of the features of the *discipline-based educational specialist* model Chasteen et al. (this volume) and Greenhoot et al. (this volume) discuss (e.g., engage in classroom observations, aim for constructive conversations, observe faculty over time) and the peer-observation of teaching model discussed in Salomone et al. (this volume), but it positions students who are not discipline experts in this role.

Cook-Sather has assessed faculty experiences through the SaLT program each semester through asking open-ended questions on anonymous surveys (e.g., What are the most important pedagogical insights you clarified or gained through working with your student partner? How have those informed your practice, and how do they position or prepare you to continue to develop as a teacher?). Also since the program's advent, she has conducted numerous ethics board-approved research studies on SaLT partnerships focused on both general and equity outcomes.

Furthermore, individual faculty partners have engaged in systematic reflection and published essays on their work with student consultants. These include explorations of how to revise course structure, assignments, and assessments in organic chemistry (Charkoudian et al., 2015), address under-representation and create more inclusive classrooms in physics (Perez, 2016), and make student engagement more active and equitable in astrophysics (Narayanan & Abbot, 2020). Charkoudian found that, after working in partnership, she "consciously created an environment of pedagogical transparency and fostered an environment in which students could come to me with continual feedback and suggestions to make the course stronger" (Charkoudian et al., 2015, p. 8). Perez (2016) found that pedagogical partnerships "create the space necessary to address with students how issues of equity and inclusion affect their classrooms and fields" (p. 4). And Narayanan found his partnership work to be "simply transformative," supporting him in moving from university systems "where the style was often combative between students and professors" toward "increasing clarity and energy," which had the effect of "deepening the in-class relationship" between faculty and students and has proven efficacious "in broadening participation and retention of underrepresented minorities in the field" (Narayanan & Abbot, 2020, pp. 193–194).

SaLT student consultants have also analyzed the efficacy of partnership work for student partners and for students enrolled in the faculty members' courses. Pedagogical partnerships effect transformations in students' sense of themselves as learners, building awareness, confidence, and capacity (Wynkoop, 2018). Student consultants underrepresented in the sciences report not only "increased sense of confidence and ability to articulate myself (Mathrani 2018)" (Mathrani & Cook-Sather, 2020, p. 162) but also capacity to support faculty in making "students from traditionally underrepresented backgrounds" feel more included (Mathrani & Cook-Sather, 2020, p. 165).

3 Micro-level Example 2: Faculty Working with Enrolled Student Partners

The second form of micro-level partnership work was initiated by students and extended into collaboration with a STEM faculty member, inspired in part by SaLT partnership work. While SaLT has supported and researched faculty-student partnerships for 13 years, this second form of partnership work we present is only recently beginning to unfold because faculty members like White have developed a commitment to working with students as partners. As this work continues to expand, it will be integrated into the various DEI-focused research projects on campus. We share it as one example of how student initiative can intersect with faculty receptivity and commitment to collaborative efforts for equity and inclusion.

Aramburu and Samuels, who had not participated in SaLT, created a student group for underrepresented students in STEM at Haverford College, and contacted White about how, in her role as director of the Integrated Science Center at the college, she might support the group. The initial intention of the student group was to provide mentorship for underrepresented minority students interested in pursuing STEM fields at Haverford with the hope of retaining more underrepresented students in the introductory chemistry sequence/major. In addition, Aramburu and Samuels aimed to reach out to STEM faculty and staff to help publicize the initiative and encourage more underrepresented students to take on roles as TAs and tutors. Over time, the group also formed a student advisory committee to communicate the student experience in STEM courses to faculty, and to provide feedback regarding curricular discussions and changes.

Faculty support for this initiative provided compensation for student leaders, mentors, and tutors associated with the group. Furthermore, the group encouraged underrepresented minority students to take on paid positions as TAs, tutors, and as members of the student advisory group.

The student group, in conversation with faculty partners, recognized the need to highlight and strengthen pathways and opportunities that already exist for students pursuing STEM fields, including peer-tutoring, on-campus research with faculty mentors, off-campus research, and travel to conferences and meetings specifically aimed at underrepresented students (e.g., The Society for Advancement of Chicanos/Hispanics and Native Americans in Science National Diversity in STEM Conference). As a result of conversations with Aramburu and Samuels, decisions regarding the funding of research and travel awards to students became need-sensitive so that resources could be better leveraged to support all students.

4 Meso-Level Example: Director of Integrated Science Center Working with a SaLT Student Consultant

Having previously worked in a SaLT partnership with a physics professor, Wynkoop brought experience with striving to support the development of culturally responsive and inclusive practices within STEM courses and was therefore well positioned to look across STEM departments. To begin their partnership focused on work at the meso level, White and Wynkoop analyzed the current discourse surrounding the participation of underrepresented populations in STEM on a broad scale. Using Ferrare and Lee's (2014) seminal study as their guide, they analyzed the ways in which discourse surrounding the economic vitality of STEM careers and different sociocultural conditions have contributed to gender-, race-, and class-based disparities in STEM. They focused in particular on the finding that, while a wide diversity of students begins their college careers as STEM majors, few from underrepresented groups continue with STEM after their first semester or first year—a failure of what is called "STEM retention" (see Callahan et al., this volume).

As they came to better understand the reasons behind the present homogeneity within STEM, White and Wynkoop shifted their focus from these cross-context findings and zeroed in on the lack of diversity in STEM majors at Haverford College. Keeping in mind the insights from SaLT partnership work and the culturally responsive theory that informs it, they decided that the best step to move forward with conceptualizing the issues in STEM retention was to survey the student body and see who exactly was enrolled in STEM classes across the different class years and what their experiences were. Their purpose was to determine whether Haverford followed the general trend of having a diversity of students enrolling in introductory STEM classes with the intent to major in STEM, followed by a decrease in diversity in students in subsequent courses and majoring in STEM fields, and to try to identify why, in this context.

White and Wynkoop contacted several STEM inclusion groups on campus to get a better sense of the experiences and challenges their members experienced in STEM courses and the various methods the groups had found most effective in empowering and supporting one another in learning and living at Haverford. Considering their conversations with these STEM inclusion groups, White and Wynkoop created surveys to gather students' experiences in STEM classes, with STEM faculty, and how they considered their own ability in STEM classes.

Through their partnership, Wynkoop and White were able to consider how faculty and student peers can play a role in retention of underrepresented students in STEM. While rooted in the intellectual framework of literature examining the inequalities present in higher education, their conversations provided a space for them to do some of the emotional work that is required to explore and reflect on what they were learning (White & Wynkoop, 2019). Through weekly conversations, White and Wynkoop discussed their relationship to and understanding of the inequalities in higher education. These conversations ranged from descriptions of personal experiences to sharing stories from their peers (faculty and students respectively) to discussing experiences that they had witnessed at Haverford. Honest and direct dialogue between White and Wynkoop, expressed in a supportive framework where the major objectives were to learn and understand, helped them both to move beyond the limits of their own perspectives as professor and student, respectively, as they worked to imagine a change strategy (see Callahan et al., this volume).

Because they exist as people at Haverford in two distinct roles, it would have been easy for them to bring in ideas about how to fix the problem of a lack of underrepresented students in STEM and assume that these ideas were the one and only way to solve the issue at hand. However, both White and Wynkoop took the time to hear one another and work together—along with seeking insight from other students and faculty engaged in conversations about equity and inclusion—to identify the most effective ways forward with the STEM-retention problem.

5 Macro-Level Example: Cross-Disciplinary Faculty Group Designing Co-Curricular Course

The macro-level example we share builds on the micro- and meso-level examples in both process and content. Drawing on the many years of SaLT-supported partnerships and on White's individual and department-level partnership work, this example illustrates what can happen when a partnership ethos begins to inform institution-wide equity efforts. Supported by the Provost's Office and multiple centers at Haverford, a group of faculty from Biology, Chemistry, Computer Science, East Asian Languages and Cultures, French, Linguistics, Sociology, and Visual Studies participated in a seminar facilitated by Cook-Sather—a variation on the Cross-course Communities of Transformation approach discussed by Klein et al. (this volume).

This cross-disciplinary group of faculty spent a semester together developing a multi-year, co-created, collaboratively facilitated, mentor structure/peer role model course designed not only to help students navigate the existing departmental norms and practices, such as courses developed by Trinity Washington University and Radford University (Sible et al., 2019), but also on transforming them. Striving also to support transformation and thinking beyond the single-semester model, the group produced a syllabus for a 3- or 4-year, 1 (total) teaching credit assignment for a faculty member and 0.25 course credit per semester for students. The course aims to provide students opportunities to: develop the cultural capital and language of the academic culture of power in order to successfully navigate the institution as it is; affirm and deploy their lived experiences, knowledge, skills, and cultural backgrounds to challenge normative institutional culture and help create a departmental and institutional culture more welcoming and equitable to a diversity of students; and contribute to an evolving curriculum for future students. It also aims to provide faculty opportunities to: be recognized and compensated for the time they spend on mentoring and advising; develop insights into what students bring and can contribute not only to this curriculum but also to a cultural shift in the department and at the College overall; and support students and other faculty in partnering to foster a sense of belonging *and* transform institutional culture.

The participating faculty are piloting the course in the 2020–2021 academic year, co-developing it with a group of students and working in collaboration with other offices and individuals on campus to forge links and share resources. The course design includes an action research component, and the faculty/staff facilitators and the student participants will be co-researchers of this pilot, thereby enacting another form of student-faculty/staff partnership that complements the "pedagogical consultancy" model (Healey et al., 2016) we already have with SaLT.

6 Conclusion

A growing body of research documents the potential of partnership to deepen engagement and enhance learning and teaching (Cook-Sather et al., 2014; Curran & Millard, 2016; Ferrell & Peach, 2018; Healey et al., 2014; Marquis et al., 2018; Mercer-Mapstone et al., 2017), foster more equitable and inclusive practices (Cook-Sather & Des-Ogugua, 2018; de Bie et al., 2019), and transform institutions (Cook-Sather et al., 2019a; Perez-Putnam, 2016). The different forms of pedagogical partnership we describe here contribute to greater equity and inclusion in several ways. The position of "student consultant" itself complicates the institutional roles of student, instructor, and educational developer; the role of student consultant and the SaLT program position students to mobilize their own cultural identities; and the partnership work contributes to the transformation of the institution into one that recognizes, values, and builds on the diverse knowledges of its members (Cook-Sather et al., 2019a).

As our examples illustrate, engaging in this work has the potential to link micro-level partnership efforts with meso- and macro-levels of transformation. As one student partner reflected, "working with [a] specific professor in the moment but also towards a far-away future Haverford in which all professors have had the same opportunity to think about their pedagogy within the space of the SaLT program," student consultants both benefit from and contribute to this equity work (Perez-Putnam, 2016), and they support faculty engagement in equity efforts.

The development of a college-wide, co-created course focused not only on navigating but also on transforming the institution suggests that work done through individual SaLT partnerships and student-faculty collaborations such as those White, as a STEM faculty member, embraced at the micro level with Aramburu and Samuels and at the meso level with Wynkoop have the potential to inform wider institutional change. Another student partner who worked with several STEM faculty partners offered an insight that might also be read as an injunction: "If we all engaged in partnerships through which we reflect and discuss how teaching and learning experiences can include and value everyone, our campuses would become places of belonging" (Colón García, 2017).

As Takayama et al. (2017) argued in their pre-conference workshop at the ASCN Transforming Institutions Conference, and as the brief descriptions we offer here of change leaders working at Haverford College at the micro (individual teacher and classroom), meso (department and center), and macro (institution-wide) levels suggest, such concerted, cross-level efforts premised on partnership between faculty and students hold great promise for transformation and systemic change.

7 About the Authors

Alison Cook-Sather is Mary Katharine Woodworth Professor of Education at Bryn Mawr College and director of the Teaching and Learning Institute at Bryn Mawr and Haverford Colleges.

Helen K. White is an Associate Professor of Chemistry and Environmental Studies at Haverford College.

Tomas Aramburu is a graduate of Haverford College and while there was the co-founder of the student organization Underrepresented Minorities in STEM.

Camille Samuels is an undergraduate student at Haverford College.

Paul Wynkoop is graduate of Haverford College and was a Student Consultant in/for the Teaching and Learning Institute (TLI) at Bryn Mawr and Haverford Colleges.

8 References

Callahan, K. M., Williams, K., & Reese, S. (this volume). “Student leaders as agents of change.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 16). Pressbooks.

Charkoudian, L., Bitners, A. C., Bloch, N. B., & Nawal, S. (2015). Dynamic discussions and informed improvements: Student-led revision of first-semester organic chemistry. *Teaching and Learning Together in Higher Education* (15). https://repository.brynmawr.edu/tlthe/vol1/iss15/5/

Chasteen, S., Code, W., & Sherman, S. B. (this volume). “Practical advice for partnering with and coaching faculty as an embedded educational expert.” In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 21). Pressbooks.

Colón García, A. (2017). Building a sense of belonging through pedagogical partnership. *Teaching and Learning Together in Higher Education* (22). http://repository.brynmawr.edu/tlthe/vol1/iss22/2

Cook-Sather, A. (2016). Undergraduate students as partners in new faculty orientation and academic development. *International Journal of Academic Development 21*(2), 151–162. https://doi.org/10.1080/1360144X.2016.1156543

Cook-Sather, A. (2018). Developing “Students as Learners and Teachers”: Lessons from ten years of pedagogical partnership that strives to foster inclusive and responsive practice. *Journal of Educational Innovation, Partnership and Change, 4*(1). https://doi.org/10.21100/jeipc.v4i1.746

Cook-Sather, A. (2019). Increasing inclusivity through pedagogical partnerships between students and faculty. *Diversity & Democracy, 22*(1). https://www.aacu.org/diversitydemocracy/2019/winter/cook-sather

Cook-Sather, A., & Agu, P. (2013). Students of color and faculty members working together toward culturally sustaining pedagogy. *To Improve the Academy: A Journal of Educational Development, 32*(1), 271–285. https://doi.org/10.1002/j.2334-4822.2013.tb00710.x

Cook-Sather, A., Bahti, M., & Ntem, A. (2019b). *Pedagogical partnerships: A how-to guide for faculty, students, and academic developers in higher education.* Elon University Center for Engaged Learning Open Access Series. https://doi.org/10.36284/celelon.oa1

Cook-Sather, A., Bovill, C., & Felten, P. (2014). *Engaging students as partners in teaching and learning: A guide for faculty*. Jossey-Bass.

Cook-Sather, A., & Des-Ogugua, C. (2018). Lessons we still need to learn on creating more inclusive and responsive classrooms: Recommendations from one student-faculty partnership program. *International Journal of Inclusive Education, 23*(6), 594–608. https://doi.org/10.1080/13603116.2018.1441912

Cook-Sather, A., Krishna Prasad, S., Marquis, E., & Ntem, A. (2019a). Mobilizing a culture shift on campus: Underrepresented students as educational developers. *New Directions for Teaching and Learning* (159), 21–30. https://doi.org/10.1002/tl.20345

Curran, R., & Millard, L. (2016). A partnership approach to developing student capacity to engage and staff capacity to be engaging: Opportunities for academic developers. *International Journal for Academic Development, 21*(1), 67–78. https://doi.org/10.1080/1360144X.2015.1120212

de Bie, A., Marquis, E., Cook-Sather, A., & Luqueño, L. (2019). Valuing knowledge(s) and cultivating confidence: Contributions of student-faculty pedagogical partnerships to epistemic justice. In P. Blessinger, J. Hoffman, & M. Makhanya (Eds.), *Strategies for fostering inclusive classrooms in higher education: International perspectives on equity and inclusion* (pp. 35–48). Emerald Publishing Ltd. https://doi.org/10.1108/S2055-364120190000016004

Delgado Bernal, D. (2002). Critical race theory, Latino critical theory, and critical raced-gendered epistemologies: Recognizing students of color as holders and creators of knowledge. *Qualitative Inquiry, 8*(1), 105–126. https://doi.org/10.1177/107780040200800107

Ferrare. J. J., & Lee, Y. G. (2014). Should we still be talking about leaving? A comparative examination of social inequality in undergraduates' major switching patterns [WCER Working Paper No. 2014-5]. http://www.wcer.wisc.edu/publications/workingPapers/papers.php

Ferrell, A., & Peach, A. (2018). Student-faculty partnerships in library instruction. *Kentucky Libraries, 82*(3), 15–18.

Greenhoot, A. F., Aslan, C., Chasteen, S., Code, W., & Sherman, S. B. (this volume). "Variations on embedded expert models: Implementing change initiatives that support departments from within." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 22). Pressbooks.

Halasek, K., Heckler, A., & Rhodes-DiSalvo, M. (this volume). "Transforming the teaching of thousands: Promoting evidence-based practices at scale." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 20). Pressbooks.

Healey, M., Flint, A., & Harrington, K. (2014). *Engagement through partnership: students as partners in learning and teaching in higher education*. Higher Education Academy.

Healey, M., Flint, A., & Harrington, K. (2016). Students as partners: Reflections on a conceptual model. *Teaching and Learning Inquiry 4*(2). https://doi.org/10.20343/teachlearninqu.4.2.3

Klein, C., Lester, J., & Nelson, J. (this volume). "Leveraging organizational structure and culture to catalyze pedagogical change in higher education." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 19). Pressbooks.

Marquis, E., Guitman, R., Black, C., Healey, M., Matthews, K. E., & Dvorakova, L. S. (2018a). Growing partnership communities: What experiences of an international institute suggest about developing student-staff partnership in higher education. *Innovations in Education and Teaching International, 56*(2), 184–194. https://doi.org/10.1080/14703297.2018.1424012

Mathrani, S. (2018). Building relationships, navigating discomfort and uncertainty, and translating my voice in new contexts. *Teaching and Learning Together in Higher Education* (23). https://repository.brynmawr.edu/tlthe/vol1/iss23/6

Mathrani, S., & Cook-Sather, A. (2020). "Discerning growth: Tracing rhizomatic development through pedagogical partnerships." In L. Mercer-Mapstone & S. Abbot (Eds.), *The power of partnership: Students, staff, and faculty revolutionizing higher education* (pp. 159–170). Elon University Center for Engaged Learning Open Access Series. https://doi.org/10.36284/celelon.oa2

Mercer-Mapstone, L., Dvorakova, S. L., Matthews, K. E., Abbot, S., Cheng, B., Felten, P., Knorr, K., Marquis, E., Shammas, R., & Swaim, K. (2017). A systematic literature review of students as partners in higher education. *International Journal for Students as Partners, 1*(1). https://doi.org/10.15173/ijsap.v1i1.3119

Narayanan, D., & Abbot, S. (2020). "Increasing the participation of underrepresented minorities in STEM classes through student-instructor partnerships." In L. Mercer-Mapstone & S. Abbot (Eds.), *The power of partnership: Students, staff, and faculty revolutionizing higher education* (pp. 181–195). Elon University Center for Engaged Learning Open Access Series. https://doi.org/10.36284/celelon.oa2

Perez, K. (2016). Striving toward a space for equity and inclusion in physics classrooms. *Teaching and Learning Together in Higher Education* (18). http://repository.brynmawr.edu/tlthe/vol1/iss18/3

Perez-Putnam, M. (2016). Belonging and brave space as hope for personal and institutional inclusion. *Teaching and Learning Together in Higher Education* (18). http://repository.brynmawr.edu/tlthe/vol1/iss18/2

Salomone, S., Dillon, H., Prestholdt, T., Peterson, V., James, C., & Anctil, E. (this volume). "Making teachers matter more: REFLECT at the University of Portland." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 17). Pressbooks.

Sible, J., Wojdak, J., Gough, L., Moss, P., Mouchrek, N. M. (2019, April 4). *Sustaining inclusive excellence* [Paper presentation]. ASCN Transforming Institutions Conference, Pittsburgh, PA.

Takayama, K., Kaplan, M., & Cook-Sather, A. (2017). Advancing diversity and inclusion through strategic multi-level leadership. *Liberal Education, 103*(3–4). http://www.aacu.org/liberaleducation/2017/summer-fall/takayama_kaplan_cook-sather

White, H., & Wynkoop, P. (2019). Pink bagels and persistence. *Teaching and Learning Together in Higher Education* (28). https://repository.brynmawr.edu/tlthe/vol1/iss28/6

Wynkoop, P. (2018). My transformation as a partner and a learner. *Teaching and Learning Together in Higher Education* (23). https://repository.brynmawr.edu/tlthe/vol1/iss23/4

16. Student Leaders as Agents of Change

KADIAN M. CALLAHAN, KAYLLA WILLIAMS, AND SCOTT REESE

1 Background

Student difficulty with learning experiences in undergraduate STEM courses have influenced their decisions to switch out of a STEM degree program (e.g., President's Council of Advisors on Science and Technology, 2012; Seymour & Hewitt, 1997); however, programmatic structures, policies, and practices also create barriers to academic achievement and retaining students, especially women and students from racial/ethnic minority groups that are traditionally underserved in STEM (Seymour & Hewitt, 1997; Seymour et al., 2019). Thus, approaches that extend beyond the classroom are needed to improve success in undergraduate STEM education.

Student Leaders (SLs; e.g., learning assistants, teaching assistants, or peer mentors) are often involved in course-related efforts to enhance teaching and learning in STEM. Interactions with more advanced peers can enhance thinking within the *zone of proximal development* so that students are able to move beyond what they would have been able to do on their own (Vygotsky, 1978) and bolsters academic outcomes for a diversity of undergraduate STEM students (Bowling, 2015; Tien et al., 2002). In addition to their ability to enhance students' learning experiences in course-related contexts, SLs have the potential to improve success in STEM more broadly. Breslin et al. (2018) assert that by valuing the expertise of SLs' ideas and lived experiences, institutions can become more student-centered. They argue that SLs should be fully engaged "not just in the delivery of services to students, but also in program development, assessment and evaluation, outreach, peer training, and research" (p. 51). Specifically, SLs' insights can help faculty, staff, and administrators understand challenges that students face and can offer suggestions for how to reshape structures, policies, and practices (Healey et al., 2010; Tien et al., 2002) in ways that may make a difference in students' decisions to persist in STEM programs (Bowling, 2015). This grass-roots approach to fostering change in undergraduate STEM involves altering the mindsets and perspectives of faculty, staff, and administrators and may be a powerful way to create and sustain change (see Klein et al, this volume).

Although existing research suggests that SLs can improve undergraduate STEM education both in and outside of course-related contexts, research is very limited on the extent of SLs' involvement in leading change, particularly in making improvements to programmatic structures, policies, and practices. Our study represents an effort to expand understandings of how SLs can serve as change agents for making broad improvements to undergraduate STEM education with an eye on influencing students' decisions to continue to pursue STEM degrees. The specific research question was: *How do Student Leaders influence efforts to improve success in undergraduate STEM education in course-related and non-course-related contexts*?

2 Theoretical Framework

Improving undergraduate STEM education most often involves training faculty to use new curriculum tools or pedagogical strategies, working to develop faculty into reflective practitioners, or enacting policies to influence change (Borrego & Henderson, 2014). While there is some evidence of success with individual instructors and courses, approaches that apply multiple levers can counteract forces that work against change (Miller & Fairweather, 2016). Henderson and colleagues (e.g., Henderson et al., 2011; Henderson et al., 2010) evaluated a wide range of STEM improvement projects and categorized them into four change strategies based on two criteria. The first focuses on the aspect of the system that is to be changed: individuals, institutions, environments, or structures. The second focuses on the outcomes of the change strategy and whether it is intended to be prescribed or emergent. The four change strategies that resulted from using these criteria were:

a) Disseminating curriculum and pedagogy,
b) Developing reflective practitioners,
c) Enacting policies to influence change, and
d) Developing a shared vision.

Although applied less often, developing a shared vision is a change strategy that works to develop new knowledge and perspectives from within the organization—often by disrupting organizational patterns (Borrego & Henderson, 2014). While SLs' involvement in course-related contexts contributes to developing reflective practitioners, inserting student voices into spaces that have traditionally only involved faculty or administrators was used as a strategy to disrupt existing tendencies and catalyze change that is more emergent and authentically addresses the needs of a diversity of learners. For this study, SLs were included to stimulate new conversations focused on improving teaching and learning in courses and changing programmatic structures and policies to support success and retention in STEM for a broader diversity of students.

3 Setting and Context

This study was conducted at a mostly undergraduate, regional institution in the southeastern United States with over 35,000 students. The diverse student body is comprised of approximately 21% African Americans and 10% Hispanics, and 19% of undergraduate students are over 24 years old. While the university retains ~75% of students from the first year to the second, the STEM programs retain only ~69% and only ~64% of students from traditionally underserved populations. Participants in this study (SLs, faculty, staff, and administrators) were situated in the STEM College that is responsible for early science and mathematics courses taken by both STEM and non-STEM majors.

Most of the SLs have a major in that STEM College and a majority are members of traditionally underserved groups. They are involved in supporting student learning during class, serve on different College committees (e.g., inclusion and diversity, curriculum alignment, grade appeals), and work as undergraduate researchers involved in examining the impact of STEM improvement efforts. Additionally, SLs have been involved in workshops designed to expand faculty and administrators' awareness of the student experience and deepen understanding of inclusive practices.

4 Methods

The primary data for this qualitative study was gathered through individual interviews with four faculty members and two SLs, and focus group interviews with seven administrators, six faculty members, two staff members, and four SLs working in the same STEM College. Each interview was conducted by one or two researchers using the same semi-structured interview protocols, which asked participants how SLs are influencing perspectives on teaching, learning, or the student experience relative to programmatic structures, policies, and practices. Interviews were audio recorded and the researchers' written notes were digitally recorded. Artifacts from committee meetings and instructional episodes served as a secondary data source to provide additional context for interview data.

Data analysis involved open coding with constant comparison (Corbin & Strauss, 2008). Each of the three researchers, the authors, independently reviewed data collected from the interviews and then coded and recoded the data to identify emergent themes reflected across the data corpus with a particular focus on SLs' influence on structures, policies, and practices. After discussing the proposed themes and supporting data, the researchers refined and came to consensus on three overarching themes:

a) Student Leaders build a sense of community
b) Student Leaders communicate information between students and faculty
c) Faculty and administrators see Student Leaders' input as advisory

These themes and illustrative data are shared in the section that follows.

5 Results

5.1 Student Leaders Build a Sense of Community

Study participants recognized the important role that SLs have in building a sense of community among students. They referenced SLs' ability to connect with students' experiences, build students' confidence and motivation, give students advice, and serve as role models. These comments were consistent across course-related and non-course-related contexts. When describing SLs who support her course, Cindy [Chemistry faculty] noted, “It is very important for the students to have someone they can go to who is more on their level … able to explain things to them in a different way … and to have that role model—this person succeeded so I can do it too. I can learn what they did or how they did it.” This quote speaks to the way that SLs can influence success in a course by helping students learn challenging material and demonstrate that it is possible for students to successfully progress through their programs—particularly important for traditionally underserved populations (Seymour & Hewitt, 1997).

SLs’ expression of care about students was also reflected outside of the classroom. After speaking with SLs about the challenges students face and witnessing their interactions with students, Chyna [associate dean] stated, “it changed me and helped me a lot to understand the student experience … how much they care about their peers, … [and] how much they enjoy being in community with each other.” Noel [dean] added, “I tend to be more purposeful in seeking student voice in terms of what is going on and chatting with them in [in]formal settings.” And, when reflecting on her involvement with the College, Neda [SL] said,

> I joined the [inclusion and diversity committee] in hopes that maybe inclusivity—I feel like our classes are not targeted for every student. I am doing observations for laboratories and math classes in hopes that that will help the research people … understand what changes we can make so students can grasp the knowledge better or be better engaged during class.

Through fostering connections among peers both in and outside of class, SLs increase students’ academic and social integration and their involvement in the academic experience—important for increasing students’ retention and persistence (Callahan, 2009; Milem & Berger, 1997). Moreover, by making faculty, staff, and administrators aware of students’ need for community, they can influence opportunities provided for students in both contexts.

5.2 Student Leaders Communicate Information between Students and Faculty

SLs played a particularly important role in course-related contexts by sharing information between faculty and students, which shaped students’ learning experiences and influenced instructional practices. One barrier to students’ academic success in STEM is the need to move beyond memorization and algorithmic thinking toward analysis and synthesis—moving from lower to higher levels of Bloom’s Taxonomy (Krathwohl, 2002). Faculty consistently described SLs as helpful to students, providing information about what content to focus on, how to study, and encouraging them to attend office hours and help sessions. Moreover, SLs helped students make connections with the content in ways that are familiar to students, addressed learning challenges, and built students’ self-efficacy. Saundra [SL] stated, “when [students] feel really confident in mathematics, their odds of staying in STEM increases." She recognized the importance of SLs helping to build students' skills and their beliefs about their ability to be successful.

Faculty noted that SLs also provided them with information about how students were learning that they could use to make instructional changes. Xavier [Physics faculty] appreciated SLs sharing information when students were working hard to understand the material. Willette [Mathematics faculty] indicated that her SLs ask questions that remind her to readjust her instructional practices to address students' needs as novice learners. And, when describing his SLs, Barker [Chemistry faculty] stated, "They have a more first-hand experience of the struggles that these students might face, so talking to [SLs] certainly allows for changing things on the fly."

Outside of course related contexts, SLs communicated information to help shape structures and policies. During a focus group, an administrator noted that SLs share "great ideas that can enhance what we do for the students." This included suggestions about improving processes for connecting students to help, creating meaningful off-ramps for challenging programs, and offering a minor that was of interest; these were areas where student voices were seriously considered. At times, SLs also communicated information to students that was gained from interacting with faculty and administrators. For example, Neda [SL] felt that it was important to share some of the information that she was learning from serving on the Inclusion and Diversity Committee, "I just tell [students] to be aware that not everybody has the same situation as them … If someone doesn't do their part or if they are a little behind on their part, they should not automatically think this person is lazy." In this and other ways, SLs were conveying messages that were central to the College's efforts to improve success in undergraduate STEM education.

5.3 Faculty and Administrators See Student Leaders' Input as Advisory

Unfortunately, many faculty, staff, and administrators did not value SLs as experts of the student experience. They appreciated SLs sharing their ideas to shape course learning opportunities; however, they responded with reluctance when taking actions in response to those ideas to adjust broader structures, policies, and practices. The primary role of SLs in course-related contexts is to assist with fostering student learning. They are not given authoritative or evaluative responsibility; thus, SLs are positioned in an advisory capacity. Cindy [Chemistry faculty] recognized the value of SLs' *advice* when she explained that SLs provide information that she can use to determine if she needs to spend more time on a topic and that helps her to anticipate questions students might ask, but ultimately, she decides whether there was a need to adjust her instructional practices. Thus, she was open to making minor changes to her practice, but hesitant about giving up authority on what was best for her students.

When SLs shared ideas with faculty and administrators informally or formally on committees, the resistance to those ideas heightened. For example, Noel [dean] said, "I am not going to change the way instructors are doing their testing or things like that, but there are some very good suggestions." Also, when an SL made a suggestion about what aspects of diversity the committee should work to expand, faculty on the Inclusion and Diversity Committee ended up explaining why they were focusing on the aspects that they were focused on rather than trying to find ways to incorporate the SLs' ideas into their work. Thus, there was a dynamic when SLs shared their perspectives about ways to improve structures, policies, and practices that minimized the consideration of those ideas—limiting the College's ability to shift away from traditional approaches.

6 Discussion

The role of change agents in undergraduate STEM improvement efforts can be complex. Some are identified as change agents without intending to serve in such a role, with no training to enact change, and needing to negotiate change within the constraints of existing systems (McGrath et al., 2016). This was largely the case for the SLs in the present study. Although SLs working in course-related contexts received pedagogical training, they were not trained on how to press faculty to rethink teaching and learning structures. Thus, faculty looked to SLs for information about their students' needs and received it as advice to consider. Faculty did not see SLs as experts for *transforming* their course to intentionally address students' needs. Kim et al. (2019) recognized the importance of SLs working with faculty to transform teaching and learning experiences in STEM classrooms and have seen promise in SLs serving as learning researchers—former learning assistants who support faculty in improving STEM courses by providing detailed weekly reports of student learning, including specific recommendations for improvement. Although faculty initially received the information with a focus on students' understanding, over time they became more reflective and open to using the feedback to change their instructional practices.

While making course adjustments in response to advice shared by SLs is helpful, improving success in undergraduate STEM requires broader changes and greater consideration of students' needs and interests. The SLs in this study who served on College committees were positioned to help identify opportunities for improvement that may have been missed because of faculty, staff, and administrators' expert blind spot (Catrambone, 2011). Unfortunately, the study participant (including SLs themselves) saw SLs as unidirectional conduits of information from the College to students. Thus, SLs' improvement ideas became more of an opportunity to educate them on why structures, policies, and practices are and should remain in place.

7 Recommendations

Students Leaders play an important role in improving undergraduate STEM education through academic-centered peer interactions that foster student learning during class (e.g., Callahan, 2016; Chan & Bauer, 2015) and create community among students outside of class (Treisman, 1992). Nevertheless, the challenge that institutions face is not finding ways to help students navigate through the current state of STEM, it is with enacting new structures, policies, and practices that *transform* undergraduate STEM education so that a broader diversity of students will be attracted to, retained in, and complete STEM degrees. One way to achieve this goal is to apply an additional change lever (see Halasek et al., this volume) of recognizing SLs as experts of the student experience and incorporate their ideas into decisions related to improving programmatic structures, policies, and practices. We suggest that institutions provide structured opportunities for guided exploration of topics moderated by change leaders where SLs are presented as experts on the student experience. This will explicitly challenge faculty and administrators to listen to the student voice as authoritative and elicit the necessary disruption to the status quo that can support institutional change, especially as they work together to foster equity and inclusion in STEM (see Cook-Sather et al., this volume).

Much more information is needed on how to position and support SLs to effectively serve as change agents, particularly given their limited decision-making authority in traditional STEM contexts. Studies also need to examine approaches for helping faculty, staff, and administrations receive SLs' ideas and perspectives with more than just interest, but rather from a curious stance where they are open to change and improvement possibilities. As this body of research expands, it is our hope that those working to foster change in undergraduate STEM education will develop a better understanding of how to leverage SLs' ideas to broaden student success and retention in STEM and continually revise efforts to improve over time. We invite others interested in this work to join us in this endeavor.

8 About the Authors

Kadian M. Callahan is the Assistant Dean for Faculty and Student Success in the College of Science and Mathematics at Kennesaw State University.

Kaylla Williams is a undergraduate research assistant for the College of Science and Mathematics at Kennesaw State University.

Scott Reese is the Assistant Dean for Curriculum in the College of Science and Mathematics at Kennesaw State University.

8 References

Borrego, M., & Henderson, C. (2014). Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. *Journal of Engineering Education*, *103*(2), 220–252. https://doi.org/10.1002/jee.20040

Bowling, B. (2015). Professionalizing the role of peer leaders in STEM. *Journal of STEM Education*, *16*(2), 30–39. https://www.jstem.org/jstem/index.php/JSTEM/article/view/1908/1662

Breslin, J. D., Kope, M. H., O'Hatnick, J. L., & Sharpe, A. G. (2018). Students as colleagues: A paradigm for understanding student leaders in academic support. *Learning Assistance Review (TLAR)*, *23*(2), 41–64. https://nclca.org/resources/Documents/Publications/TLAR/Issues/23_2.pdf

Callahan, K. M. (2009). Academic-centered peer interactions and retention in undergraduate mathematics programs. *Journal of College Student Retention, 10*(3), 361–389. https://doi.org/10.2190/CS.10.3.f

Callahan, K. M. (2016). Prospective middle school teachers' generalizing actions as they reason about algebraic and geometric representations of even and odd numbers. *Teacher Education & Practice, 29*(4), 630–641.

Catrambone, R. (2011, June). *Task analysis by problem solving (TAPS): Uncovering expert knowledge to develop high-quality instructional materials and training* [Paper presentation]. *2011 Learning and Technology Symposium*, Columbus, GA.

Chan, J. Y., & Bauer, C. F. (2015). Effect of peer-led team learning (PLTL) on student achievement, attitude, and self-concept in college general chemistry in randomized and quasi experimental designs. *Journal of Research in Science Teaching, 52*(3), 319–346. https://doi.org/10.1002/tea.21197

Cook-Sather, A., White, H., Aramburu, T., Samuels, C., & Wynkoop, P. (this volume). "Moving toward greater equity and inclusion in STEM through pedagogical partnership." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 15). Pressbooks.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research* (3rd ed.). Sage.

Halasek, K., Heckler, A., & Rhodes-DiSalvo, M. (this volume). "Transforming the teaching of thousands: Promoting evidence-based practices at scale." In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 20). Pressbooks.

Healey, M., O'Connor, K. M., & Broadfoot, P. (2010). Reflections on engaging students in the process and product of strategy development for learning, teaching, and assessment: An institutional case study. *International Journal for Academic Development*, *15*(1), 19–32. https://doi.org/10.1080/13601440903529877

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952–984. https://doi.org/10.1002/tea.20439

Henderson, C., Finkelstein, N. D., & Beach, A. (2010). Beyond dissemination in college science teaching: An introduction to four core change strategies. *Journal of College Science Teaching, 39*(5), 18–25.

Klein, C., Lester, J., & Nelson, J. (this volume). "Leveraging organizational structure and culture to catalyze pedagogical change in higher education." In K. White, A. Beach, N. Finkelstein, C.

Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 19). Pressbooks.

Kim, Y. A., Cox, J., Southard, K. M., Elfring, L., Blowers, P., & Talanquer, V. (2019). Learning researchers: Promoting formative assessment in STEM courses. *Journal of College Science Teaching*, *48*(5), 36–41.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into Practice*, *41*(4), 212–218. https://doi.org/10.1207/s15430421tip4104_2

McGrath, C., Barman, L., Stenfors-Hayes, T., Roxå, T., Silén, C., & Laksov, K. B. (2016). The ebb and flow of educational change: Change agents as negotiators of change. *Teaching & Learning Inquiry*, *4*(2), 1–14. https://doi.org/10.20343/teachlearninqu.4.2.9

Milem, J. F., & Berger, J. B. (1997). A modified model of college student persistence: Exploring the relationship between Astin's theory of involvement and Tinto's theory of student departure. *Journal of College Student Development, 38*, 387–400.

Miller, E. R., & Fairweather, J. S. (2015). The role of cultural change in large-scale STEM reform: The experience of the AAU Undergraduate STEM Education Initiative. In G. Weaver, W. D. Burgess, L. Slakey, & A. L. Childress (Eds.), *Transforming Institutions: Undergraduate STEM Education for the 21st Century* (pp. 48–66). Purdue University Press.

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. President's Council of Advisors on Science and Technology. https://files.eric.ed.gov/fulltext/ED541511.pdf

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Westview.

Seymour, E., Hunter, A. B., & Weston, T. J. (2019). Why we are still talking about leaving. In E. Seymour & A. B. Hunter (Eds.), *Talking about Leaving Revisited* (pp. 1–53). Springer. https://doi.org/10.1007/978-3-030-25304-2_1

Tien, L. T., Roth, V., & Kampmeier, J. A. (2002). Implementation of a peer-led team learning instructional approach in an undergraduate organic chemistry course. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 39*(7), 606–632. https://doi.org/10.1002/tea.10038

Treisman, U. (1992). Studying students studying calculus: A look at the lives of minority mathematics students in college. *The College Mathematics Journal, 23*(5), 362–372. https://doi.org/10.2307/2686410

Vygotsky, L. S. (1978). *Mind in society*. Harvard University Press.

17. Making Teaching Matter More: REFLECT at the University of Portland

STEPHANIE SALOMONE, HEATHER DILLON, TARA PRESTHOLDT, VALERIE PETERSON, CAROLYN JAMES, AND ERIC ANCTIL

1 Introduction

Four of us sat at a round table at the WIDER PERSIST conference in Boise, Idaho in April 2016 and scribbled ideas furiously on colored post-it notes. Our charge was to create a vision statement that reflected the teaching and learning outcomes that we would most like to see on our home campus. Twenty minutes later, we had the following, which guided our team to create the REFLECT program, Redesigning Education for Learning through Evidence and Collaborative Teaching:

> The culture of teaching and learning at the University of Portland will be characterized by institution-wide support for faculty to collaborate, develop, reflect, and implement evidence-based, student-centered practices; students developing a habit of confidence in seeking knowledge; and students learning to engage, challenge, and collaborate using questioning, justification, and modern tools.

We spent the rest of the day delving into barriers and drivers for a change effort that would seek to overhaul teaching practices, brainstorming ways to mitigate obstacles and leverage existing resources, and listing allies and change agents who would be on board to help when we returned home. We decided to focus on STEM faculty development based on an urgent campus need to align instructional practices in use with those that have been demonstrated to be most effective and inclusive.

What emerged from this process was a program called REFLECT. The REFLECT program at the University of Portland is a 3-year pilot program funded by the National Science Foundation (NSF DUE IUSE:EHR #1710735). Our program has been successfully leveraged to create systematic change at our university and beyond, but our story of why this worked is a useful narrative for any university interested in changing the culture of improving STEM teaching on campus.

2 Background

2.1 Model of Change

The literature on institutional and cultural change is rich and deep. We started our journey by thinking about some of the most popular change models and how they might be applied on our campus. Fisher and Henderson (2018) have a great review of the different change models and contrasts them for different groups. Since none of our team members had high-level leadership roles on campus, we were drawn to emergent structures for change rather than prescriptive models. We also used a grid visualization developed by Henderson et al. (2011) to help us organize our thinking about change. One method we used was to consider how we could address each quadrant of the grid on our own campus as shown in Figure 1.

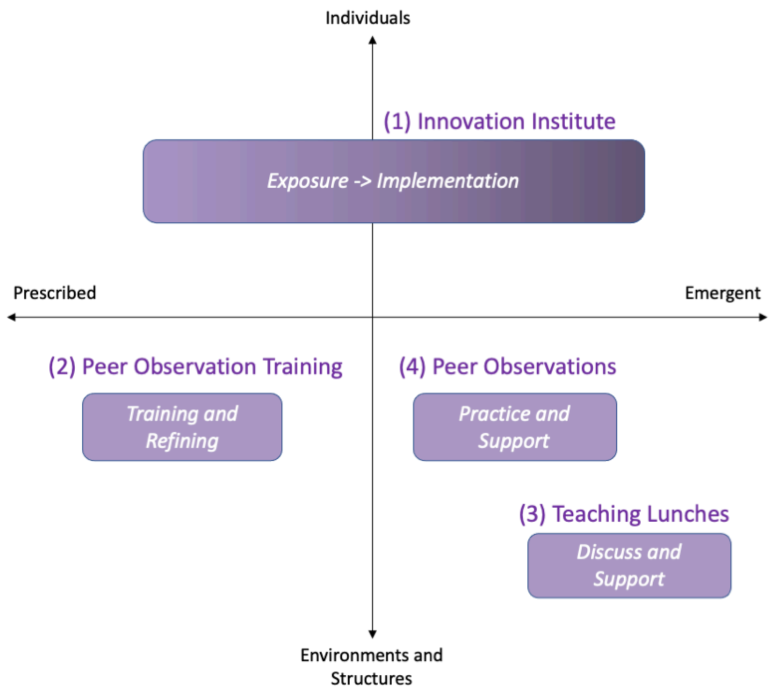


Figure 1. Using the Quadrants Suggested by Henderson et al. (2011) We Mapped Our Project Activities. The result shows how our team tried to address by prescriptive and emergent methods for change. (web: click on image to enlarge)

In selecting a theory of change to which we would anchor our work, we considered the relatively recent ways in which change theory has been adapted for higher educational use (Reinholz & Apkarian, 2018). These recommended adapting methods that align with individual beliefs, include long-term interventions, and align with institutional culture (Henderson et al., 2011). When possible, we sought to avoid the practices that change literature considered less helpful, like top-down policies.

These findings guided us, and continue to give us signposts as we move forward with the project. This intentional approach supported faculty autonomy and allowed us to meet participants at any stage of "adoption readiness," with an eye toward moving everyone forward from their own starting point. Each faculty member was on a unique journey from awareness to curiosity to mental tryout to actual trial and finally to adoption.

We selected the CACAO model for change (Marker et al., 2015) in part because it is flexible enough to allow change agents to weigh the benefits and drawbacks of the proposed change, incorporate the beliefs of adopters and their relative stages of adoption, and consider the institutional context in recruiting a diverse project team and developing a customized plan. That is, it allowed us to meet our change agents where they were on the adoption spectrum, and for the changes to be emergent, rather than prescribed. There are four dimensions addressed by the CACAO change model: Change, Adopters, Change Agents, and Organization. Each dimension considers the proposed change and guides thinking about mindset relative to change (awareness, curiosity, mental tryout, actual trial, sustained adoption). The dimensions include thinking about organizational hierarchy and matching change agents with roles. We found this framework helpful as we organized several elements of institutional change. Our project overview, with the CACAO elements, is shown in Figure 2.

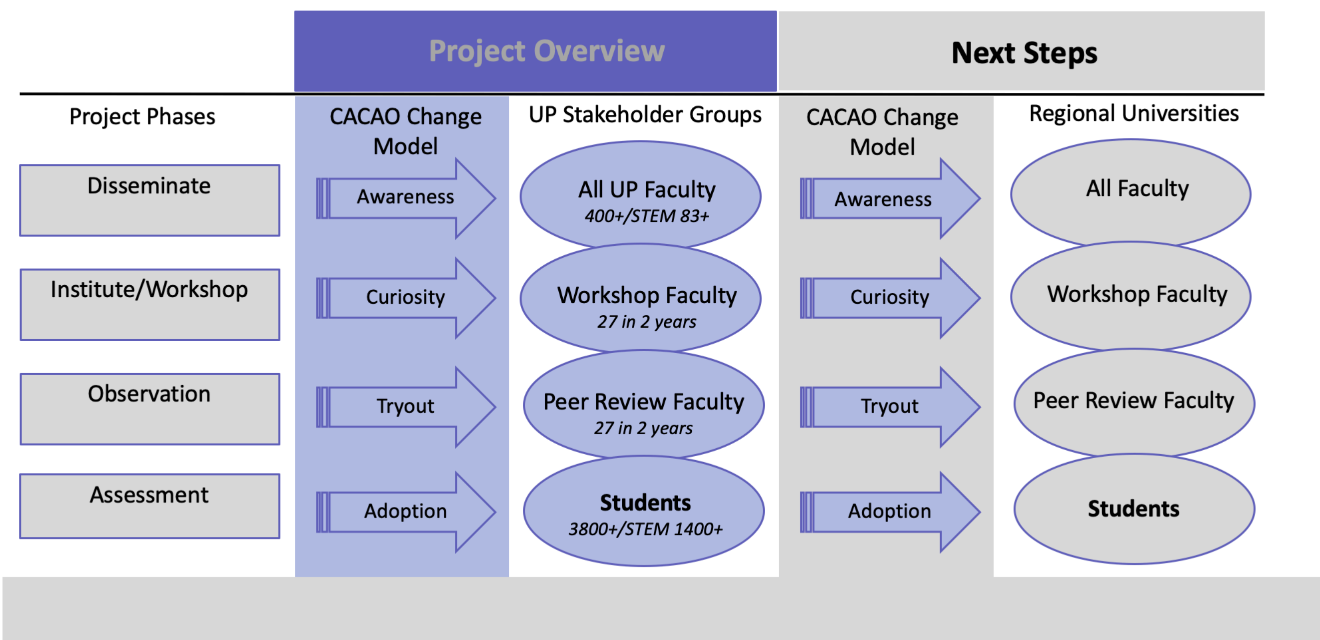


Figure 2. Summary of the REFLECT Project with the Change Model Mapping to CACAO. (web: click on image to enlarge)

2.2 Peer Observation of Teaching

The primary tool we used to sustain and inspire change is faculty peer observation because it offers many benefits to the instructors (Bernstein, 2008). One of the most important benefits is providing alternative data from traditional student evaluations of teaching. Other benefits of peer observation include teaching growth for the observer and the one observed (Gormally et al., 2014; Martin & Double, 1998) and improved faculty relationships.

The challenge for most faculty is the fear associated with peer observation and time for observations. Fear is often rooted in concerns about observer bias and power relationships in academia, such as those between untenured or contingent faculty and senior faculty and department chairs (Brent & Felder, 2004; Lomas & Nicholls, 2005). The time required for peer observation is also a factor, particularly with observation methods that require significant training time for calibration (Smith et al., 2013).

Many peer observation protocols have been developed over time for STEM classrooms. To understand this landscape, we did a careful literature review of existing protocols (Dillon et al., 2019). We found most existing protocols focusing on STEM faculty were summative (Brent & Felder, 2004; Drew & Klopper, 2014; Eddy et al., 2015). Others focused on the time that students and instructors spent in specific activities like the Classroom Observation Protocol for Undergraduate STEM (Smith et al., 2013); these protocols required the most training time (Hora et al., 2013; Smith et al., 2013). Still other protocols focused on student engagement and student outcomes rather than faculty formation (Lane & Harris, 2015; Shekhar et al., 2015). Table 1 provides a summary of our protocol in the context of other work.

Table 1: Summary of the Peer Observation Elements Included in the REFLECT Protocol. Adapted from Dillon et al. (2019).

Peer Observation Framework Elements	Traditional Peer Observation Protocols	REFLECT Peer Observation Protocol
1. Pre-Observation Meeting	X	X
2. Dimensions of Instruction		X
3. Pre-Observation Self-Assessment		X
4. Classroom Observation	X	X
5. Student Minute Papers		X
6. Observer Student Comment Summary		X
7. Post-Observation Meeting	X	X

After careful review of the existing protocols, we determined that we would develop our own with a specific goal of providing formative feedback to faculty that would support cultural change on our campus (Dillon et al., 2019). Our peer observation is unique in the way it allows faculty to select a specific dimension of teaching to be observed, making the observation a more manageable time commitment, and allowing the observed faculty member to have control over which aspects of their instructional practice are being considered. The dimensions of teaching in the REFLECT peer observation protocol are listed below, with new elements under development at this time. Additional details about the protocol and the design methods used for the sections are included in prior work (Dillon et al., 2019).

1. Clarity of instruction
2. Use of technology
3. Responding to student thinking
4. Challenging content
5. Equity of student engagement
6. Goal-Oriented instruction
7. Types of student engagement
8. Group work
9. Other (to be developed by your observation team)

3 Method for Change Leader Creation

3.1 REFLECT Institute

We designed the REFLECT Institute based on key ideas we read in the change literature. There are several elements that we built into the institute to create change leaders. Each of these is a lesson learned and a take-away from our own work.

First lesson: motivate faculty change based on incentive structures on campus. We could have named our training "faculty development," but we know that most faculty perceive faculty development to be prescriptive (or required). In contrast, we wanted everything about our workshop to be focused on nurturing change. By making it clear that we had a selective process to be included, we made our STEM institute something worthy of adding to a vita. We signaled the importance of taking an intentional deep dive into teaching practice with participant titles (STEM Innovation Fellow), labeling of our work together (REFLECT Institute), and by highlighting the work by reporting it to our administrators. Once the faculty were selected for the institute, we published their names in our campus newsletter and emailed the Deans and Provost with a list of their names. At the conclusion of the institute, we gave them each a nameplate for their office that made it clear they were part of the instructional change leadership on our campus.

Second lesson: create a culture of change agents. This was an important facet of the workshop. Many trainings are available about evidence based instructional practices (EBIPs). What makes our training unique is the way we wove in the elements of change on campus. We were explicit, and told our participants repeatedly they were going to become change agents. We included one activity where our participants crafted a vision statement about teaching on our campus. This allowed all the faculty participants to see themselves as change agents, as shown in an example crafted by the members of our 2019 cohort:

> Teaching and Learning at the University of Portland will be characterized by students, faculty, and an entire community of educators and learners who are engaged in collaborative, experiential, and innovative evidence-based practices. Teaching and learning cultures are evolving, flexible, and responsive to student needs and to new evidence about learning. Classrooms are inclusive spaces where different perspectives and identities are celebrated. Educators hold high standards and engage learners in challenging content, thereby instilling in students a desire to identify contemporary problems. Students become creative, confident, and curious thinkers with the tools and courage to solve these problems. Students, faculty, and administrators develop and nurture empathy, humility, and vulnerability. Students embrace their vocations as resilient agents of change and social justice. Faculty are supported with classroom resources, including right-sized classes, and ongoing professional development dedicated to teaching. Excellence in teaching is recognized, valued, and compensated.

After the participants crafted a vision statement, we emailed it to the Deans, Provost, and President of the University and gave credit to the individual faculty participants. This small act made it clear to the leadership on our campus that our cohort of faculty participants had a leadership role in each unit for creating this change. *We made it clear to the participants that we planned to support them in creating change on this campus at the highest levels.*

Another important structure in the workshop for supporting change was making sure each participant spent a significant amount of time building trust with other change agents from across campus. To accomplish this, we designed the activities so participants changed tables and groups frequently, most often outside of discipline groups. This was important for them to build trust in future peer observation partners, but also to create conversations around change at each table.

Third lesson: compensate faculty participants for their time and effort. We gave each faculty participant a stipend for their time. On our campus, the administration likes to talk about how focused on excellent teaching we are in student brochures, but few financial incentives exist. We did not provide much funding, but we made it clear we valued this work in the same way as disciplinary research. In *Levers for Change*, Laursen (2019) concludes that external rewards and policies are needed for the adoption and implementation of instructional approaches that positively impact student learning.

3.2 Faculty Peer Observation

We developed a formative peer observation protocol as a second tool to facilitate culture change on our campus. The peer observation process had several benefits that aligned with our change strategy.

1. The literature on change indicates that many faculty members need ongoing support to sustain energy for change. Faculty partnerships and ongoing contact help support this work.

2. The act of observing a colleague using EBIPs may help someone move along the adoption spectrum.
3. The positive feedback and self-reflection from being observed may support and grow a newly adopted teaching practice.

We found that faculty peer observation also led to other collaborations on campus, an exciting take-away. One example was a microbiologist and environmental engineering research collaboration. The two faculty members met through the peer observation process and the REFLECT institute. A few months later, a research challenge led the environmental engineering professor to ask for collaboration on a water-cleaning study. The project recently led to a peer reviewed paper in a journal (Beattie et al., 2019).

Another exciting facet of the peer observation protocol was the support it provided to faculty that wished to work on improving diversity and inclusion in the classroom. The dimension of teaching that is by far the most popular for faculty in the first cohort was "Equity of Student Engagement." This part of the protocol provides faculty tools for understanding if they are supporting all students in the classroom. We are currently working to develop new dimensions of teaching that would focus on best practices for diversity and inclusion.

The peer observation process served as a tool for self-reflection as well as collaboration, as noted by prior researchers (Cosh, 1999). Faculty participants were asked to reflect not only on their experience as an observer, but to critically examine their beliefs and the alignment of those beliefs with the realities of their teaching environments. **We found the formative peer observation process was an impactful way to elicit, engage with, and potentially shift participants' beliefs** (Peterson et al., 2019).

3.3 Leveraging University Initiatives

The last lesson used to create change on our campus was to strategically leverage other activities on campus. Each university has projects or mission statements that provosts and administrators care about. Determining the projects that high-level administrators spend time thinking about is an important lever for change. In our project, we tried to align our work as part of the solution to specific problems, or to align our work as leadership in specific areas.

One example is how we tied our work to mission at our university. We wrote a small grant that provided funds for lunches focused on "The Joy of Teaching." These lunches allowed us to gather our REFLECT STEM cohorts several times each semester to discuss teaching through the lens of mission. We invited all members of the community to participate and had wonderful and rich conversations about student-focused teaching practices. We hosted nine lunches over one academic year and averaged 15 participants at each lunch. Most of the lunch themes were closely aligned with specific traits we hope our students (and colleagues) might strengthen in the classroom.

4 Results

4.1 Change Leaders Created

After faculty had participated in the REFLECT project for one year, we sent them a survey online using Qualtrics. The survey distribution was reviewed by our university ethics review board. Although the sample size is very small (11 responses), some of the survey responses confirm that we have been successful at creating change agents on our campus. A few key responses have been included in Table 2.

Table 2: Summary of Survey Results about the REFLECT Institute. The results are based on 11 responses to the survey.

Questions	A great deal	A lot	A moderate amount	A little	Not at all
Did the REFLECT Institute increase your awareness of evidence-based teaching practices?	36.4%	27.3%	27.3%	0%	9.1%
Did the REFLECT institute inspire or support you to create a culture of reflective teaching at the university?	54.6%	36.4%	9.1%	0%	0%
Did the REFLECT institute inspire you to make changes in your classroom?	27.3%	54.6%	18.2%	0%	0%
Did the REFLECT Institute support you to increase communication with other disciplines on campus?	36.4%	36.4%	27.3%	0%	0%

How has participating in the REFLECT Institute influenced your practice of reflective teaching?

- "The project has helped me identify other people on campus who are committed to reflective teaching and can serve as a support system when something new doesn't go well or my resolve weakens."
- "I feel more comfortable taking small incremental risks in my teaching. I understand that these changes may be difficult for my students, but it's ultimately to their benefit."
- "Having a community that pushes for better teaching and learning practice provides the support I need to keep doing the work … Especially when others do not or question trying new things."

Another data point in the creation of change leaders surfaced during our annual faculty development day. A small group from our first cohort hosted a session on the importance of peer observation. This brave group of leaders did this without any guidance or support from the REFLECT leadership team, strong evidence that we have empowered our participants to carry the banner for educational change on our campus.

Figure 3. Word Cloud of Comment Themes from Participant Survey Question, "How has participating in the REFLECT Institute influenced your practice of reflective teaching?" (web: click on image to enlarge)

The external evaluation of our project also suggests success in several ways. Prior to participating, all but one of our Fellows reported having negative experiences with peer observation, citing nervousness, fear, and intimidation around the experience. After working with our team, their cohort colleagues, and utilizing the REFLECT protocols, faculty expressed much more positive feelings about observation, including the following:

- "It prompted me to think about things to do in my class. Being observed caused me to pick up on things I may not be noticing."
- "I loved peer observation. I would like to make that part of our evaluation process."

Faculty participants also reported implementing changes both to pedagogy and assessment that they learned about in the REFLECT institute. These included group work/group projects, technology, project-based learning activities, peer review, jigsaw, think/pair/share, and gallery walk. Some also talked about assessment techniques they tried: zero consequence quizzes, feedback on and homework solutions posted online, pretests, informal group discussions. All faculty said they would continue with those additions, improvements, and changes the next time they taught that class.

4.2 Institutional Change Created

As our project continues, we have directly trained 30.5% (27 members) of the STEM faculty at the University of Portland. Each STEM unit on campus has included at least one participant; in most units, we have several faculty members/change agents. At least four program chairs have been participants in the REFLECT project, and are working to make peer observation common practice. It has become routine for faculty in mechanical engineering, with 40% of the faculty participating in the REFLECT project. In the mathematics department, half of the full-time faculty (seven members) are involved in REFLECT either as project leaders or as STEM Innovation Fellows.

When surveyed, the REFLECT cohorts responded to several question prompts. A few informative responses are included here that support our hypothesis of change on our campus. *Did you have a favorite moment or positive experience using the REFLECT Peer Observation Protocol? What worked well?*

- “Probably that I learned just as much observing as being observed.”
- “The most effective part of this experience was discussing teaching with another faculty member. The protocol provided a framework for these discussions.”

Give a specific example of something that you changed in your class during this project. How did it go?

- “I attempted discussions with the entire class (25 students), and really worked on strategies to give all students the chance to participate. I thought it went really well, and now that I am over my initial fear/hesitation, I will definitely try it some more. The energy and points of view of the entire group made the discussion informative, interesting, and enlightening.”
- “Using the word ‘conjecture’ for every student idea—this worked well as it helped me to not be immediately evaluative of their ideas. It also allowed for other students to evaluate ideas rather than just me saying if an idea was worth pursuing. I allocated more time for students to share their ideas with each other through think-pair-share, through speed networking, through problem-solving, and through gallery walks. Doing these things helped me re-center that my discipline is collaborative and it is important to give students a chance to practice collaboration and sharing ideas in the classroom environment.”

Our external evaluator for the projected summed up the key element of institutional change we created, “For most, a major advantage of being involved in REFLECT was being part of a community with a common mindset: it was ‘good to find other people on campus thinking about how they teach and improving their teaching and so that was great.’ Being a part of REFLECT did impact thinking about instruction. As one instructor put it, I learned to try new things and ‘give myself permission to fail miserably.' All participants were happy to have been part of the project and planned to continue incorporating EPIBs into their instruction."

5 Discussion

Our research team has confirmed that institutional change is a journey, much like teaching is. Each institution has a culture and pressure points that can be leveraged by emergent and prescriptive change methods to move the needle. We believe that formally and systematically empowering change agents on campus can be supported with formal and formative faculty peer observation.

At our own institution our next steps are to continue training STEM faculty in peer observation and change agency. We hope to build our work at the regional and national level. At other universities our methods could be adapted and enhanced. This work is underway at the University of Calgary, where grant funding has allowed the training of one cohort in the fall of 2019. One cohort has also been trained at the Columbus State University in Georgia. In both cases, the type of training and change agent conversation have taken different forms, but all the early adopters have included the peer observation protocol as a foundation for institutional change.

Our journey with REFLECT continues. Since 2016, when this idea emerged, we have developed our own vision for our campus, applied for and received funding, trained faculty to change their pedagogical practices and supported them in implementation. We developed and piloted a new type of peer observation protocol for formative assessment of teaching. Whenever our energy flags for a moment, our team returns to our mantra, which is tied to our vision for the ways that our changes could impact, and have impacted, our community:

Your teaching matters. Make it matter more.

6 About the Authors

Stephanie Anne Salomone is the Director of the STEM Education and Outreach Center and Associate Professor and Chair of Mathematics at the University of Portland.

Heather Dillon is a Professor and Chair of Mechanical Engineering at the University of Washington Tacoma.

Tara Prestholdt is an Associate Professor in the Departments of Biology and Environmental Studies at the University of Portland.

Valerie Peterson is an Associate Professor in the Department of Mathematics at the University of Portland.

Carolyn James is Calculus Coordinator and Instructor in the Mathematics Department at University of Portland.

Eric Anctil is an Associate Professor of media and technology and director of the Higher Education and Student Affairs Program at the University of Portland.

7 References

Beattie, A., Dillon, H., Poor, C., & Kenton, R. (2019). Solar water disinfection with parabolic and flat reflectors. *Journal of Water and Health, 17*(6), 921–929. https://doi.org/10.2166/wh.2019.174

Bernstein, D. J. (2008). Peer review and evaluation of the intellectual work of teaching. *Change: The Magazine of Higher Learning, 40*(2), 48–51. https://doi.org/10.3200/CHNG.40.2.48-51

Brent, R., & Felder, R. M. (2004). *A protocol for peer review of teaching* [Memo]. American Society for Engineering Education. https://www.researchgate.net/publication/265997249_A_protocol_for_peer_review_of_teaching

Cosh, J. (1999). Peer observation: A reflective model. *ELT Journal, 53*(1), 22–27. https://doi.org/10.1093/elt/53.1.22

Dillon, H., James, C., Prestholdt, T., Peterson, V., Salomone, S., & Anctil, E. (2019). Development of a formative peer observation protocol for STEM faculty reflection. *Assessment & Evaluation in Higher Education, 45*(3), 387–400. https://doi.org/10.1080/02602938.2019.1645091

Drew, S. & Klopper, C. (2014). Evaluating faculty pedagogic practices to inform strategic academic professional development: A case of cases. *Higher Education, 67*(3), 349–367. https://www.jstor.org/stable/43648658

Eddy, S. L., Converse, M. & Wenderoth, M. P. (2015). PORTAAL: A classroom observation tool assessing evidence-based teaching practices for active learning in large science, technology, engineering, and mathematics classes. *CBE—Life Sciences Education, 14*(2), ar23. https://doi.org/10.1187/cbe-14-06-0095

Fisher, K. Q., & Henderson, C. (2018). Department-level instructional change: Comparing prescribed versus emergent strategies. *CBE—Life Sciences Education, 17*(4). https://doi.org/10.1187/cbe.17-02-0031

Gormally, C., Evans, M. & Brickman, P. (2014). Feedback about teaching in higher ed: Neglected opportunities to promote change. *CBE—Life Sciences Education, 13*(2), 187–199. https://doi.org/10.1187/cbe.13-12-0235

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952–984. https://doi.org/10.1002/tea.20439

Hora, M. T., Oleson, A. & Ferrare, J. J. (2013). *Teaching Dimensions Observation Protocol (TDOP) user's manual*. Wisconsin Center for Education Research. http://tdop.wceruw.org/Document/TDOP-Users-Guide.pdf

Lane, E. & Harris, S. (2015). Research and teaching: A new tool for measuring student behavioral engagement in large university classes. *Journal of College Science Teaching, 44*(6), 83–91. https://doi.org/10.2505/4/jcst15_044_06_83

Laursen, S. L. (2019). *Levers for change: An assessment of progress on changing STEM instruction*. American Association for the Advancement of Science. https://www.aaas.org/sites/default/files/2019-07/levers-for-change-WEB100_2019.pdf

Lomas, L. & Nicholls, G. (2005). Enhancing teaching quality through peer review of teaching. *Quality in Higher Education, 11*(2), 137–49. https://doi.org/10.1080/13538320500175118

Marker, A., Pyke, P., Ritter, S., Viskupic, K. Moll, A., Landrum, R. E., Roark, T., & Shadle, S. (2015). Applying the CACAO change model to promote systemic transformation in STEM. In G. C. Weaver, W. D. Burgess, A. L. Childress, & L. Slakey (Eds.), *Transforming institutions: Undergraduate STEM education for the 21st century* (pp. 176–188). Purdue University Press.

Martin, G. A., & Double, J. M. 1998. Developing higher education teaching skills through peer observation and collaborative reflection. *Innovations in Education & Training International, 35*(2), 161–170. https://doi.org/10.1080/1355800980350210

Peterson, V., James, C., Dillon, H. E., Salomone, S., Prestholdt, T., & Anctil, E. (2019). Spreading evidence-based instructional practices: Modeling change using peer observation. In *The 22nd Annual Conference on Research in Undergraduate Mathematics Education* (pp. 801–810). Mathematical Association of America.

Reinholz, D. L., & Apkarian, N. (2018). Four frames for systemic change in STEM departments. *International Journal of STEM Education, 5*(1), ar3. https://doi.org/10.1186/s40594-018-0103-x

Shekhar, P., Demonbrun, M., Borrego, M., Finelli, C. J., Prince, M. J., Henderson, C., & Waters, C. (2015). Development of an observation protocol to study undergraduate engineering student resistance to active learning. *International Journal of Engineering Education, 31*(2), 597–609.

Smith, M. K., Jones, F. H. M., Gilbert, S. L., & Wieman, C. E. (2013). The Classroom Observation Protocol for Undergraduate STEM (COPUS): A new instrument to characterize university STEM classroom practices. *CBE—Life Sciences Education, 12*(4). https://doi.org/10.1187/cbe.13-08-0154

18. Discipline-Based Teaching Development Groups: The SIMPLE Framework for Change from within

JILL K. NELSON AND MARGRET A. HJALMARSON

1 Introduction

While a significant body of research provides evidence that interactive, student-centered teaching improves learning, engagement, and retention, adoption of these teaching practices in STEM disciplines has been slow (National Research Council, 2012). This paper studies the value of an ongoing faculty development model to support instructors as they change their teaching to adopt research-supported, student-centered teaching practices. The teaching development model is structured around discipline-based faculty learning communities (SIMPLE groups) that meet regularly for at least one academic year. SIMPLE groups operate according to five principles put forth by the SIMPLE model for faculty teaching development: Sustained, Incremental change, Mentoring, People driven, and Learning-Environment focused. The focus of the project on which we report was to scale the SIMPLE model to multiple STEM departments at a single institution and to study how the principles of the model were enacted across the different teaching development groups. In this paper, we consider the following research question: How does the nature of SIMPLE groups support the adoption of reflective teaching practices? Through examining this research question, we aim to understand how ongoing teaching development groups can contribute to department-focused change toward evidence-based teaching practices.

2 Literature Review

This project used a variation on professional learning communities. Both in higher education and K–12 contexts, professional learning communities bring together instructors to discuss professional practice (Cox, 2004; Richlin & Cox, 2004). Wenger-Trayner and Wenger-Trayner (2015) define such communities of practice as “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (p. 1). Other researchers describe particular features of such communities: practice, community, and domain (Mercieca, 2017; Wenger, 1999/1998). Wenger (1999/1998) describes this practice as intertwined with community as “collective learning results in practices that reflect both the pursuit of our enterprises and the attendant social relations. These practices are thus the property of a kind of community created over time by the sustained pursuit of a shared enterprise” (p. 45). To achieve this community, membership is voluntary (Gehrke

& Kezar, 2019). Also, members develop relationships and trust among the group over time and with ongoing discussion. Finally, professional learning communities have a focused domain of interest that brings participants together in a voluntary way. In a community of practice or a professional learning community, members should have a shared interest in learning about their practice in a specific domain. In our case, we created discipline-based groups focused on developing student-centered teaching approaches.

The concept for social learning about teaching parallels social learning by students (Lattuca et al., 2014; Wenger, 1999/1998). In the higher education context, professional learning communities have been used as a model for instructional change, but research is still emerging (Kezar et al., 2018). Often, they are created for teaching development (e.g., Anderson & Finelli, 2014; Furco & Moely, 2012). Existing research indicates such experiences should be closely tied to the questions about their teaching identified by the instructors (Henderson & Dancy, 2011; Kezar et al., 2018). While learning communities should recognize that faculty may have different motivations for participating and varied interests in teaching (Gehrke & Kezar, 2019), there is also a sense of common purpose related to a shared interest in teaching overall (Mackenzie et al., 2016). Faculty learning communities also help faculty feel less isolated in what they are trying (Terry et al., 2018). Having a safe and supportive environment for peer-to-peer learning is a key component of the learning community in order to support changes in teaching (Furco & Moely, 2012; Kezar et al., 2018; Mackenzie et al., 2016).

3 SIMPLE Model for Discipline-Based Learning Communities

Each faculty learning community was situated within a particular discipline; participating instructors (and occasionally graduate students) were drawn from the same or closely related academic departments. We focused on discipline-based groups because colleagues frequently remarked that available resources for identifying active learning techniques did not lend themselves to STEM fields. STEM instructors wanted an environment to discuss how to implement active learning in STEM and learn from their colleagues' experiences. In a prior project, we observed that when instructors in a faculty learning community shared the same STEM discipline, the ability to share experiences and make connections allowed them to consider how to translate recommendations for teaching into their specific contexts (Hjalmarson & Nelson, 2014). Discipline- (or department-) based professional development has been shown to have additional advantages, including obtaining administrative support, building community and a sense of belonging within departments, facilitating the development of shared vision, and supporting regular discussion of teaching, curriculum, and assessment within departments (e.g., Laursen et al., 2019 and references therein). In addition, local faculty advocates for reformed teaching have been shown to significantly influence changes in teaching (Laursen et al., 2019).

A Diffusion of Innovations framework (Rogers, 2003) guided the development of the SIMPLE Model and our approach to the implementation of SIMPLE groups. Our goal was to support faculty in developing their teaching and learning about new teaching strategies. The group leaders we identified were often what Rogers (2003) refers to as "opinion leaders" who had expertise in student-centered teaching or were regarded as authorities on teaching by their colleagues. As facilitators who guided group participants through the teaching innovation process, they act as agents of change toward adoption of evidence-based teaching practices. Another important piece of Diffusion of Innovations is the sharing of knowledge among possible early adopters of a teaching strategy. Hence, participation was not mandatory; we encouraged leaders to identify and recruit members. We were seeking people likely to persist even if they encountered barriers to new teaching approaches. Rogers (2003) describes communication behaviors of early adopters as being more well connected with other people, having greater knowledge of the innovation, and having greater connections to change agents (p. 283). We anticipated that they would be people who might have already tried innovative teaching strategies or were highly interested in exploring new teaching strategies. This would create a departmental network of knowledgeable adopters and support for them as they tried new approaches. Indeed, several groups have remained active since inception (up to four years), with participants now leading follow-on efforts to promote teaching change in their departments.

The faculty learning communities studied in this project follow the SIMPLE model for faculty teaching development. The guiding principles of the SIMPLE model, detailed in Table 1 and further discussed in Nelson et al. (2016), are designed to guide the organization and activities of SIMPLE groups while allowing flexibility across contexts, institutions, and departments.

Table 1: Summary of SIMPLE Principles for Faculty Teaching Development

	Principle	Description
Sustained	SIMPLE groups are designed to be ongoing in nature, in operation for at least one academic year if not longer.	The ongoing nature of SIMPLE groups facilitates creation of community around teaching and provides the time necessary for participants to identify new strategies, tailor those strategies to their own teaching, implement, and revise those strategies. Groups that remain active over time have strong leadership, provide ongoing value to participants, and require a reasonable level of effort for beneficial participation.
Incremental change	SIMPLE groups are designed to encourage participants to make small changes in their teaching.	Instructors participating in our preliminary study of ongoing teaching development noted that when they undertook large changes (e.g., flipping a course that had been a traditional lecture), the burden of making the change and addressing any hurdles that arose in implementation greatly reduced its chances of success and sustained use. Hence, SIMPLE group participants engage in teaching change slowly, making small changes that can accumulate to create larger change.
Mentoring	SIMPLE groups are designed to provide participants with support and mentoring as they learn about, implement, assess, and revise teaching changes that move them toward active learning.	While SIMPLE groups do not include formal instruction, they are facilitated by group leaders who have knowledge of and experience with active learning practices. With input from participants, group leaders identify resources to scaffold SIMPLE group meetings such as books and videos that introduce new teaching practices and structure group discussion.
People-driven	SIMPLE groups are designed to support participants in addressing their individual teaching needs.	One of the key unique features of the SIMPLE model is that participants are not asked to adopt prescribed teaching strategies. Instead, participants are asked to bring their own teaching challenges and needs to the group and are introduced to a menu of possible strategies through resources and group meeting discussions. Because participants select and implement strategies consistent with their own needs, sustained implementation of the teaching change is more likely.
Learning environment	SIMPLE groups are designed to focus on the environment in which students are engaging with STEM content, peers, and instructors.	Participants are encouraged to make changes toward interactive teaching and student-centered learning, and the teaching strategies introduced through resources and discussion are selected to support these types of changes.

4 Research Design

In this NSF-funded research project (#1347675), the SIMPLE model was scaled to five STEM departments (Biology, Civil Engineering, Computer Science, Mathematics, and Physics) at a large, public, research-focused institution (Nelson et al., 2016; Nelson & Hjalmarson, 2019). SIMPLE groups were established in each department and remained active for at least two academic years. A leader for each SIMPLE group was recruited by the PI team. Leaders were identified based on their interest in teaching reform and their influence within their department. Most leaders participated in a semester-long training led by the project PIs. (One leader joined after training had taken place, and one group changed leaders after the first year.) Following training, leader meetings (facilitated by the project PIs) were held monthly to provide ongoing support.

As our research goal was to understand the participants' experience in SIMPLE groups and how they valued participation, we focus on data about that experience and the SIMPLE principles themselves (Patton, 2017). This is consistent with recommendations for the evaluation of learning communities and understanding the value they have for participants before attempting to understand more distal impacts like student learning (Wenger et al., 2011). Data collected as part of the project included participant interviews, recordings of group leader meetings, and participant check-in forms (completed two to three times each academic year). Group leaders and participants were interviewed at the end of each year of the project. Interviews were conducted by members of the project research team, including a graduate research assistant supported by the project, and were typically between 15 and 45 minutes in length. Interview questions explored participants' motivation for joining the group, how group meetings were structured, what benefits they gained from participation, and what challenges to participation they faced. In this paper, we consider interview data from the end of the first and second years of operation for each of the five SIMPLE groups listed above. 34 individuals were interviewed. Table 2 summarizes the number of interviews per group each year.

Table 2: Interviews per Department Each Year

Department	**Year 1**	**Year 2**
Biology	2 leaders 5 participants	1 leader 3 participants (2 repeats)
Civil Engineering	1 leader 4 participants	1 leader 2 participants (2 repeats)
Computer Science	1 leader 4 participants	1 leader 4 participants (3 repeats)
Mathematics	1 leader 8 participants	1 leader 2 participants (2 repeats)
Physics	1 leader 4 participants	1 leader (new) 2 participants (1 repeat)
Total	*31*	*18*

Note: "Repeats" indicates a participant was also interviewed in Year 1. There was also one new group leader in year 2.

Interviews as primary data source are useful for understanding the participants' perspectives

(Gubrium et al., 2012) in order to understand the principles that guided the group design (Patton, 2017). To address questions of descriptive validity (Maxwell, 2005; Maxwell & Chmiel, 2014), multiple reviewers read the interviews and we discussed our interpretations as we were coding the data to ensure consistency. We used a qualitative content analysis approach to develop codes and describe common themes in participant responses (Schreier, 2014). To begin coding the data for this analysis, we each reviewed prior analyses of the data set and a subset of the interviews. A preliminary coding of the data identified segments where participants discussed aspects connected to the SIMPLE principles using a content-focused approach following existing theory (Schreier, 2014). However, content analysis should also include data-driven codes that emerge through analysis (Schreier, 2014). This analysis based on our existing SIMPLE framework and data-driven codes helped us define a coding frame.

5 Findings

Several themes emerged with respect to how SIMPLE groups supported group members' development of reflective teaching practices. While some themes aligned with SIMPLE principles, interview analysis also revealed the importance of the discipline-based nature of the groups for supporting reflective teaching practices.

5.1 Discipline-Based and Discipline-Led

A common value of the SIMPLE groups for participants was their discipline-specific nature, i.e., having teaching conversations with other people in the same discipline in a group led by someone in their department. In our coding, two variations emerged about the value of discipline-based groups. The first is that participants discussed teaching strategies in ways that were specific to their discipline (e.g., structuring oral reviews for a calculus course or implementing collaborative coding activities in a programming course). The discipline-based group provided an opportunity for feedback about different ways to incorporate a teaching strategy that accounted for the content, common class structures, or student expectations for the discipline. Group members appreciated that colleagues could share their experiences about using similar strategies in related courses. Having a group leader from their own discipline also encouraged them to participate in the first place and help to create trust in the group.

The second discipline-based variation that was valuable to group members was their shared knowledge, expertise, and understanding. This supported reflection by helping group members focus on their particular teaching dilemmas but also for a shared context for advice/feedback from others. Shared understanding increased the relevance of the discussion for participants by focusing on strategies they were likely to use and on means for implementing them that made sense in the discipline. This allowed a more efficient conversation by eliminating the need to explain content to other group members. The group leaders also supported faculty as they were making by changes by guiding the conversation with requests for updates, sharing of new resources, etc.

5.2 Sustained and Incremental Change

The most common theme identified related to sustained and incremental operation of the SIMPLE groups was group members' desire to build community around teaching. Several participants noted that their department structure previously had no discussion devoted to teaching. They valued the opportunity to engage in a teaching discussion with their colleagues in a comfortable, supportive environment. As described by one group member, "You can ask what's going well, what's not going well, what would you recommend doing, and it's all of that information sharing to build the community. A support network is what you're building—that's what I enjoyed most about it." The value of discipline-specific groups ties to this theme, as well, since group members saw value in building a department-based community around teaching. This community building takes time and may require a long period before large teaching changes result. Hence, providing a structure for long-term support of teaching development is necessary to promote sustained change.

Tied to sustainability, the incremental principle relates to participants making small changes to their own teaching. We mention the incremental principle here not because participants raised it directly in their interviews, but rather because the comments they made seemed critical to understanding potential value. SIMPLE groups made space for participants to learn about new strategies and try what seemed most appropriate for their own classes. For example, "I think you want to take baby steps … Even though it's something really cool, it's not completely transformative, right? But they are doing some cool stuff, and you see how in the course of 4–5 semesters it will add up to something huge, but they're almost embarrassed about it because they are thinking you're gonna think it just isn't that big a deal." This participant is describing needing a comfortable space for discussion, connecting to the sustained principle, and the idea that small change in teaching can add up over time. The incremental principle values the idea that change takes time. Faculty need opportunities to try things, solicit (and receive) feedback, and try again. Noting the incremental process of change supported by group participation, a group leader remarked, "Many of our discussions involved theory of these things. And now it's actually incorporating them and moving beyond it. Again, so some people took the first couple of steps in what's a 20-step process, right? So, now they are going to be teaching the same course or courses over and over and over, so what we need to do is move beyond that into greater complexity." The groups helped faculty move from learning about new teaching strategies to implementing them more effectively.

5.3 Mentoring

Mentoring in SIMPLE groups can be best described as a combination of guidance from experienced colleagues and collaborative learning. 28 interviews included some mention of mentoring. A particularly valuable aspect of participation was hearing from people from the same discipline with similar challenges in their teaching. Group members felt learning about other people's experiences helped them avoid pitfalls and work through challenges in new teaching strategies. In many groups, there was an informal dynamic of new faculty being informally mentored within the group by members who were more experienced. As one group leader described the mentoring role, "for several years I think I've been incorporating these things into my classes, and so I think my role was to be a cheerleader for people, right? … Some of the things that I've incorporated, like everybody else, have failed measurably. But instead of just giving up, it's really helpful to have people in a room to say, 'Look, you can expect this. Don't worry about it.' That's very powerful to have someone who's gone through the experience that had as tough a time as you had, … It's really terrific advice, so I think it's a mentorship role is what I see." The group leader in this way is both learning and providing support to other participants. The powerful experience is in learning from someone in the same discipline.

Mentoring is specifically related to the discipline-based nature of the groups because the participants were receiving feedback from people in their own department who might have more experience with the particular types of courses they were teaching. This is supported by existing research suggesting that instructors learn from trusted and supportive peers in their own discipline (Kastens & Manduca, 2017).

One SIMPLE group participant described the applicability of the discussion as, "So, I feel like what was beneficial about this project was that in meeting with the other people in my department to talk about it, the strategies that were discussed were applicable to my classes versus other things that I've been to, strategies that were discussed may or may not apply, and it was not always useful to me."

5.4 People-Driven

The people-driven principle describes how SIMPLE groups should work from the teaching goals and interests of their members. In 18 interviews, the people-driven nature was mentioned as a valuable aspect of the group. When asked why instructors continued to attend group meetings, a group leader stated in their second-year interview,

> First and foremost they have to feel like it's worthwhile. It has to somehow meet whatever reason they have for coming, most of which is kind of, "Make my teaching easier, more satisfying, and my goal is to be effective. But if it takes my entire—all day and all night every day for seven days a week to be effective, I'm in trouble 'cause I have other responsibilities and I have a life outside of a total work commitment." So, there have to be some ways of making it that this was productive. And, not someone sort of driving a meeting with an agenda that wasn't my agenda. So it has to be an organic kind of thing where they feel like, "If I have an issue it's gonna get taken care of, and if I have something useful to contribute it's gonna be heard and taken up so that my time is not, you know, it's not a waste of my time."

Group leaders played a role by structuring the discussion to encourage everyone to share and creating an open space. For instance, one participant said her group leader opened meetings with the questions, “Hey … Does anybody have anything that they need people to help them with? Or did anybody do something that was really amazing?” Participants appreciated meetings that included time for them to bring their own dilemmas and challenges up for discussion, possibly balanced with reading or discussion of other department issues. As a counterpoint, some participants who became less engaged in SIMPLE groups over time spoke to those groups having specific agendas or interests that were not their own.

6 Discussion and Implications

Interviews of SIMPLE group leaders and participants indicate that SIMPLE groups supported instructors in trying new teaching strategies, reflecting on the strategies they were adopting, and finding a community of instructors with a similar interest in transforming teaching. The SIMPLE principles created a structure that allowed flexibility to meet instructors’ varying needs and was supportive of change over time. Recruiting group leaders from the discipline helped participants connect easily to pedagogical conversation. An important take-away from this work is that change in teaching practice takes time and that faculty need ongoing support for sustained change. Connections made through SIMPLE groups have continued indefinitely, sometimes through formal groups but often through informal conversations and teaching discussions. Instructors who participated in SIMPLE groups have begun to lead department-focused change efforts via, e.g., follow-on funded efforts or administrative roles. Ongoing questions that need further exploration include how the value of SIMPLE groups to participants can be sustained over multiple years and how the existence of an active group may impact departments over the long term. Further investigation is also needed to understand how to support and develop group leaders and facilitators over time as participants’ needs evolve.

7 Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 1347675 (DUE) and while Margret Hjalmarson was serving at the National Science Foundation. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

8 About the Authors

Jill Nelson is an Associate Professor of Electrical and Computer Engineering at George Mason University.

Margret Hjalmarson is a Professor in the School of Education at George Mason University.

8 References

Anderson, O. S., & Finelli, C. J. (2014). A faculty learning community to improve teaching practices in large engineering courses: Lasting impacts. *Proceedings of the 121st ASEE Annual Conference*, 24.46.1–24.46.9. https://doi.org/10.18260/1-2–19938

Cox, M. D. (2004). Introduction to faculty learning communities. *New Directions for Teaching and Learning* (97), 5–23. https://doi.org/10.1002/tl.129

Furco, A., & Moely, B. E. (2012). Using learning communities to build faculty support for pedagogical innovation: A multi-campus study. *The Journal of Higher Education*, *83*(1), 128–153. https://doi.org/10.1080/00221546.2012.11777237

Gehrke, S., & Kezar, A. (2019). Perceived outcomes associated with engagement in and design of faculty communities of practice focused on STEM reform. *Research in Higher Education*, *60*(6), 844–869. https://doi.org/10.1007/s11162-018-9534-y

Gubrium, J., Holstein, J., Marvasti, A., & McKinney, K. (2012). *The SAGE handbook of interview research: The complexity of the craft*. SAGE Publications, Inc. https://doi.org/10.4135/9781452218403

Henderson, C., & Dancy, M. H. (2011). *Increasing the impact and diffusion of STEM education innovations* [White Paper commissioned for the Characterizing the Impact and Diffusion of Engineering Education Innovations Forum, Feb. 7–8, 2011.]. National Academy of Engineering. https://www.nae.edu/File.aspx?id=36304

Hjalmarson, M., & Nelson, J. K. (2014). Creating small interactive teaching development groups. *Proceedings of the 121st ASEE Annual Conference*, 24.334.1–24.334.6. https://doi.org/10.18260/1-2–20225

Kastens, K., & Manduca, C. (2017). Leveraging the power of a community of practice to improve teaching and learning about the earth. *Change: The Magazine of Higher Learning*, *49*(6), 14–22. https://doi.org/10.1080/00091383.2017.1398997

Kezar, A., Gehrke, S., & Bernstein-Sierra, S. (2018). Communities of transformation: Creating changes to deeply entrenched issues. *Journal of Higher Education*, *89*(6), 832–864. https://doi.org/10.1080/00221546.2018.1441108

Lattuca, L. R., Bergom, I., & Knight, D. B. (2014). Professional development, departmental contexts, and use of instructional strategies. *Journal of Engineering Education*, *103*(4), 549–572. https://doi.org/10.1002/jee.20055

Laursen, S. L., Andrews, T., Stains, M., Finelli, C. J., Borrego, M., McConnell, D., Johnson, E., & Foote, K. (2019). *Levers for change: An assessment of progress on changing STEM instruction*. American Association for the Advancement of Science. https://www.aaas.org/sites/default/files/2019-07/levers-for-change-WEB100_2019.pdf

Mackenzie, H., Tolley, H., Croft, T., Grove, M., & Lawson, D. (2016). Senior management perspectives of mathematics and statistics support in higher education: Moving to an “ecological” approach. *Journal of Higher Education Policy & Management*, *38*(5), 550–561. https://doi.org/10.1080/1360080X.2016.1196932

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach* (2nd ed.). Sage Publications, Inc.

Maxwell, J. A., & Chmiel, M. (2014). Generalization in and from qualitative analysis. In U. Flick (Ed.), *The SAGE handbook of qualitative data analysis* (pp. 540–553). SAGE Publications Ltd. https://doi.org/10.4135/9781446282243.n37

Mercieca, B. (2017). What is a community of practice? In J. McDonald & A. Cater-Steel (Eds.), *Communities of practice: Facilitating social learning in higher education* (pp. 3–25). Springer. https://doi.org/10.1007/978-981-10-2879-3_1

National Research Council. (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering* (S. R. Singer, N. R. Nielsen, & H. A. Schweingruber, Eds.). The National Academies Press.

Nelson, J. K., & Hjalmarson, M. (2019). *Insights into the nature of change and sustainability in an ongoing faculty development effort* [Paper presentation]. 2019 ASEE Annual Conference and Exposition, Tampa, FL. https://doi.org/10.18260/1-2–32968

Nelson, J. K., Hjalmarson, M., Bland, L. C., & Samaras, A. P. (2016, June 26). *SIMPLE design framework for teaching development across STEM* [Poster session]. 2016 ASEE Annual Conference & Exposition, New Orleans, LA. https://doi.org/10.18260/p.26187

Patton, M. Q. (2017). *Principles-focused evaluation: The GUIDE*. Guilford Press.

Richlin, L., & Cox, M. D. (2004). Developing scholarly teaching and the scholarship of teaching and learning through faculty learning communities. *New Directions for Teaching and Learning* (97), 127–135. https://doi.org/10.1002/tl.139

Rogers, E. (2003). *Diffusion of Innovations* (5th ed.). The Free Press.

Schreier, M. (2014). Qualitative content analysis. In U. Flick (Ed.), *The SAGE handbook of qualitative data analysis* (pp. 170–183). SAGE Publications Ltd. https://doi.org/10.4135/9781446282243.n12

Terry, L., Zafonte, M., & Elliott, S. (2018). Interdisciplinary professional learning communities: Support for faculty teaching blended learning. *International Journal of Teaching & Learning in Higher Education*, *30*(3), 402–411. https://eric.ed.gov/?id=EJ1199424

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press. (Original work published 1998)

Wenger, E., Trayner, B., & de Laat, M. (2011). *Promoting and assessing value creation in communities and networks: A conceptual framework*. Open University of the Netherlands. https://wenger-trayner.com/resources/publications/evaluation-framework/

Wenger-Trayner, E., & Wenger-Trayner, B. (2015). *Communities of practice: A brief introduction*. https://wenger-trayner.com/wp-content/uploads/2015/04/07-Brief-introduction-to-communities-of-practice.pdf

19. Leveraging Organizational Structure and Culture to Catalyze Pedagogical Change in Higher Education

CARRIE KLEIN, JAIME LESTER, AND JILL NELSON

Active and inquiry-based learning has a positive effect on student engagement at all levels of curriculum (e.g., Coalition for Reform of Undergraduate STEM Education, 2014; Freeman et al., 2014; National Research Council, 2012). These approaches have an even greater influence on historically underrepresented populations, particularly women, and on students who held lower achievement rates (Kogan & Laursen, 2014; Laursen et al., 2014). Despite their value, the change required to integrate these practices can be difficult, especially in higher education. Motivating faculty to make significant changes to their teaching practices is challenging (Austin, 2011). As a result, there has been uneven adoption of active learning and inquiry-based approaches.

The literature on pedagogical change in academic departments indicates that departmental norms and organizational structures have a large impact on the way STEM faculty teach (Austin, 2011; D'Avanzo, 2013; Brownell & Tanner, 2012; Henderson et al., 2012; Lee, 2007; Sunal et al., 2001; Fairweather, 2008). Institutional barriers, including fragmented organizational sub-structures and sub-cultures, mean that innovative teaching practices often become siloed (Bergquist, 1992; Birnbaum & Edelson, 1989; Bolman & Deal, 1991; Kezar, 2011; Tierney, 2008). The dependence of change on departmental norms and siloed institutional structures makes it difficult to spread changes, like innovative teaching practices, across higher education. Given this context, it is important to investigate how organizational change practices that mitigate fragmentation and leverage departmental norms can be used to diffuse pedagogical innovations within and beyond individual and department level practice.

1 Project Goals

The purpose of our current National Science Foundation (NSF)-funded IUSE project (1821589) is to better understand the process of organizational change for pedagogical diffusion that occurs via peer-to-peer learning communities engaged in implementation of active- and inquiry-based pedagogy in STEM fields. We are interested in how these teams, which we call Cross-course Communities of Transformation (CCTs), can be used to facilitate broad adoption of active learning within departments and across STEM disciplines. We also want to develop knowledge of how faculty-driven, grassroots approaches to change combined with institutional support can build a culture of active learning. The purpose of this work is to study effective strategies for removing barriers for faculty implementation of new, evidenced-based teaching methods and to prepare the next generation of diverse STEM educators.

Relying on extant literature and best practices from organizational theories of change and instructional and pedagogical design, the following research questions are guiding our work: 1) How do the tactics outlined in grassroots change theory help to create sustainable course-level and department-level changes toward the use of inquiry-based learning? 2) To what extent do graduate apprentice instructors and undergraduate learning assistants assist in diffusing course-level change to the department or college level? 3) How do grassroots tactics, implemented through CCTs, influence organizational learning and diffuse course-, department-, and institution-level change? We provide a model for organizational change, based on CCTs, discuss the model-informed change process, share observations from our work and conclude with practical recommendations for faculty and administrators seeking to create organizational change.

2 Change Model

The theoretical framework for this project is informed by higher education focused grassroots change and organizational diffusion models. Developed by Kezar and Lester (2011), the grassroots leadership model provides evidence and a mechanism for understanding how to engage individuals and teams to achieve organizational change on college campuses. Grassroots leadership research (Kezar & Lester, 2011) shows that providing professional development opportunities, enabling faculty discussion of curricula and classroom activities, working with and mentoring students, using data to tell a story, partnering with stakeholders, and leveraging existing networks are effective change mechanisms in higher education that work to mitigate the organizational structures and norms that can limit change.

Diffusion and organizational learning are central to the grassroots model. Integrating change into higher education institutions requires altering individual mindsets or perspectives, including those of campus leadership. Organizational learning, a social cognitive change theory, is a process of sharing knowledge that guides behavior and shapes meaning for individuals and groups (Crossan et al., 1999). Organizational learning consists of four processes: knowledge acquisition, information distribution, information interpretation, and organizational memory, and occurs when shared knowledge embeds in organizational structures, processes, and culture (Huber, 1991). Once embedded, change can diffuse further into the institution (Rogers, 2003).

Kezar and Lester (2011) note that diffusion requires the convergence of bottom-up (grassroots) and top-down efforts. This project combines top-down support with a grassroots design that begins with educational innovators within the faculty and ends with the laggards identified in Rogers' (2003) diffusion theory. Figure 1 provides more detail on how this model applies to the CCT change efforts in this study.

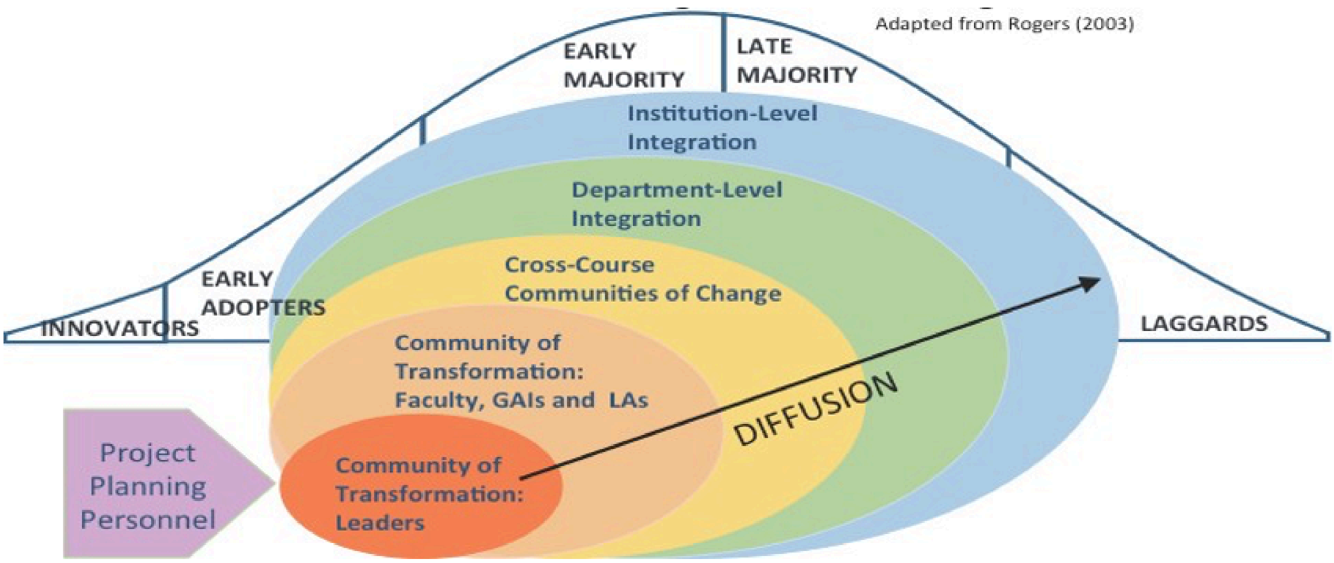


Figure 1: Innovation Diffusion and Organizational Change Model (web: click on image to enlarge)

We seek to expand Kezar and Lester's work by examining the impact of CCTs on changing pedagogy, processes, and culture through learning and diffusion. Peer-to-peer learning communities have been shown to provide support for organizational learning (Mittendorf et al., 2006), the development of new pedagogical interventions, and shifting faculty values surrounding teaching and learning (Snyder et al., 2003; Boud & Middleton, 2003; Davis & Sumara, 1997; Gallucci, 2003; Sanchez-Cardona et al., 2012; Viskovic, 2006). The CCT model draws from a prior faculty teaching development project in which discipline-based learning communities were used to support sustained adoption of active learning practices in STEM (Nelson et al., 2016). While the previous approach encouraged participants to select strategies to address their individual needs, the CCT model focuses on building a shared vision for the nature of the change toward active learning.

3 Putting the Model into Practice: The Process of Change

As of Fall 2019, two of the planned four CCTs have begun the process of integrating active learning pedagogy and change across introductory math and physics courses. Because our project staggers the start and implementation of CCT work, the Math CCT and Physics CCT are at different stages of the change process (to be followed by Computer Science and Biology). Since Spring 2019, the Math CCT has worked to incorporate pedagogy change in introductory calculus courses. Meanwhile, the Physics CCT members began their efforts related to introductory physics courses in Fall 2019. As a result, this paper is focused on the Math CCT change process.

In Spring 2019, project team members met with faculty and graduate teaching assistants (GTAs) in the Math department to provide an orientation explaining the project and providing insight into the benefits of active learning and the process of organizational change. Attending and speaking in support of the project was a vice provost, college dean, and the chair of the Math department. The strong administrative support of this effort is tied to campus-wide efforts to improve active learning strategies and resources. Improving teaching and learning is tied to both our institutional identity as a large, regional comprehensive public university and our most recent strategic plan, which sought to balance our very high research status with our commitment to public education. The active learning discussion was led by a nationally recognized disciplinary expert on active learning pedagogy in math. The majority of 50 Math faculty members participated in the orientation.

Following this orientation, Math CCT members, who are a subset of early-adopter faculty from the Math department (nine total), began meeting every two weeks to identify areas for change and to plan for change implementation. Facilitating these meetings is a departmental change agent, who is also a member of our research team. The change agent is a well-respected member of the Math department, having worked at the institution for nearly 30 years and previously been department chair. They are also actively engaged in active learning on a national level. In these meetings, Math CCT members have established change goals, engaged in peer-learning, and discussed effective active learning practices that they have used in their own classes. To support their learning in the active learning space, the CCT change agent has also invited speakers from outside the institution to provide seminars on active learning and inquiry-based classroom practices. The research team provided ongoing support to the change agent and CCTs in monthly meetings, connecting the change agent with resources and strategies to leverage their departmental norms and structures to facilitate change.

As a group, the Math CCT members decided to restructure course recitation sessions for introductory calculus courses to include active learning practices, which began in Fall 2019. This decision was based on review of disciplinary literature and on departmental data. To support this change, Math CCT members hired and trained a number of GTAs and undergraduate learning assistants (LAs) and created bi-weekly meetings to support GTA professional development. These meetings provide peer-learning, sharing, and training opportunities, with additional guidance provided by the change agent.

To study the process of organizational change, we are using a collective case study design to allow for “in-depth exploration of a bounded system (e.g., an activity, event, process or individuals) based on extensive data collection” (Creswell & Poth, 2012, p. 476) designed around a specific theory and literature (Stake, 2005). The use of a collective case study will allow us to study organizational change from multiple, interrelated perspectives of the CCTs as they go through the change process. Our primary data collection methods are observations of CCT meetings and interviews with CCT members. We have also collected reflective memos from CCT change agents. Data collection is focused on CCT processes, change, and change management. Consistent with methodological norms of qualitative inquiry, the systematic coding of these data (i.e., interview transcripts, documents, field notes and memos) serves as the primary means of data analysis (Strauss & Corbin, 1990). Examples of current codes include: shared leadership, visible commitment, shared goals, respect, experience, culture, process, communication, and assessment.

4 Observations

Although we have many emerging findings, among the most prominent observations we have made are the importance of aligning process and culture and of leveraging visible and respected leadership across levels to encourage organizational learning and change diffusion.

4.1 Alignment of Change to Cultural Norms Encourages Adoption and Learning

Attention and alignment of organizational change efforts to cultural norms matters to promote and diffuse organizational learning and change. Across Math CCT member interviews, participants communicated that shared leadership as a mechanism for change is culturally valued in their department. The chair of the department explains, “So usually the way things change is that, um, you know, someone has an idea and they get a few people on board with it. They implement the idea, people see that it’s successful, and then more people kind of jump on that.” The Math CCT change agent used this cultural perspective to guide his facilitation of meetings by encouraging shared approaches to change. We observed that while the change agent calls CCT meetings to order, the group participates collaboratively in conversations about interests, goals, and outcomes and in learning about inquiry-based pedagogy. In this case, when the process of group work is aligned with the cultural value of shared leadership, it can act as a catalyst for change.

Equally important for the Math CCT is collegial relationships. Multiple participants noted that respect for their colleagues and their colleagues’ ideas is valued culturally. As a tenure-track faculty member noted, “We’ve worked well together. We’re very respectful of each other’s ideas.” Examples of respectful relationships were observed across Math CCT and GTA meetings. As a group, participants were supportive of each other’s ideas and encouraged full participation of members (including GTAs). This culturally held value of respect has also informed the processes associated with the change work on which the CCT members are focused. A term faculty member explained that a respectful environment has resulted in a CCT group that has “done a really good job of communicating … you know, we’re a pretty cohesive group already.” Their cohesiveness has laid the groundwork for effective work to take place, resulting in what another term faculty described as “a good initial plan of attack on how to kind of get what we want out of this.” In this case, by aligning process to a cultural norm of collegial relationship interactions, Math CCT members were able to effectively move their active learning goals forward.

Among the work they have moved forward is pushing organizational learning beyond their initial group. The Math department and, as we have observed, CCT members in particular value professional development and growth. The CCT’s work and seminars are seen as a way for faculty members to grow professionally, as a new tenure-track faculty member notes, “I really do believe in active learning, but I struggle with being an active learning teacher. So, I think that the [CCT] group helps me kind of get ideas, confidence from it, um, and to bounce ideas off of people who do it successfully or have seen it in other places.” The cultural importance of learning and developing professionally acted as a lever for change in this new faculty member. By aligning cultural norms with change efforts, CCT members have created learning opportunities for faculty in the department. Moreover, incorporating learning seminars was an important strategic decision by the change agent, as participants noted that the seminars were among their favorite parts (beyond seeing students’ development and growth) of participation in this project.

4.2 Visible and Respected Leadership at Multiple Levels Legitimizes Change Efforts

Tied to the culture and process is the role of visible and respected leadership, at multiple levels, to legitimize change efforts. From CCT orientation on, there has been visible support for this project by the administration and department leaders. At the Math CCT’s orientation, a vice provost, college dean, and department chair were there to signal their support. The department chair has also attended Math CCT meetings. Notably, as mentioned in the change agent’s memos, both he and the department chair have led and participated in robust conversations about the change efforts in departmental meetings, which has resulted in increased interest by faculty. This top-down, visible support of the inquiry-based change efforts through this project have helped facilitate faculty interest and involvement in the process.

However, to effectively facilitate change, grassroots leadership is also needed. CCT members universally indicated their respect for the change agent’s experience and his social capital among the group as a vital component of their participation in the change efforts. For example, when we asked a term faculty member why she joined the CCT efforts, she explained that she and the change agent had similar perspectives on teaching and “had great conversations about teaching, like, way before [the start of the CCT’s work].” The change agent’s prior relationship and teaching experience was a draw for this CCT member. Similarly, the department chair explained how the change agent’s reputation acts as a boon to the active learning change efforts:

> [The Change agent] is, um, you know, extremely well respected in the department and, uh, and he’s taken very seriously by people, especially in regard to teaching, you know, ‘cause everyone knows that this has been his thing for years and years. And you know, people go to [the change agent] about [active learning] with the questions about teaching and, and things like that. So, the fact that [he] is, uh, is taking the lead on this is extremely helpful.

The Math CCT change agent’s experience and reputation with department members helped legitimize the active learning efforts in the department. The legitimation was given further heft through the support of top-level leaders and the visibility both top-down and grassroots actors have given to the process.

5 Recommendations for Practice

Based on the initial findings from our project, we have a number of recommendations for both faculty and departmental administrators seeking to enact organizational change within their disciplines and across their campus communities.

5.1 For Faculty

Faculty interested in changing their departmental culture and practices should leverage resources and relationships to help catalyze that change. To start, we recommend seeking out resources (e.g., literature, evidence, examples, experts, etc.) and sharing them broadly within your departmental community to help legitimize your efforts. These resources can help establish shared understanding and goals with colleagues around a proposed change strategy. Importantly, these efforts should align with departmental cultural norms, including acceptable communication and meeting processes, to both encourage participation and increase buy-in from potential participants. As Lee (2007) has found, attention to department-level culture is integral to change.

The attention to culture is tied to effective grass-roots change efforts. Kezar and Lester (2011) found that effective change agents are able to leverage departmental and organizational culture for change efforts. Change agents should leverage both departmental culture and their social capital to not just encourage participation in the change process, but also to advocate for people, spaces, resources, and other needs related to desired change. Austin (2011) argues that these aspects of organizations can be used to leverage a willingness by faculty to innovate their teaching practices. Central to long-term change is the inclusion of future generations of disciplinary colleagues, so graduate and undergraduate students (GTAs and LAs in this project) should be mentored in the change process by actively including them in CCT meetings, seminars, and other events. Finally, CCT change work, progress, strategies, “wins,” and related professional development opportunities should be made visible by sharing them broadly, both within and beyond the department. This socio-cognitive approach of leveraging culture, capital, and organizational learning aligns with Crossan et al.’s (1999) socio-cognitive approach and provides opportunities for learning to be embedded and diffused through the fabric of organizations (Huber, 1991).

5.2 For Department Leadership

Among the best things departmental leaders can do to support organizational change are to provide visible, top-down support while simultaneously allowing for bottom-up leadership. This dual level of support can help encourage organizational change by providing visibility and legitimization to organizational change efforts (Kezar & Lester 2011). This support of CCT work can be shown through attending change strategy meetings and seminars and by working with change agents to advocate at the college or institutional level for people, spaces, resources, incentives, and rewards.

Departmental leadership can also work with change agents to leverage organizational culture to support desired changes. To encourage department-level buy-in, department chairs should provide incentives, rewards, and professional development opportunities to department members. Like with other organizational resources, Austin (2011), in her study of faculty pedagogy change, found incentives and rewards (e.g., course buy-outs, increased funding, formal recognition, etc.) are effective institutional and managerial levers for change. Leadership should also give time during department meetings for change agents, CCT members, or other project champions to share change efforts, processes, strategies, successes and opportunities. Finally, department leadership would champion change strategy "wins" in deans' and department chairs' meetings, to incorporate organizational learning and change within and beyond the department level. Effective communication of positive change outcomes, within and beyond the department-level, is central to grassroots effectiveness, organizational learning, and diffusion of change (Crossan et al., 1999; Huber, 1991; Kezar & Lester, 2011; Rogers, 2003).

6 Conclusion

The first year of this project has created an incredible opportunity for learning for project team members and for members of the Math CCT. Course recitation sessions rooted in active-learning inquiry began this fall, and we are beginning to see positive results of that change in students. Math CCT members are still actively engaged in the change process and working toward learning from the first semester of change implementation. As a research team, we are beginning to see how CCTs can work to effectively implement change within the department. Among the positive changes that have occurred are additional faculty joining the CCT efforts and improved outcomes for students in active learning courses. We look forward, as the Math CCT and Physics CCT members begin to meet in the coming year, to how these changes can diffuse across STEM departments and to provide recommendations for necessary conditions for change that can be used across disciplines to improve active learning implementation and, ultimately, student outcomes.

7 Acknowledgements

This research was supported in part by a grant from NSF under grant IUSE-1821589.

8 About the Authors

Carrie Klein is a Senior Fellow on the Future of Privacy Forum's Youth & Education team and an adjunct faculty member in George Mason University's Higher Education Program.

Jaime Lester is the Associate Dean for Faculty Affairs and Strategic Initiatives and a Professor of Higher Education in the College of Humanities and Social Sciences at George Mason University.

Jill Nelson is an Associate Professor of Electrical and Computer Engineering at George Mason University.

9 References

Austin, A. E. (2011). *Promoting evidence-based change in undergraduate science education*. National Academies National Research Council Board on Science Education. http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072578.pdf

Bergquist, W. H. (1992). *The four cultures of the academy*. Jossey-Bass, Inc.

Birnbaum, R., & Edelson, P. J. (1989). *How colleges work: The cybernetics of academic organization and leadership*. Taylor & Francis.

Bolman, L. G., & Deal, T. E. (1991). Leadership and management effectiveness: A multi-frame, multi-sector analysis. *Human resource management*, *30*(4), 509–534. https://doi.org/10.1002/hrm.3930300406

Brownell, S. E., & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and… tensions with professional identity? *CBE—Life Sciences Education, 11*(4), 339–346. https://doi.org/10.1187/cbe.12-09-0163

Boud, D., & Middleton, H. (2003). Learning from others at work: Communities of practice and informal learning. *Journal of Workplace Learning*, *15*(5), 194–202. https://doi.org/10.1108/13665620310483895

Coalition for Reform of Undergraduate STEM Education. (2014). *Achieving systemic change: A source-book for advancing and funding undergraduate STEM education* (C. L. Fry, Ed.). Association of American Colleges and Universities. https://www.aacu.org/sites/default/files/files/publications/E-PKALSourcebook.pdf

Crossan, M. M., Lane, H.W., & White, R. E. (1999). An organizational learning framework: From intuition to institution. *Academy of Management Review, 24*(3), 522–537. https://doi.org/10.2307/259140

Creswell, J. W., & Poth, C. N. (2012). *Qualitative inquiry and research design: Choosing among five approaches*. SAGE Publications.

D'Avanzo, C. (2013). Post-vision and change: Do we know how to change? *CBE—Life Sciences Education, 12*(3), 373–382. https://doi.org/10.1187/cbe.13-01-0010

Davis, B., & Sumara, D. (1997). Cognition, complexity, and teacher education. *Harvard Educational Review*, *67*(1), 105–125. https://doi.org/10.17763/haer.67.1.160w00j113t78042

Fairweather, J. (2008). *Linking evidence and promising practices in science, technology, engineering, and mathematics (STEM) undergraduate education* [Status report]. National Research Council Workshop, Washington, DC. https://www.nsf.gov/attachments/117803/public/Xc–Linking_Evidence–Fairweather.pdf

Freeman, S. Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Gallucci, C. (2003). Communities of practice and the mediation of teachers' responses to standards-based reform. *Education Policy Analysis Archives, 11*(35), 1–19. https://doi.org/10.14507/epaa.v11n35.2003

Henderson, C., Beach, A., & Finkelstein, N. D. (2012). Four categories of change strategies for transforming undergraduate instruction. In P. Tynjälä, M.-L. Stenström, & M. Saarnivaara (Eds.), *Transitions and Transformations in Learning and Education* (pp. 223–245). Springer Netherlands. https://doi.org/10.1007/978-94-007-2312-2

Huber, G. P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88–115. https://doi.org/10.1287/orsc.2.1.88

Kezar, A. (2011). Understanding and facilitating organizational change in the 21st century: Recent research and conceptualizations. *ASHE-ERIC Higher Education Report, 28*(4).

Kezar, A., & Lester, J. (2011). *Enhancing shared leadership: Stories and lessons from grassroots leadership in higher education*. Stanford University Press.

Kogan, M., & Laursen, S. (2014). Assessing long-term effects of inquiry-based learning: A case study from college mathematics. *Innovative Higher Education, 39*(3), 183–199. https://doi.org/10.1007/s10755-013-9269-9

Laursen, S. L., Hassi, M.-L., Kogan, M., & Weston, T. J. (2014). Benefits for women and men of inquiry-based learning in college mathematics: A multi-institution study. *Journal of Research in Mathematics Education, 45*(4), 406–418. https://doi.org/10.5951/jresematheduc.45.4.0406

Lee, J. J. (2007). The shaping of the departmental culture: Measuring the relative influences of the institution and discipline. *Journal of Higher Education Policy and Management, 29*(1), 41–55. https://doi.org/10.1080/73600800601175771

Mittendorf, K., Evjset, F., Hoeve, A., deLaat, M., & Nieuwenhius, L. (2006). Communities of practice as stimulating forces for collective learning. *Journal of Workplace Learning, 18*(5), 298–312. https://doi.org/10.1108/13665620610674971

National Research Council. (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. (S.R. Singer, N.R. Nielsen, & H.A. Schweingruber, Eds.). The National Academies Press.

Nelson, J. K., Hjalmarson, M., Bland, L. C., & Samaras, A. P. (2016, June 26). *SIMPLE design framework for teaching development across STEM* [Poster session]. 2016 ASEE Annual Conference & Exposition, New Orleans, LA. https://doi.org/10.18260/p.26187

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Simon and Schuster.

Sánchez-Cardona, I., Sánchez-Lugo, J., & Vélez-González, J. (2012). Exploring the potential of communities of practice for learning and collaboration in a higher education context. *Procedia-Social and Behavioral Sciences, 46*, 1820–1825. https://doi.org/10.1016/j.sbspro.2012.05.385

Snyder, W. M., Wenger, E., & de Sousa Briggs, X. (2003). Communities of practice in government: Leveraging knowledge for performance; Learn how this evolving tool … performance outcomes in your backyard. *The Public Manager, 32*(4), 17–21. https://www.researchgate.net/publication/245706269_Communities_of_practice_in_government_Leveraging_knowledge_for_performance

Stake, R. E. (2005). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (pp. 443–466). SAGE Publications.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research*. SAGE publications.

Sunal, D. W., Hodges, J., Sunal, C. S., Whitaker, K. W., Freeman, L. M., Edwards, L., Johnston, R. A., & Odell, M. (2001). Teaching science in higher education: Faculty professional development and barriers to change. *School Science and Mathematics, 101*(5), 246–257. https://doi.org/10.1111/j.1949-8594.2001.tb18027.x

Tierney, W. G. (2008). *The impact of culture on organizational decision-making: Theory and practice in higher education*. Stylus Publishing, LLC.

Viskovic, A. (2006). Becoming a tertiary teacher: Learning in communities of practice. *Higher Education Research & Development, 25*(4), 323–339. https://doi.org/10.1080/07294360600947285

20. Transforming the teaching of thousands: Promoting evidence-based practices at scale

KAY HALASEK, ANDREW HECKLER, AND MELINDA RHODES-DISALVO

1 Introduction

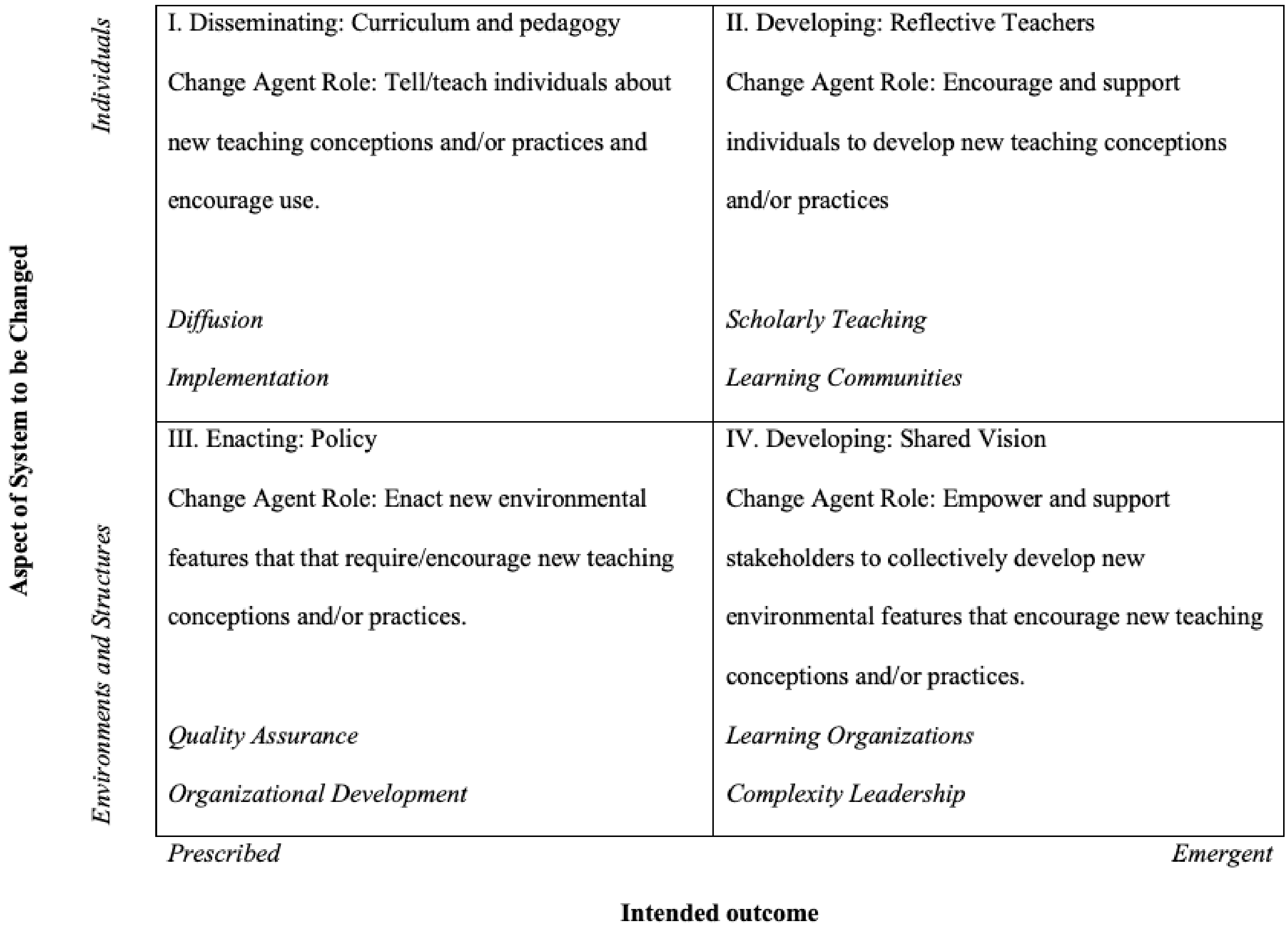
A variety of models of higher education institutional change focus on improving instruction, including examples of initiating such change at all levels from individual faculty to multi-institutional collaborations. In this paper, we describe, analyze, and reflect upon the change process for implementing a recent and ongoing institution-wide teaching enrichment program from both diachronic and synchronic perspectives. Envisioned and initiated by the university president, the Teaching Support Program (TSP) at The Ohio State University has engaged over 82% of full-time tenure- and clinical-track faculty and lecturers from undergraduate-serving colleges.

In this chapter, we consider the change process from two nested theoretical perspectives. The first comprises the comprehensive framework of four categories of change strategies by Henderson et al. (2011) (see also Borrego & Henderson, 2014). Although this framework was constructed with special attention to STEM higher education research, it was also based on the work of faculty development and higher education researchers, and we assume here that it is suitable for university-wide application. The second perspective is Kotter's (1996) model, which articulates an eight-step process for leading institutional change. We briefly describe these theoretical frameworks in the next section.

Working from these conceptual frameworks, we retrospectively analyze recent and ongoing institutional change processes through a synchronic analysis, which takes a deep dive into a critical point during the life of institutional change, to investigate how simultaneously occurring and dynamic factors, features, and values (both aligned and conflicting) impact and oftentimes have significant implications for institutional change. Our goal is not to contest others' models but to supplement them in an effort to demonstrate that examining discrete, synchronic, changes in institutional contexts offers insights into understanding and implementing change through responsive action—a phenomenon we understand metaphorically as a shifting or realignment of gears.

2 Theories of Institutional Change

Henderson et al.'s (2011) four categories of change strategies (Figure 1) are described in detail in several papers (e.g. Borrego & Henderson, 2014).



Aspect of System to be Changed	Prescribed	Emergent
Individuals	I. Disseminating: Curriculum and pedagogy Change Agent Role: Tell/teach individuals about new teaching conceptions and/or practices and encourage use. *Diffusion* *Implementation*	II. Developing: Reflective Teachers Change Agent Role: Encourage and support individuals to develop new teaching conceptions and/or practices *Scholarly Teaching* *Learning Communities*
Environments and Structures	III. Enacting: Policy Change Agent Role: Enact new environmental features that that require/encourage new teaching conceptions and/or practices. *Quality Assurance* *Organizational Development*	IV. Developing: Shared Vision Change Agent Role: Empower and support stakeholders to collectively develop new environmental features that encourage new teaching conceptions and/or practices. *Learning Organizations* *Complexity Leadership*

Intended outcome

Figure 1: The four change strategies. Reproduced from Borrego and Henderson (2014). (web: click on image to enlarge)

Through a comprehensive analysis of the literature, Henderson et al. (2011) identified two binary dimensions of primary importance with respect to institutional change strategies. The first dimension relates to *what* aspect of the system is targeted for change. They identified two discreet possibilities: *individuals* and *environments and structures*. In the second dimension, related to the nature of the outcome, they again identified two discreet possibilities: *prescribed* and *emergent*. These two binary dimensions result in the four possible categories. For example, consider Category III: *Enacting Policy*, which lies at the intersection of Prescribed and Environments and Structures, and is relevant to our analysis. This strategy is characterized by enacting new policies that "[guide] organizations (and the people within them) towards a pre-identified goal" (Borrego & Henderson, 2014, p. 235), such as adopting evidenced-based teaching practices. In contrast to Salomone et al.

(this volume) and Klein et al. (this volume), who implemented bottom-up models of institutional change, we pursued a top-down approach that employs the underlying logic that "instruction will be changed by administrators with strong vision who can develop structures and motivate faculty to adopt improved instructional practices" (Borrego & Henderson, 2014, p. 237). It important to note that Borrego & Henderson place Kotter's (1995, 1996) top-down model of change within the Category III strategy. Kotter (1995, 1996) sets out an eight-step process of organizational transformation. Although later revised into a more dynamic model in which "steps" were redefined as "accelerators" of change deployed "concurrently and continuously" (Kotter, 2014, pp. 27–34), the process retains roughly the same set of steps: 1) establish an exigence, 2) form a coalition, 3) articulate a vision, 4) communicate that vision, 5) empower others to act, 6) create short-term wins, 7) consolidate improvements to produce additional change, and 8) institutionalize change (Kotter, 1995, p. 61).

The TSP and other University Institute for Teaching (UITL)[1] programs and activities impacting the teaching culture at Ohio State map effectively onto the four categories of Henderson et al. (2011) (see Table 1). Categories I and II (with their emphasis on individual change and outcomes) align with the phases of the Teaching Support Program, while Categories III and IV extend impact through changes in and outcomes for the institutional environment and structures.

Table 1: UITL Programs and Activities Aligned with Henderson et al.'s (2011) Categories

Henderson et al. Category	Aligned Program or Activity
Category I: Disseminating curriculum and pedagogy	TSP Phases I and II
Category II: Developing reflective teachers	TSP Phase III
Category III: Enacting policy	Adopt evidence-based practices
Category IV: Developing shared vision	UITL Affiliates and Alliance program

We recognize that while all four categories (Borrego & Henderson, 2014) are relevant to the program we analyze, we focus here on Category III. In the course of our investigation, we realized that this relatively rarely used strategy fits well with the strategy used at our institution. However, we also found that analyzing the institutional changes at our institution in terms of Category III and Kotter's model requires a modified, more synchronic perspective of the change process, as we discuss below.

3 Leaders' Visions for Change

To analyze retrospectively the change and decision-making philosophies of university leaders and gather their perspectives on future directions for effecting change in the teaching culture at the University, we conducted interviews with both Ohio State University President Michael V. Drake and Provost Bruce A. McPheron about their vision for the UITL and its signature Teaching Support Program (TSP), a three-part professional learning initiative launched in 2018. Figure 2 depicts the chronology of UITL and the TSP.

Figure 2: Timeline of the Establishment of UITL and the TSP (web: click on image to enlarge)

Intended to engage all faculty across all six campuses of the University in learning about and deploying evidence-based practices in their teaching, the TSP comprises a validated Teaching Practices Inventory (TPI) (Weiman & Gilbert, 2014) that promotes self-reflection (Part 1); a five-module online Teaching@OhioState course on evidence-based practices and purposeful immersion in those practices and the research supporting their implementation through reflecting upon selections from a curated reading list (Part 2); and an opportunity to engage in instructional redesign, implementation, and assessment (Part 3).

Part of an IRB-approved research project, the interviews were designed to gain insight into administrative perspectives on the implementation of UITL and leaders' theories of change and their strategies, tactics, goals, and general views of the institute and its signature program. (See Appendices 1 and 2 for interview questions.)

The interviews demonstrate that, in action at an institutional level at Ohio State, Kotter's (1996) model of change holds conceptually—as President Drake's comments in his interview bear out. He remembers clearly encountering Kotter during a seminar he attended some 15 years earlier: "We had him for two days, and he … was totally invested in … the idea of having an authentic concept of what you want to have happen, and then having people around you … to support that and then relentlessly following up with that … [and] communicating, over-communicating … short-term wins and continuing that feedback." He subscribes to Kotter's model, noting the various stages and engagements as aligning with his strategic leadership approach. He also mentions, for example, that he identified an urgency, an exigence, for the initiative. (In fact, he identified two exigencies, a matter we address below.) He also speaks to identifying and engaging stakeholders and volunteers in the earliest stages. Faculty leaders (e.g., those individuals recognized as exceptional teachers, faculty from the College of Education and Human Ecology, representatives from all campuses, and a broad range of colleges and appointment types) met in a series of convenings to collectively envision the Institute, and he seeks "small wins." "We took the Kotter model of eight people in the corporation and modeled it at a university and had 80 people" as part of the guiding coalition that led to the creation of the UITL in 2016.

In both interviews, the leaders demonstrate a commitment to "considering the 'why' and 'what' of change first" (Kezar, 2018, p. 1): positively impacting undergraduate student success by encouraging faculty reflection on and continued professional learning in support of their teaching. Although certainly situated within and recognizing the political context and external pressures to which university leaders must attend, both the president and provost attend to the motivations for change as situated within and driven by the mission of the University. Both take seriously and acknowledge their roles in "setting a direction" (Kotter, 2014, p. 60) and articulating a clear vision and reasons for change, a point the provost makes explicitly when he reflects on the staying power of the president's vision, noting the "consistency with which we have anchored back to [the president's investiture speech]…. That was maybe eight, nine, ten months into his tenure, and we find ourselves talking about the 2020 vision all the time." In his interview, the provost also acknowledges the power of leaders to affect change when he notes that "just this notion of getting people talking about teaching and learning in yet another way—I think that that central drive from the president, from him motivating all of us around him … to really dig into that has been incredibly important. It has been essential, really, to getting where we are."

At the same time, the leaders acknowledge that their initial visions—which were informed by the through-line of engaging faculty with the goal of positively impacting undergraduate student success—were complicated by two specific institutional realities. Associated faculty and graduate students play prominent and critical instructional roles, particularly in the first two years of the undergraduate and general education curriculum and in "stumbling block" courses. Not initially among the faculty groups to whom base salary increases were extended, full-time associated faculty argued successfully for identical compensation for completing the TSP.[2] As the provost frames it, leaders were "making sure that we were hearing the voices of the associated faculty because they actually often track back to the very classes and students that … we were most concerned about from the start." Graduate teaching associates (GTAs) (particularly in the arts and sciences) also teach in the undergraduate and general education curriculum and in "stumbling block" courses, a matter that the president notes led to modifications in the timeframe and scope of the initiative. A GTA-specific version of the online course, *Teaching@OhioState*, was launched in Fall 2018, the first step in recognizing graduate students' critical role in impacting student learning outcomes and realizing the president's goal of also "making graduate students better teachers."

4 Perspectives of UITL Leadership

Kotter's (1996) model holds conceptually, as we note above. However, in practice, individual initiatives exist alongside one another, bumping up against or moving forward with them. In any large institution, models of change—instances of initiatives intended to leverage change—often run concurrently, synchronously. Successful change on an institutional level of any one of the initiatives is dependent upon its relationship to the others. In short, the degree of alignment between or among these various initiatives stands as perhaps the most critical matter when we reflect on the implementation of the TSP at Ohio State.

To better account for the dynamic nature of institutional initiatives and their relationships, we examined them both synchronically (existing at a given time) *and* diachronically (unfolding over time) and *in concert with* the other efforts. This kind of analysis offers a means of complicating—nuancing—Kotter's (1996) framework. Rather than only understand the establishment of UITL or creation of the TSP i*n situ*—in *only* its origin form—and examining it alone, we find greater benefit to examining the larger ecosystem of institutional features, values, and initiatives and how they inform, impact, complicate, and even potentially compromise one another at a given time. We have come to think of these various initiatives as sets of interlocking gears (Figure 3).

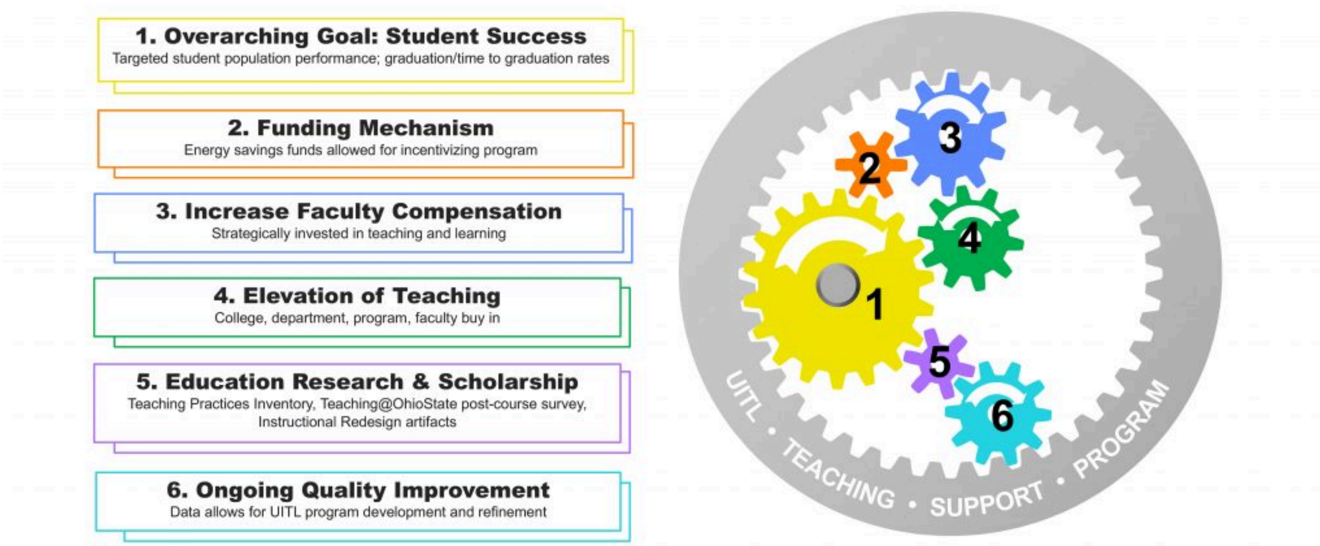


Figure 3: Institutional Features, Values, and Initiatives Driving UITL and TSP. (web: click on image to enlarge)

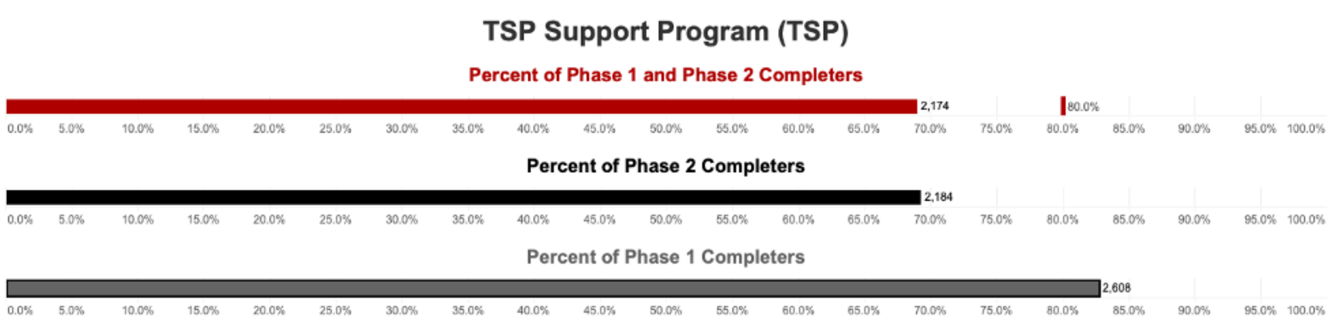
The rotation and turn ratio of the gears are dependent upon one another; they must work in tandem for institutional leaders to realize desired outcomes. A gear that slips stalls the others. A gear that turns counter to the whole grinds them all to a halt, as does a foreign object inserted or jammed into the mechanism. The importance of this systemic metaphor was evident to President Drake, who used open and separated hands to indicate the starting point, "we were here," and then interlocked his fingers, "and ended with this." When larger and smaller gears mesh, mechanical advantages are produced, yet when several gears are involved, inevitable frictions require more effort to turn and keep them moving, much like interlocking programs and policies at an institution.[3]

The most salient example of this interlocking gears model relates to the pairing of three strategic institutional goals: impacting undergraduate student success (Gear 1), increasing faculty salaries relative to other Big Ten institutions (Gear 3), and elevating teaching and learning (Gear 4). In speaking to his own model for institutional change, the president noted the importance of creating contexts that motivate people to engage in particular behaviors that also align with their personal interests (“easy to do, fun to do, and in their personal interest to do so”). The ease of engagement or compliance arose as a theme in the President’s interview. By tying together two goals, which he noted were initially “entirely separate,” he created a context that encouraged and rewarded faculty engagement in professional learning (Gear 4) *and* had the collateral effect of raising faculty salaries (Gear 3).

5 Evidence of Success

Throughout the process of implementation, we have gathered participation and qualitative data that speak to the breadth of engagement among faculty and their reception of the program—two factors integral to the continued growth of and impact on a robust culture of teaching through evidence-based practices that impact student outcomes.

By May 15, 2020 (at the close of incentivized participation), 2,608 eligible faculty (82.7%) in undergraduate-serving colleges had completed Part 1; 2,174 (69%) had completed both Parts 1 and 2. More detailed participation statistics appear in Figure 4.



TIU College/VP	Cohort	Phase 1 and 2 Completers	Phase 1 Completers	Phase 2 Completers
Arts and Sciences	1,025	784	914	787
Coll of Education & Human ..	168	132	150	132
Coll of Food,Agr,Envir Scie..	311	193	231	197
College of Engineering	376	245	310	247
College of Medicine	74	48	62	48
College of Nursing	69	62	66	62
College of Pharmacy	48	28	36	28
College of Public Health	53	35	45	35
College of Social Work	32	24	30	24
Fisher College of Business	109	83	95	83
John Glenn College Public ..	22	17	20	17
Not Applicable	865	523	649	524
Grand Total	3,152	2,174	2,608	2,184

Figure 4: TSP Completion Rates (Phases 1 and 2): All Eligible Faculty in Undergraduate-Serving Colleges. (web: click on image to enlarge)

Survey results in Table 2 indicate positive views and reception of the online course and suggest that faculty participants are reflecting on evidence-based practices, an important component of instructional professional development.

Table 2: Survey Responses for the Online Teaching@OhioState Course

Survey Item	% agree or highly agree	Total Number of responders
The course was helpful.	88.77	2,601
The course was relevant to my teaching.	85.17	2,602
I would recommend the course to a colleague.	82.86	2,603
The course provided me with multiple perspectives on teaching and learning.	94.09	2,621
The course exposed me to evidence-based practices.	92.67	2,618
The course encouraged me to reflect on my teaching practices.	94.19	2,615
I will apply what I learned from this course to improving my teaching practices.	93.32	2,605

UITL has also gained through its analysis of these and other data (such as phone logs and emails) insight into factors that influence faculty engagement in professional learning and the contexts, characteristics, and strategies of academic units with the highest completion rates. For example, a survey of non-completers revealed that the most frequently cited barriers were time to complete the program and lack of awareness of the program or their own eligibility for financial incentives. Departments and colleges with leadership who actively reached out to faculty to encourage engagement and congratulate completers were, not surprisingly, those with the highest completion rates.

UITL received feedback from faculty through dozens of emails and calls received each day for the first month after the program was launched in Fall 2018. In addition to clarifying participation processes and confirming compensation eligibility, these calls and email exchanges, although anecdotal evidence, nonetheless served as productive means of gathering feedback on the program that allowed UITL to make adjustments to the course content, further refining it to address faculty articulated needs and interests. During the first few months of deployment, designers clarified questions in module quizzes and later created additional content and resource links on inclusive teaching and working with international students. A customized version of the course focusing on the needs of GTAs was created in 2019, and over 800 GTAs new to their teaching appointments in 2019–2020 were enrolled.

The TSP has now reached the close of its incentive phase (May 15, 2020) as an initiative to support continued professional learning among all instructors at the university. Direct measures of changes in instructional practice and impact on undergraduate student success are the gold standard for documenting impact of the initiatives; however, full evaluation of the impact of the TSP has not yet begun and is beyond the scope of this chapter. Future research activities include examining the TPI for various trends in self-reported use of evidence-based practices, coding post-course satisfaction and implementation surveys in the online Teaching@OhioState, and coding and conducting qualitative analyses of UITL reading reflection submissions for trends in and across instructional contexts, subject matters, and disciplinary applications. Part 3 of the TSP (launched in Spring 2019), which engages faculty in instructional redesign, implementation, and assessment of instruction and includes faculty portfolio artifacts and assessment reports, will allow UITL to begin analyzing TSP impact on student learning at the classroom, department, and program level.

6 Reflections and Next Steps

Analyses by multiple researchers have made it clear that lasting and meaningful improvement of instruction in higher education cannot involve just one approach; rather, it requires holistic, multifaceted strategies (Cook-Sather et al., this volume; Corbo et al., 2016; Henderson et al., 2011; Kezar, 2018; Klein et al., this volume). In our case study, university leaders were deeply engaged in the institutional change: They initiated (and continued oversight of) the effort, and this involvement of leadership cued us to more deeply consider top-down approaches in our analysis. From the perspective of Henderson et al.'s (2011) framework, this involved a closer examination of Category III: Enacting Policy, and Kotter's model, which is a related top-down model. It is by synchronically examining this institutional change, as evidenced for example by the creation, implementation, and success (to date) of the TSP, that we discovered that the top-down strategy involved multiple aspects of the university, including aspects of the university not typically seen as directly related to instructional improvement (see Figure 3.) One might in fact view this as a native advantage of a strong top-down component to a university change strategy, and this strategy has a clear need for engagement by the institutional leadership.

Our observation of the purposeful engagement of separate yet inevitably interacting university-wide features, values, and initiatives also uncovered a need to more carefully characterize the multi-component complexity of a top-down strategy as "tied to the culture and process … at multiple levels" (Klein et al., this volume). One cannot simply consider a change as singular or isolated, such as "improving instructional practice" but must also consider the implications on multiple, large-scale institutional policies and practices. In retrospect, we find Kezar's (2018) critique of Kotter's eight-stage process (which she describes as "helpful" but ultimately "too simple, linear, and generalized" [p. xii]) to account for the complex systems and multiple categories of change strategies that were concurrently implemented in the TSP. In fact, culture change relies on different primary strategies at different points along a timeline; moreover, the length of time from initiative creation to culture change might be compressed with a conscientious shift from Category IV to Category III once a certain consensus or agreement has been established.

Considering our metaphor of gears in a complex system, institutions and organizations seeking to change culture through a set of incentives are best served when executive leadership positions the change mechanism as a priority.[4] This top-down approach ensures the cooperation of necessary offices and a solutions mindset among units that will implement policy and incentive structures.

In addition, once the goals and outcomes of culture change mechanisms have been articulated, leaders of necessary support offices must be brought to the table to identify and articulate challenges and solutions. Moreover, given the complex mechanisms required to both develop and successfully launch a multi-part faculty professional learning program to influence culture that relied as much on structural support as on champions, this careful and considered promotion of change by top leadership is essential, effective, and, perhaps, preferred. Such a "top-down" model to focus attention and initiate change is, in fact, preferable, if not necessary—as President Drake and Provost McPheron both noted in their interviews—in institutions as large as Ohio State. As faculty and staff in the UITL, we were charged not only with implementing (enlisting volunteers, enabling action, and generating short-term wins) but also leading, nurturing, and sustaining the guiding coalition. The top-down charge provided the Institute with the rationale for calling together collaborators and for those collaborators to elevate the work of the coalition internally.

At the same time, sustaining such change in a teaching culture over time, as anecdotal evidence suggests, cannot rely solely on the vision articulated by leadership. As acknowledged, for example by Henderson et al. (2011), there is an inherent danger to implementing a top-down strategy, namely that a one-size-fits-all approach ignores critical local contextual factors. On the other hand, a bottom-up approach risks actions at odds with the university system and not institutionally sustainable. Deploying top-down strategies encompassing multiple aspects of the university structure allows for productive alignment and lasting, systemic institutional change, a conclusion also reached by Klein et al. (this volume). Given this understanding, UITL—along with departmental leaders—must next take up the banner. Looking forward toward creating sustainable change, we recognize the value of engaging Kezar's (2018) six perspectives as means of anchoring that change (p. 44). Perhaps our greatest challenge will be moving from the individualized incentive and reward structure of the TSP (a form of scientific management in Kezar, 2018) to voluntary (but expected) participation.[5] Central to this shift will be engaging the social, cultural, and political perspectives that acknowledge the critical role of change agents in a variety of activities: agenda setting, coalition building, mapping power structures, and negotiating (Corbo et al., 2016, p. 6). We have identified the importance of creating formal alliance structures with department chairs and establishing a faculty fellows' network in departments as among our next steps, initiatives not unlike those described by Nelson and Hjalmarson (this volume), Greenhoot et al. (this volume), Chasteen et al. (this volume), and others.

Rather than focusing only or primarily on aligning UITL activities to the University strategic plan, we now recognize that the success of the Institute and TSP in particular are a function of an alignment between and among the gears (Figure 3) driving and impacting the culture of teaching at the University. Institutional change takes place over time and, understandably, models of institutional change (e.g., Kotter, 1996; Borrego & Henderson, 2014) conceptualize and consider means of facilitating that change over time—diachronically. By also examining change synchronically and analyzing critical points during the life of institutional change, as we do here, we have investigated how simultaneously occurring and changing factors, features, and values impact and oftentimes have significant implications for institutional change. Higher education leaders seeking to change culture might benefit from considering more explicitly how even seemingly diverse objectives might be served or aligned when promoting or developing change mechanisms.

7 About the Authors

Kay Halasek is the Director of the Michael V. Drake Institute for Teaching and Learning and professor of English at The Ohio State University.

Andrew Heckler is Professor of Physics at the Ohio State University and Research Fellow for the OSU Drake Institute for Teaching and Learning.

Melinda Rhodes-DiSalvo, Ph.D., is Associate Director for Strategic Partnerships and Operations with the Michael V. Drake Institute for Teaching and Learning at The Ohio State University.

8 References

Borrego, M. & Henderson, C. (2014). Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. *Journal of engineering education, 103*(2), 220–252. https://doi.org/10.1002/jee.20040

Chasteen, S., Code, W., & Sherman, S. B. (this volume). Practical advice for partnering with and coaching faculty as an embedded educational expert. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 21). Pressbooks.

Cook-Sather, A., White, H., Aramburu, T., Samuels, C., & Wynkoop, P. (this volume). Moving toward greater equity and inclusion in STEM through pedagogical partnership. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 15). Pressbooks.

Corbo, J. C., Reinholz, D. L., Dancy, M. H., Deetz, S., & Finkelstein, N. (2016). Framework for transforming departmental culture to support educational innovation. *Physical Review—Physics Education Research, 12*(1), 1–15. https://doi.org/10.1103/PhysRevPhysEducRes.12.010113

Greenhoot, A. F., Aslan, C., Chasteen, S., Code, W., & Sherman, S. B. (this volume). Variations on embedded expert models: Implementing change initiatives that support departments from within. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 21). Pressbooks.

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of research in science teaching*, *48*(8), 952–984. https://doi.org/10.1002/tea.20439

Kezar. A. J. (2018). *How colleges change: Understanding, leading, and enacting change*. Routledge.

Klein, C., Lester, J., & Nelson, J. (this volume). Leveraging organizational structure and culture to catalyze pedagogical change in higher education. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 19). Pressbooks.

Kotter, J. P. (1995). Leading change: Why transformation efforts fail. *Harvard business review, 73*(2), 59–67. https://hbr.org/1995/05/leading-change-why-transformation-efforts-fail-2

Kotter, J. P. (1996). *Leading change*. Harvard Business School Press.

Kotter, J. P. (2014). *Accelerate: Building strategic agility for a faster moving world*. Harvard Business Review Press.

Nelson, J. K., & Hjalmarson, M. A. (this volume). Discipline-based teaching development groups: The SIMPLE framework for change from within. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 18). Pressbooks.

Salomone, S., Dillon, H., Prestholdt, T., Peterson, V., James, C., & Anctil, E. (this volume). Making teachers matter more: REFLECT at the University of Portland. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 17). Pressbooks.

Weiman, C., & Gilbert, S. (2014). The teaching practices inventory: A new tool for characterizing college and university teaching in mathematics and science. *CBE—Life Sciences Education, 13*(3), 552–569. https://doi.org/10.1187/cbe.14-02-0023

9 Appendix

9.1 President Interview Questions

1. When you reflect on the establishment of the University Institute for Teaching and Learning and the Teaching Support Program in particular, how would you describe your strategic approach for affecting change at an institutional level? What was/were the critical problem or problems you saw the TSP initiative addressing?
2. What were your primary motivations for launching the TSP? What were your most salient objectives?
3. What change or leadership scholarship or models of institutional change do you read or call upon—especially with regard to UITL and the TSP? What critical applications or practices do you derive from that scholarship?
4. As we have been reflecting on our work in UITL, we have come to realize that the change associated with the TSP shares characteristics with "top-down" theories of change, like Kotter's (1995, 1996). Models like Kotter's state that change can be driven by "administrators with strong

vision who can develop structures and motivate faculty to adopt improved instructional practices" (Borrego & Henderson, 2014, p. 237) Did you have a model like Kotter's in mind as you conceived of UITL and the TSP? In what ways did those models shape your approach and vision?
5. When undertaking large-scale institutional change (as you did through UTIL with the TSP), how did you reconcile the affordances and constraints of a top-down versus a constituent-driven or bottom-up approach to change?
6. What barriers to development and implementation of the TSP did you anticipate? Which of those were most challenging? What other, unexpected, barriers arose? How did you address them?
7. Moving forward, what strategies you anticipate using to sustain your effort to transform the university culture around teaching?

9.2 Provost Interview Questions

1. When you reflect on the establishment of the University Institute for Teaching and Learning and the Teaching Support Program in particular, how would you describe the strategic approach for affecting change at an institutional level? What was/were the critical problem or problems you saw the TSP initiative addressing?
2. What would you identify as the primary motivations for launching the TSP? What were the most salient objectives?
3. When undertaking large-scale institutional change (as OSU did through UTIL with the TSP), how would you reconcile the affordances and constraints of a top-down versus a constituent-driven or bottom-up approach to change?
4. What barriers to development and implementation of the TSP did you anticipate? Which of those were most challenging? What other, unexpected, barriers arose? What strategies did the University use to address them?

Moving forward, what strategies you anticipate the University using to sustain its effort to transform the university culture around teaching?

[1] In June 2020, the University Institute for Teaching and Learning was renamed in honor of President Michael V. Drake, becoming the Michael V. Drake Institute for Teaching and Learning. Because the incentivized TSP described here was implemented before the change in the name of the institute, we have elected in this chapter to retain references to the UITL.

[2] The financial structure for full-time tenure-track, clinical, and associated faculty included a $400 increase to base salary for completing Part 1, a $1,200 increase to base salary for completing Part 2, and a $1,150 one-time cash stipend for completing Part 3. Part-time tenure track and clinical faculty received one-half the base pay compensation for Parts 1 and 2. Part-time associated faculty (lecturers) received one-time payments of $200 and $600 but are not eligible for Part 3. Because one

of the goals leadership articulated involved increasing OSU faculty salaries relative to the median in the Big 10, that measure in future years will be a partial indicator of program success.

[3] Salomone et al. (this volume), as well, note the importance to align work with mission of university and leadership and “strategically leverage other activities on campus” as a means of realizing goals.

[4] Cook-Sather et al (this volume), Salomone et al. (this volume), and Greenhoot et al. (this volume) also deployed financial incentives as features of their programming. Greenhoot et al. speak to the significant value of financial incentives and major institutional investments in programs to support teaching enrichment programs, naming funding as a “critical lever for promoting buy-in and engagement from department faculty and leadership”.

[5] The incentive structure noted above ended in May 2020. Subsequently, completion of the TSP will be an expectation of hire for faculty new to the university.

21. Practical Advice for Partnering with and Coaching Faculty as an Embedded Educational Expert

STEPHANIE CHASTEEN, WARREN CODE, AND SARAH BEAN SHERMAN

1 Introduction

Experts engaged within a department ("embedded experts") can be effective agents of change. One type of embedded expert is a *discipline-based educational specialist* (DBES), who has expertise in the relevant discipline as well as in education. DBESs were at the heart of the Science Education Initiative (SEI), in which departments competed for institutional grants primarily used to hire DBESs. This model was used at the University of Colorado Boulder and the University of British Columbia, and eventually other institutions (Wieman, 2017; Chasteen & Code, 2018).

DBESs were a critical feature of the SEI: they provided valuable time, guidance, and support to faculty undertaking *course transformations*, substantial course (re)development projects that provided a practical focus for change work. This is in contrast to other change efforts (like faculty learning communities) which are less intensive and more general, and in which the faculty members themselves serve as their own educational expert (as in the chapters in this volume by Salomone et al., Klein et al., and Nelson & Hjalmarson), or programs in which faculty partner with students, which focus more on improving student experiences, rather than larger-scale course transformations (as in the chapters in this volume by Callahan et al. and Cook-Sather et al.)

The DBES model served as an effective lever for engaging faculty in instructional reform efforts (Wieman, 2017), leading to sustained use of evidence-based instructional practices—particularly in large courses—with accompanying approval by students (Wieman et al., 2013; Jones, 2018). This approach is well-aligned with the change literature, which suggests that engaging teachers in reflective practice and developing a shared vision within a department are valuable (e.g., Henderson et al., 2011) and that faculty need long-term customized support to encourage adoption of new practices (Froyd et al., 2017). DBES programs are not without their challenges; these are discussed in the companion chapter in this volume aimed at initiative leaders by Greenhoot et al.

A free, open-licensed *Science Education Initiative Handbook* (Chasteen & Code, 2018) provides a complete guide to such an initiative based on accumulated wisdom across the projects. This chapter summarizes advice from the Handbook related to the most common issues DBESs face, as well as concrete examples from our own experiences as current and former DBESs. As the role was so novel when it was introduced, many of these approaches developed over time in response to the initial struggles of DBESs to integrate into departments (e.g. Laursen & Budd, 2008).

2 What Is a DBES?

A Discipline-Based Education Specialist (DBES) is our generic title for a person who provides expertise both in a *discipline* and in effective *education*, and thus can act as an agent of instructional change in a department. They bring expertise to facilitate implementation of research-based instruction, with a primary goal of fostering expertise in teaching and learning among faculty. To this end, we suggest the DBES think of themselves as a coach, and a catalyst of change in their department. We caution against considering the DBES as a teacher, teaching assistant, instructional designer, or education researcher—while the role contains these elements, the combination is what makes the DBES uniquely effective.

Typical DBES duties may include:

- Facilitating development of learning goals (Pepper et al., 2011)
- Developing curricular materials
- Collecting and analyzing data on student learning
- Facilitating faculty discussions
- Serving as a departmental resource
- Conducting research
- Disseminating results within and outside the department

Figure 1: DBES Brett Gilley Works with Faculty (Credit: Centre for Teaching, Learning and Technology / University of British Columbia. All rights reserved.)

3 Who Can Be a DBES?

A DBES should have high-level training in the academic discipline (e.g., a Master's or Ph.D.), good interpersonal skills, and be patient and persistent. They should also be experts in teaching and learning, or have an interest in such topics and receive on-the-job training.

People who might serve as a DBES include:

- Postdoctoral scholars (used primarily in the SEI)
- Discipline-based education research (DBER) faculty
- Faculty or instructors with a focus on education (e.g., "Professors of practice," or the "change agent" faculty member in the Cross-course Community of Transformation described in Klein et al. [this volume])
- Graduate students with a background in education (e.g., from School of Education)
- Other faculty leaders with expertise in education (e.g., from School of Education, or those who have undergone extensive training or engagement with education such as a faculty learning community, as in Nelson & Hjalmarson [this volume])

Over a decade of work by Tanner and colleagues sheds light on the faculty who might fill a DBES role, and how to support them (Bush et al., 2017). DBESs usually require specific training and on-the-job support in order to be successful (Wieman, 2017); this is not unusual for those new to academic development (Jessop et al., 2018). DBESs must hone their interpersonal skills (including the ability to persuade and negotiate), have excellent project management skills, and develop the education research expertise required for course transformation work. Due to the training needs and time needed to integrate into the department, we recommend that a DBES be hired directly into a department ("embedded") for at least two years or ideally as a permanent faculty hire. One disadvantage of DBESs is that their often temporary, lower-status position can undermine their ability to support long-term change.

4 How Can a DBES Persuade Faculty to Consider Changes to Their Teaching?

It is best if the DBES begins by working with faculty who have already committed to changing their course(s), so that they are not in the tricky position of trying to recruit faculty at the start of their work. As the DBES builds their network of relationships in the department, they will develop opportunities to persuade additional faculty to make changes to their teaching. A DBES might consider a motto of "spread seeds and nurture sprouts," working with as many faculty as possible, staying open-minded about who might be interested, and being patient and persistent. Resistant faculty may show interest with time. More detailed advice for a DBES follows.

Get off to a good start. In the first few months, there are a variety of ways for you to establish yourself in a department:

- Observe teaching in the department. This is an extremely important part of your own training: it gives you perspective beyond your own teaching, helps you see the context and results of instructional choices for others, and provides a lot of information about the culture of teaching and student learning in a department.
- Engage in department activities (seminars, faculty meetings, chatting in the hall, etc.).
- Initiate conversations with students about their experience in courses.
- Establish credibility as a colleague in the field (e.g., give a talk on prior research).
- Develop an "elevator speech": a brief, clear description about you and your unusual role, to help explain to faculty and staff what you do and how you can help.
- Teaching a course may help establish credibility and give you a space to demonstrate techniques, though this alone will not build the connections needed (and there is a risk that it will take a lot of time away from training and project work).

We note that the importance of a change agent's credibility, reputation, and respect, including relevant teaching experience, were also cited as particularly important in fostering productive partnerships in the chapter by Klein et al. (this volume).

Meet faculty where they are. Being responsive to faculty interests and constraints can help you frame your role as a productive resource and better understand their motivations (Froyd et al., 2017).

- Discover what faculty are interested in learning about their course (a useful opener for such exploration is "How is your course going?").
- Offer faculty something they want. You might offer to perform a demo for their class, or figure out some technological hurdle for them.
- Directly address faculty beliefs about teaching and learning. You can mention examples of success in similar settings, highlight faculty who have changed their teaching for the better, discuss teaching vs. research (Brownell & Tanner, 2012), and suggest alternative teaching approaches.
- In a large project like a course transformation, meet regularly to start collaborating some months before the course is taught to develop the course and get to know each other. The course instructor may not have a good idea of what they have signed up to do, so be prepared to offer examples of course design strategies and teaching approaches.

Leverage the classroom. The classroom itself provides a rich and authentic environment for seeding ideas and encouraging discussion.

- Invite faculty to observe active learning in action (in your course, or a colleague's).
- Use observations as a conversation starter. Ask someone if you can visit their class, and if there is anything they would like you to pay attention to.
- Partner with instructional assistants. These can be powerful allies and can suggest changes to faculty, inform you about what is happening in the course, and provide instructors with direct

access to the student perspective. (Note that in this same volume both Callahan et al. and Cook-Sather et al. also describe an approach using undergraduate students as partners.)

Use data persuasively. Data, including good visualizations, can be powerful in persuading faculty.

- Use a variety of data types (quantitative and qualitative, local and national, rigorous and informal).
- Focus on student voices, as these are often more convincing for faculty.
- Gather data which speak to the instructor's interests.
- Try to gather data as early as possible; baseline data can be challenging to collect but will offer a clearer picture of where to direct efforts and will be valuable when demonstrating how improvements to the course have affected student learning (many faculty will be keen on this).

Make the work of teaching and learning visible. Teaching in higher education can be a very private endeavor; it is rare for faculty to discuss their teaching or observe each other teach. Bringing teaching into public spaces in the department, celebrating successes, and sparking discussion can be very effective in engaging the department more broadly.

- Highlight efforts of departmental faculty (e.g., in faculty meetings, websites, newsletters).
- Create a newsletter.
- Host faculty discussions and workshops around teaching and learning.

Do not take setbacks personally. Sometimes you will come up against negative reactions to ideas about teaching, or general complaints from faculty. Their reaction is likely not related to you personally—among other pressures, they may feel frustrated by local constraints, or their identity as an excellent educator may feel under threat. Listen, and move on.

Use faculty champions. Your faculty supervisor is very important; have them introduce you to faculty and broker conversations about shared expectations for your work in specific projects. In our experience, if there are conflicts in a partnership around expectations, you (the DBES) may need an advocate to help manage sensitive matters.

5 How Can a DBES Partner Well with Faculty?

Forming partnerships with faculty is essential for DBESs, and the most successful DBESs see themselves as a departmental resource and a coach for faculty. It is thus important to meet faculty where they are (see above) and give them meaningful, actionable feedback that empowers rather than overwhelms them—it is imperative not to come across as pushy. Dormant (2011) has several tactics for change agents. Below are our suggestions:

Observe classes and provide immediate feedback. Classroom observations are a critical piece of coaching faculty. Ask in advance if there is anything the faculty member would like you to pay attention to. Discuss briefly right after the class while it is still fresh (while walking back to the office, for example). Ask how they thought it went and if there was anything they were happy with or concerned about. Mention positive things that you noticed and commiserate by sharing problems you have dealt with yourself. These observations will be particularly important in a course transformation project, to help shape your plans.

Aim for constructive conversations focused on small, concrete changes. Focus on a few concrete, achievable strategies. These small wins can motivate instructors to try larger changes. For example, you might tell a course instructor: "Rather than solve four examples, could you solve two and have the students solve one or two?" or, "There's no need to be afraid of silence when you ask a question."

Model evidence-based reasoning. As much as possible, focus on evidence of student learning or non-learning from the course. Aim to move the discussion away from opinions (yours and theirs) and towards the goals and challenges in teaching along with the evidence you have that supports previous choices and suggests future changes. "How do we/you know that?" can be a useful question to guide faculty in supporting their statements.

Plan to support faculty over time. It takes time and effort to learn how to incorporate active learning strategies. An activity may need to be run several times in order for it to work smoothly and effectively. Help the faculty member see this as part of the process (i.e., a growth orientation towards pedagogical change) rather than a sign that things are not going well. You may develop some early materials and assessments in order to move the work forward, though we recommend "fading out" such support over time and shift toward reviewing materials that the instructor has created.

Act as project manager and champion during a course transformation. Organize meetings and facilitate consensus when there are multiple sections/instructors, as interest and experience with course development work will vary. Start before the teaching term, then monitor progress, giving gentle reminders to faculty about making timely decisions and about upcoming deadlines (e.g., an opportunity for an important measurement like a survey or test). Show the team the progress that has been made. Apart from a few cases where the faculty involved are highly experienced, the DBES is usually the main person responsible for ensuring the project's continued momentum and observing how efforts are playing out in the classroom.

Meet with other department faculty for additional input and context. We recommend conducting individual interviews or discussions to identify interests, followed by working group meetings among several faculty, to identify priorities and learning goals (Chasteen & Code, 2018, Chapter 7; Pepper et al., 2012). It is particularly useful to have discussions with faculty who have taught the course or teach succeeding courses.

6 What Are some Common Challenges Faced by DBESs?

Finally, because this is not an easy role, or one that an academic is typically prepared for, the DBES must engage in self-care and their own professional development. Advice for overcoming common hurdles is given below.

Maintaining morale is one common concern, especially in the face of slow progress or pushback. Change takes time, which can be tough if you are in a relatively short-term position. As with anyone learning something new, faculty will need reasons to try new teaching approaches (e.g. to address a problem in the course) and to continue these practices (e.g., have enough practice and feedback to feel successful). Be realistic about expectations and try not to get discouraged. Commiserating with others in a similar position can be a big help, as can documenting your progress.

Combating isolation is another common challenge. There are likely other DBESs, or people on your campus working on teaching and learning projects. Partnerships can be valuable for helping you feel less isolated, as well as to develop a strong network of resources and professional development.

Junior-ranking DBESs (such as postdoctoral fellows) and **DBESs in instructor positions** may experience challenges such as lack of visibility, prestige, power, and time; see Chasteen and Code (2018, Chapter 9) for discussion.

7 Serving as a DBES: Three Vignettes

Here, we share some of our direct experience as DBESs to illustrate how these ideas have played out in faculty partnerships.

7.1 Working Together Productively

> One of the first instructors I worked with on transforming a course said that they were very interested in improving their course. However, whenever I would try to schedule a meeting with them, they would cancel or postpone. When I did manage to meet with them, they would express guilt over not having done any work on the course since our previous meeting. I found that the best way to make the meetings productive and move forward was to use the meeting time to get work done. This included any work that I would typically suggest as preparation for a meeting, like watching a short video on 2-stage exams. Instead of having the instructor feel guilty because they hadn't watched the video ahead of time, we would watch it together. This removed the guilt and helped make the meetings productive. With the "homework" removed, the instructor was less likely to postpone meetings because of feeling unprepared. And because we were getting work done, they enjoyed the sessions more.

7.2 Developing and Implementing In-Class Activities

> This instructor had never used clickers before and was quite nervous about using them. When we designed an activity, we started by discussing the learning goals of the activity first. After we ran the activity, we would consider the effectiveness of the activity. We usually ran a clicker question or two to assess the learning or had a reflection activity where we could get feedback from the students. I went to several of their classes, so if anything went wrong, I was there to fix the problem. The instructor knew they had a safety net and felt more willing to try the new technology because they had someone there who could help right away.

7.3 Using Student Voices Persuasively

> The instructor was quite resistant to running activities in class because they thought activities took up too much time. They were very concerned about covering content. I found that one of the most effective ways for the instructor to assess the usefulness of in-class activities was to hear from the students. I could say that active learning is more effective than lecturing until I was blue in the face, and the instructor wouldn't change their mind. But the student voice carried more weight. We ran a mid-semester survey and the instructor really responded well to what the students wrote. We specifically asked about the use of clickers and in-class activities, and the majority of the students commented that both were really helpful. Later in the course, if the instructor pushed back on using clickers or in-class activities I was able to remind them that the students felt that these were helpful.

These vignettes represent particularly productive responses to situations often encountered by DBESs.

8 Conclusions

Serving as a DBES can be personally and professionally rewarding, and transformative for the department or institution. For temporary DBESs, they are often in high demand for subsequent employment due to the training and experience they receive in evidence-based teaching, course design, faculty development, and educational research and evaluation (Wieman, 2017). These types of positions can be an opportunity for an enthusiastic individual to learn a great deal about teaching, learning, and the research around them, and to join an emerging community of scholars fostering improvements in classrooms for many thousands of students while helping faculty towards more rewarding teaching experiences. The work of a DBES will be most impactful, however, when accompanied by strong departmental leadership to guide the DBES and strategize about broader issues such as faculty evaluation and course policies (Chasteen & Code, 2018).

9 About the Authors

Stephanie Chasteen is a research associate in the Center for STEM Learning at the University of Colorado Boulder.

Warren Code is the Associate Director of the Science Center for Learning and Teaching (Skylight) at the University of British Columbia.

Sarah Bean Sherman is the Science Education Specialist in the Earth Ocean & Atmospheric Science Department at the University of British Columbia.

10 References

Brownell, S. E., & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and… tensions with professional identity? *CBE—Life Sciences Education, 11*(4), 339–346. https://doi.org/10.1187/cbe.12-09-0163

Bush, S. D., Stevens, M. T., Tanner, K. D., & Williams, K. S. (2017). Origins of science faculty with education specialties: Hiring motivations and prior connections explain institutional differences in the SFES phenomenon. *BioScience, 67*(5), 452–463. https://doi.org/10.1093/biosci/bix015

Callahan, K. M., Williams, K., & Reese, S. (this volume). Student leaders as agents of change. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 16). Pressbooks.

Chasteen, S.V. & Code, W. J. (2018). *The Science Education Initiative handbook*. Pressbooks. https://pressbooks.bccampus.ca/seihandbook/.

Cook-Sather, A., White, H., Aramburu, T., Samuels, C., & Wynkoop, P. (this volume). Moving toward greater equity and inclusion in STEM through pedagogical partnership. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 15). Pressbooks.

Dormant, D. (2011). *The chocolate model of change*. lulu.com.

Froyd, J.E., Henderson, C., Cole, R. S., Friedrichsen, D., Khatri, R., & Stanford C. (2017). From dissemination to propagation: A new paradigm for education developers. *Change: The Magazine of Higher Learning, 49*(4), 35–42. https://doi.org/10.1080/00091383.2017.1357098

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952–984. https://doi.org/10.1002/tea.20439

Jessop, T., Saunders, C., & Pontin, C. (2018). The challenges of academic development as a first graduate job: "Am I doing it right?" *International Journal for Academic Development, 24*(4), 1–13. https://doi.org/10.1080/1360144X.2018.1555758

Jones, F. (2018). Comparing student, instructor, classroom and institutional data to evaluate a seven-year department-wide science education initiative. *Assessment & Evaluation in Higher Education, 43*(2), 323–338. https://doi.org/10.1080/02602938.2017.1343799

Klein, C., Lester, J., & Nelson, J. (this volume). Leveraging organizational structure and culture to catalyze pedagogical change in higher education. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 19). Pressbooks.

Laursen, S. & Budd, D. (2008). *Formative feedback from the science teaching fellows on the Science Education Initiative at CU Boulder* [Evaluation report excerpt]. https://www.colorado.edu/eer/sites/default/files/attached-files/stfsurveyexecsummjun08finredacted.pdf

Nelson, J. K., & Hjalmarson, M. A. (this volume). Discipline-based teaching development groups: The SIMPLE framework for change from within. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 18). Pressbooks.

Pepper, R. E., Chasteen, S. V., Pollock, S. J., & Perkins, K. K. (2012). Facilitating faculty conversations: Development of consensus learning goals. *AIP Conference Proceedings, 1413*(1), 291–294. https://doi.org/10.1063/1.3680052

Salomone, S., Dillon, H., Prestholdt, T., Peterson, V., James, C., & Anctil, E. (this volume). Making teachers matter more: REFLECT at the University of Portland. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 17). Pressbooks.

Wieman, C. (2017). *Improving how universities teach science: Lessons from the Science Education Initiative*. Harvard University Press.

Wieman, C., Deslauriers, L., and Gilley, B. (2013). Use of research-based instructional strategies: How to avoid faculty quitting. *Physical Review Special Topics—Physics Education Research, 9*(2), 023102. https://doi.org/10.1103/PhysRevSTPER.9.023102

22. Variations on Embedded Expert Models: Implementing Change Initiatives that Support Departments from within

ANDREA FOLLMER GREENHOOT, CAROLYN ASLAN, STEPHANIE CHASTEEN, WARREN CODE, AND SARAH BEAN SHERMAN

1 Introduction

Educational change efforts focused at the department level can be particularly powerful because the department is both the unit of academic organization and where faculty see themselves as having the greatest influence (Tagg, 2012). This chapter focuses on a successful model designed to engage and support work at the department level: the use of discipline-based educational specialists (DBESs) embedded within departments as catalysts of change. As leaders from four different university implementations of this “embedded expert” model, we provide a synthesis of similarities and differences among our instantiations to produce practical guidance, informed by theory and research on change, for change leaders who are organizing similar programs.

The embedded expert model involves short-term placement of DBESs in departments to partner with faculty to redesign courses with evidence-based practices. Departments develop proposals for course transformation in response to competitive calls, fostering shared vision and goals. Awarded funds are used primarily to hire DBESs, who are typically recent Ph.D.s in the field, and receive pedagogical training from a central organization. DBESs collaborate with faculty to identify course learning goals, design and implement new practices, and assess student learning; thus, they bring pedagogical knowledge and practical support to faculty and encourage them to reflect and think critically about their teaching. A central unit provides coordination, DBES training, department support, oversight, and outreach. Departments appoint project directors to serve as the DBESs’ supervisor and liaison with the central unit.

The theory of change underlying the DBES model proposes that department-level planning and DBES-faculty collaboration will produce departmentally-owned transformed courses and changes in faculty practice that will shift department norms and yield sustained change in department teaching culture and student learning (Wieman, 2017).

The DBES model shares elements with other change initiatives described in this section. Like the Teaching Support Program (Halasek et al., this volume), the DBES model enhances faculty knowledge of evidence-based practices, but accomplishes this through hands-on collaboration with an expert partner, rather than through a course on evidence-based teaching strategies. Several of other chapters in this volume present approaches that use collaboration with other faculty (like faculty learning communities, as in the chapters by Klein et al., Salomone et al., and Nelson & Hjalmarson) or with students (as in the chapters by Callahan et al. and Cook-Sather et al.) to foster reflection and teaching improvement; in contrast to these approaches, the DBES-based course reform model is a more intensive, project-based approach which provides both human capital and expertise in the form of the DBES.

The model is designed to address common barriers to change, including lack of faculty knowledge, time, and rewards for changing their teaching (Brownell & Tanner, 2012; Fairweather 2008; see also Halasek et al., this volume). Consistent with the institutional change literature, the DBES model combines multiple change strategies that address both individual and environmental/structural elements of the system, including *support structures* for evidence-based teaching, actively *engaging faculty* in the change process, promotion of *reflective teaching practice*, fostering *community* and *common vision*, and working towards shared, *measurable goals* for continuous improvement (Borrego & Henderson, 2014; Henderson et al., 2011; Tagg, 2012).

This chapter provides the first synthesis of strategies and lessons learned from the DBES programs implemented at our four universities. They include the two founding programs: the Science Education Initiatives (SEIs) at the University of Colorado Boulder (CU-Boulder) and the University of British Columbia (UBC), launched in 2006 and 2007, respectively. The other two institutions, Cornell University and the University of Kansas (KU), separately launched adaptations of the model in 2013. As demonstrated by the comparative data in Table 1, the programs are at varying stages of maturity and have diverse resource and infrastructure capacities, but all four have been successful in producing high levels of faculty engagement in course transformation (see also Chasteen et al., 2011; Wieman et al., 2013; Wieman, 2017), with demonstrated improvements to student learning and success (e.g., Ballen et al., 2017; Ballen & Zamudio, 2019; Jones, 2017; Jones, 2018; Moradi et al., 2018; Roberts et al., 2018). Long-term assessments of the original two programs have also shown changed norms and culture in departments, uptake of evidence-based teaching strategies into new courses and by faculty who were not directly involved, and supportive changes in departmental infrastructure and policy (see Wieman, 2017). More detail about each individual case can be found in in Chasteen and Code (2018, Appendix 1). Because our goal is to provide focused advice for potential leaders/directors of such initiatives, we organize our synthesis around three major challenges (cost/resources, department and faculty engagement, and sustainability) that initiative leaders will have to grapple with. These challenges relate to some of the most fundamental structural and cultural barriers to systemic change within higher education (Kezar, 2014), and they frame the most commonly asked questions that we get from potential program organizers.

In the sections that follow, we provide brief overviews of each institution's initiative (as of the time of this publication, November 2020), highlighting key differences. Next, we explore the research-informed strategies and specific approaches used by the programs to address the three main challenges. We conclude with cross-cutting themes and recommendations for the design and implementation of programs that support department-level change. A chapter by Chasteen, Code, and Sherman in this volume details more about the DBES position, with relevant advice for DBESs.

Table 1: Comparative Data on the Four DBES Program Cases.

Feature	University of Colorado Boulder	University of British Columbia	Cornell University	University of Kansas
Undergraduate student enrollment	35,000	50,000 (Vancouver campus)	15,000	19,700
Total USD investment	$5.3M	$11M	$10M committed to date (ongoing)	$2.2M
Funding source	University funded	University and donor funded	University and donor funded	University funded + NSF grant
Duration	2006–2014 (8 years)	2007–2017 (10 years)	2013–present (7 years, ongoing)	2013–2019 (6 years)
Breadth across departments	7 departments, 25 DBESs	7 departments, 50 DBESs	16 departments, 30 DBESs so far	8 departments/ units, 8 DBESs
Intensity per department	1–3 DBESs and avg. $650K/dept	1–4 DBESs and avg. $1.3M/dept	1–3 DBESs and avg. $500K/dept	1 DBES and avg. $215K/dept
Productivity (expectation per DBES)	2–3 year terms 1–2 courses per DBES/year 2 years per course	3–5 year terms 1–2 courses per DBES/year 2–3 years per course	2–3 year terms 1–3 courses /year 2 or more iterations per course	3-year terms 1–3 courses per DBES/year 2 or more iterations per course
Impact	71 courses 102 faculty	164 courses 180 faculty	57 courses (so far) 110 faculty (so far)	69 courses* 75 faculty*
Central organization	New central organization (SEI Central)	New central organization (SEI Central) initially, then Science Centre for Learning and Teaching	Center for Teaching Innovation coordinates program	Center for Teaching Excellence coordinates program and related initiatives

**Note: Represents impact in DBES-supported departments only; KU program intentionally engaged non-DBES-supported departments, with total impact on 161 courses and 188 faculty from 43 departments.*

2 The Four Program Cases

2.1 University of Colorado Boulder/University of British Columbia

The SEIs began at CU-Boulder as an experiment in creating large-scale change in STEM education; a partner program was implemented at UBC when the initiative founder moved to that institution. With no appropriate unit to coordinate the program, each campus established a new organizational unit, SEI Central, that developed extensive training, resources, and a community of practice for the DBESs. Although the UBC implementation was larger and informed by some of CU-Boulder's early experiences, we group them together for the purposes of this chapter.

2.2 Cornell University

The Active Learning Initiative at Cornell started with funding for three departments to transform seven large undergraduate courses in biology and physics. The success of these projects convinced faculty and administrators of the efficacy of the model for improving undergraduate education beyond STEM. The initiative grew rapidly, and so far 16 departments (20% of all undergraduate departments) have participated. Grants are open to all undergraduate disciplines (i.e., broader than the SEIs), which has resulted in sharing and adaptation of teaching practices between STEM, social sciences, and humanities faculty. The initiative is situated within the Center for Teaching Innovation.

2.3 University of Kansas

KU's Teaching Fellows Program was launched in 2013 as part of a broader undergraduate Course Transformation Initiative promoting student-centered, active learning pedagogy. KU's program involved fewer experts and less funding than the other institutions, but amplified the DBESs' impact by building communities around course transformation within and across departments and by connecting to related initiatives and programs. Seven departments in Liberal Arts and Sciences, plus the School of Engineering, received funding to hire DBESs. KU's program was led by their Center for Teaching Excellence (CTE).

3 Navigating Three Key Challenges

Our four DBES programs were intentionally structured to address key challenges in scaling educational reform, guided by the literature on effective institutional change strategies, but specific approaches varied across the campuses. In this section, we draw on the cases to explore how initiative leaders can navigate three major challenges in their institutional contexts: How can new and existing resources support elements of their initiatives (Cost and Resources)? How do initiatives motivate the level of department and faculty buy-in and engagement that is needed for the model to be effective (Department and Faculty Engagement)? What can programs do to foster sustainable changes (Sustainability)? For each challenge, we describe the DBES program strategies designed to address it, and the specific approaches applied at each campus.

3.1 Costs and Resources

Most of the funds for the four DBES programs were distributed to departments to support DBES salaries and, to a lesser extent, direct faculty incentives, with additional funds for central program support. All four used strategic distribution of funds to departments, through waves of grant competitions, to promote department planning and foster the shared goals and vision needed for systemic change. The total investment, expected output, use of new versus existing resources, and duration, distribution and spacing of funding have varied among the four program cases.

3.1.1 University of Colorado Boulder/University of British Columbia

The UBC program represented a major financial investment, at about $11M ($1.3M per department), through a combination of donor and university funds. CU-Boulder was funded at about half that amount with university funds only; the impact of the lower investment was noticeable. While the bulk of SEI department grants went to DBES salaries, an important minority went to faculty incentives and travel. Supporting the SEI Central unit and its staff of two full-time employees (FTE) comprised 15–20% of the overall budget (more than anticipated).

Although department proposals were typically funded for five years, in reality most projects spanned six to seven years to allow for ramp-up (hiring DBESs and planning) and wrap-up (creating structures for sustainability). DBES turnover sometimes further stretched department timelines so that work was staggered across time due to gaps in staffing. The size and duration of grants also varied according to department readiness; sometimes this meant funding a pilot that might or might not lead to further funding.

3.1.2 Cornell University

Cornell's funding levels have been similar to UBC, based on its higher productivity relative to CU-Boulder, with grants to departments capped at $1M and average grants of $500K. Initial funding by a donor was later supplemented by university funding, allowing the initiative to expand university-wide. In contrast to the SEIs, the Cornell initiative leverages the existing Center for Teaching

Innovation for coordination and support provided by two FTE staff members and an associate director (.5 FTE).

Grant competitions have been intentionally spaced two to three years apart to allow time for word to spread between departments and for participants to learn from people further along in the process. Distributing the active projects over time also eases the workload for the central staff. The program started in 2013 and is currently ongoing with multiple departmental projects planned at least through 2024.

3.1.3 University of Kansas

KU implemented a much smaller and less costly program with university and external grant funds. About $1.8M in institutional funds went to departments as grants ($195K to $230K) to support DBES hires, travel, supplies, and events. The initiative leveraged CTE for coordination and support. With about $25K/year, CTE created a synergistic program, the C21 Course Redesign Consortium, to engage faculty and staff within and beyond the DBES-supported departments. C21 funds supported a university-wide community, regular workshops, faculty mini-grants, and graduate student fellows to support the work of faculty participants.

Once the program began, KU found that more central unit staffing was needed for the optimal level of coordination, professional development, and community for the DBESs. In 2015, a five-year, multi-institutional National Science Foundation grant enabled KU to enhance its initiative with a program coordinator (.5 FTE), faculty mini-grants ($1K to $3K each), and team travel grants ($5K each) for information-gathering visits to other campuses. The grant also expanded the community and support for the DBESs across a network of seven institutions (the “TRESTLE” network; TRESTLE, 2020). KU’s funding for DBESs and NSF funds for the intervention ended in 2019, but several program elements have been integrated into CTE’s ongoing work (see Sustainability section).

3.1.4 Costs and Resources: Recommendations for Future Directors

- Allocate the bulk of the funds to departments for DBES salaries, but also set aside resources (funds and human) for central program support.
- Allow funding to be carried over year-to-year, as projects may take longer than anticipated.
- Consider staggered funding competitions and/or pilot funds to support the development of department interest and readiness, and build early successful examples that can become support structures and influence faculty communities.
- Leverage existing programs and infrastructure and look for synergies with other programs to make less resource-intensive adaptations possible.

3.2 Department and Faculty Engagement

The funding attached to DBES programs is a critical lever for promoting buy-in and engagement from department faculty and leadership. The DBES hires address key impediments (lack of time and expertise), direct faculty incentives help counteract institutional disincentives (lack of rewards for change), and the significant funding levels signal the overall value of the endeavor. The four programs also incorporate multiple other strategies aligned with theory and research on change to promote department and faculty engagement, including engaging faculty as collaborators in the change, fostering community and common vision, and working towards measurable goals. Key elements include the use of the department proposal process as a catalyst to generate faculty enthusiasm, commitment, and input, and to create accountability for carrying out plans; encouraging strong support from department leadership to facilitate shared ownership; and rewarding the work and making it visible both within and outside the department to deepen and spread faculty engagement. Consistent with Klein et al.'s (this volume) recommendations, these elements combine support for bottom-up change leadership with visible top-down encouragement for change. All four programs host cross-department events to showcase the work to others at the institution, but their specific approaches to other elements have varied.

3.2.1 University of Colorado Boulder/University of British Columbia

The SEIs adopted an interactive process to help departments develop effective proposals while also ensuring broad faculty engagement. Typically, grants included funds for direct faculty incentives (e.g., reduced teaching responsibilities, teaching or research assistants, summer salary). Departments were encouraged to promote early successes, foster discussion, and communicate the importance of the work through time at faculty meetings, department colloquia, informal "lunch and learns," newsletters, or teaching guides. Department chairs were encouraged to provide other incentives (e.g., desirable teaching assignments), and to visibly reward and celebrate teaching improvements through award nominations, using teaching excellence in merit evaluations, and reassuring faculty that they would not be penalized for low student ratings during initial implementations.

3.2.2 Cornell University

Like the SEIs, Cornell implemented an interactive proposal process and included faculty incentives in grant budgets. They also encouraged departments to involve senior faculty, to signal their support and reduce the burden on pre-tenure or non-tenure-track faculty.

Efforts at rewarding work and making it visible focus on three levels: Cornell's college deans have played a strong role by sending announcements and organizing opportunities for faculty to talk to other faculty about their projects. Faculty stories about their course transformation projects and how much more they enjoy teaching with active learning methods are used to generate interest among other faculty. And collaboration with the university's communications staff has highlighted initiative efforts through campus media.

3.2.3 University of Kansas

Unlike the other programs, KU's department grant budgets did not allow for direct faculty incentives, but course transformation mini-grants and team travel grants from CTE provided additional incentives for faculty collaborating with DBESs, and a mechanism for broadening faculty engagement beyond that group. This was particularly important given that only eight departments received funds to hire a DBES and each worked on four to five courses.

KU emphasized community building at multiple levels to expand faculty engagement, give visibility to the work and shift social norms. This included department teaching working groups led by the DBES and department project director, the university-wide C21 community, and the NSF-funded TRESTLE network. Initiative leaders seeded these communities with existing faculty leaders in teaching improvement, and also leveraged external opportunities to build faculty leadership for change. The CTE, Provost, and deans' offices pooled resources to send faculty from DBES departments to conferences and national network meetings on educational change, and to send teams of department chairs to workshops on the role of chairs in supporting educational change.

3.2.4 Department and Faculty Engagement: Recommendations for Future Directors

- Use a competitive proposal process to foster department enthusiasm, commitment, planning, and accountability.
- Use an interactive proposal process to help shape the plan and ensure broad buy-in and leadership support, so the proposal is not the product of a lone champion.
- Fund direct incentives to recognize faculty efforts and create additional layers of accountability.
- Emphasize and support the building of community to expand faculty engagement and foster leadership development.
- Fund rewards for the work and help make it visible, to deepen and spread faculty engagement.

3.3 Sustainability

The four programs also have used multiple strategies to produce outcomes that will be sustained beyond the temporary influx of DBESs and faculty incentives. The strategies that promote broad faculty engagement within departments beginning at the proposal stage are also intended to lay the groundwork for long-lasting cultural change. Additional strategies to solidify those gains align with the change literature and focus on individual and structural supports that foster a sense of shared ownership of transformed courses, processes for continuous improvement, and departmental or institutional norms that prioritize evidence-based teaching. Specific strategies including supporting faculty learning communities and leadership development, or encouraging departments to revise departmental policies and procedures, charge a committee with curricular reform, incorporate course improvement activities in faculty reviews, or create teaching awards. All four programs advocated co-teaching arrangements that allow faculty new to evidence-based teaching to become accustomed to the methods alongside more experienced instructors. They also developed department repositories of course materials and lesson plans, but observed that these were most effective when combined with human support for implementation (e.g., co-teaching or mentorship). Each of our four programs have developed several additional solutions to sustain course improvements and the broader momentum for educational progress.

3.3.1 CU-Boulder/UBC

The SEIs found that support at the dean's level was critical for creating institutional priority for the initiative, especially given the traditionally low prioritization of teaching improvements (Dolan et al., 2016). To secure the dean's involvement, SEI Central provided regular reports to administrators. As a step toward synthesizing and documenting the outcomes of departmental projects, the SEIs created a central repository, though most course projects did not add materials; one challenge was that materials were typically not developed for re-use, and repackaging them was more effort than most projects could handle.

UBC also developed a "Teaching Start-Up Program" where the dean co-funds (with departments) paired teaching: full collaboration between an instructor experienced with the course and a new faculty member (Strubbe et al., 2019). Another structural support was the dean's introduction of a requirement that any new course proposal include detailed learning goals.

3.3.2 Cornell

At Cornell, several departments have used a "turn-key" approach to develop repositories such that the materials (e.g., polling questions, worksheets, activity instructions) are intentionally packaged for subsequent instructors. Some instructors are pleased to have well-designed learning activities, which reduces their preparation time. However, others report that the transformed courses have become overly complex and time-intensive because there are so many "moving parts." Departmental culture also varies in whether courses are "owned" by individual faculty or shared by the department; the latter cases have had more success in rotating repositories of course materials between instructors. A current goal is to find better systems to make the course materials and teaching methods easier to transfer from one instructor to another.

The Cornell program has also found that training TAs for active learning courses is essential, yet also challenging because TAs frequently change. Therefore, some departments have included the development of such training as part of their projects. Halasek et al. (this volume) also note the need to include graduate students in the change process, given their critical role in the undergraduate STEM curriculum.

3.3.3 KU

At KU, program leaders supported sustained change by prioritizing proposals from departments that indicated all instructors of targeted courses would teach them in the transformed way. In the best cases, all faculty responsible for teaching a course participated in the transformation, through course working groups that agreed on learning outcomes, major activities, and assignments. In some cases, department chairs reassigned instructors who were resistant to the changes.

To sustain momentum, KU focused on developing faculty leaders for educational improvement, similar to the REFLECT program described in the Salomone et al. chapter in this volume, and several of those are now in formal leadership positions at KU. The creation of a new promotable (but non-tenured) teaching faculty stream also contributes to continuous improvement efforts, as these individuals take up the role of supporting educational transformation and studying the process, often in partnership with tenure-track faculty. Administering the program through a university-wide teaching center has fostered productive synergies with other programs, including a learning analytics program that empowers faculty to track student success and downstream curricular effects of course transformation, a curriculum innovation program, and an initiative to better align teaching evaluation with evidence-based pedagogy (see Finkelstein et al., this volume).

3.3.4 Sustainability: Recommendations for Future Directors

- Scaffold sustainability at the proposal stage by asking departments to outline sustainability plans and by ensuring broad faculty engagement in the work.
- Promote shared course ownership so that changes do not depend on one individual; this requires structural support through policies and procedures and depends on department culture.
- Create repositories of course materials to support sustainable use, though these are rarely sufficient on their own.
- Fund/encourage co-teaching or mentorship of instructors who are new to the transformed course to “transfer” teaching methods and materials.
- Build support among university leadership through regular data collection and reports, and by developing new leaders for educational improvement.
- Foster synergies with other educational improvement programs, external funding, or national networks (e.g., TRESTLE) to sustain momentum.

4 Conclusions and Recommendations

The lessons learned in these four programs provide useful guidance for the design and implementation of programs that support departmental change from within. All four programs have found that funding DBESs to guide course transformation in departments is an effective lever for change when combined with central support, community, and accountability. There are few examples of interventions that have affected undergraduate STEM teaching practice at this scale. We have explored how initiative leaders navigated challenges around costs and resources, department and faculty engagement, and sustainability. Some key themes emerge: **leveraging existing structures and networks** to support management and training; **scaffolding department planning** of course transformation and implementation, teaching assignments, and transfer of materials; **providing incentives** to promote engagement, including direct incentives and rewards; **supporting ownership** through policies, co-teaching, and shared course materials; and **making the work and its impact visible**, to highlight successes to administrators, influence department norms, and build community. As demonstrated by the KU implementation, organizing the program through an existing center that can foster synergies with other programs can make less resource-intensive adaptations feasible, although it remains to be seen whether the impact is as sustained as that of the deeper investments in the other three programs. An ongoing NSF-supported study (TRESTLE, 2020) of less costly program adaptations on six campuses is gathering more evidence about the "minimum requirements" for this program to be effective. Additional information about the four programs and the DBES model can be found in the free online SEI Handbook (Chasteen & Code, 2018).

5 Acknowledgements

This material is based upon work supported, in part, by the National Science Foundation, Award numbers: DUE1525775 (KU), DUE1525331 (CU) and DUE1525345 (UTSA). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

This article reports on research conducted under the auspices of the Bay View Alliance, an international network of research universities exploring strategies to support and sustain the widespread adoption of instructional methods that lead to better student learning. https://bayviewalliance.org

6 About the Authors

Andrea Follmer Greenhoot is Professor of Psychology, Director of the Center for Teaching Excellence, and Gautt Teaching Scholar at the University of Kansas.

Carolyn Aslan is the Associate Director of the Active Learning Initiative at Cornell University's Center for Teaching Innovation.

Stephanie Chasteen is a research associate in the Center for STEM Learning at the University of Colorado Boulder.

Warren Code is the Associate Director of the Science Center for Learning and Teaching (Skylight) at the University of British Columbia.

Sarah Bean Sherman is the Science Education Specialist in the Earth Ocean & Atmospheric Science Department at the University of British Columbia

6 References

Ballen, C.J., Wieman, C., Salehi, S., Searle, J., & Zamudio, K.R. (2017). Enhancing diversity in undergraduate science: Self-efficacy drives performance gains with active learning. *CBE—Life Sciences Education, 16*(4), ar56. https://doi.org/10.1187/be.16-12-0344

Ballen, C. J., & Zamudio, K. R. (2019). Active learning reduces misconceptions about evolution and promotes inclusivity in large classrooms. In J. Golding, C. Rawn & K. Kern (Eds.), *Strategies for teaching large classes effectively in higher education* (pp. 81–103). Cognella Academic Publishing.

Borrego, M. & Henderson, C. (2014). Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. *Journal of engineering education, 103*(2), 220–252. https://doi.org/10.1002/jee.20040

Brownell, S. E., & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and... tensions with professional identity? *CBE—Life Sciences Education, 11*(4), 339–346. https://doi.org/10.1187/cbe.12-09-0163

Callahan, K. M., Williams, K., & Reese, S. (this volume). Student leaders as agents of change. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 16). Pressbooks.

Chasteen, S. V., Perkins, K. K., Beale, P. D., Pollock, S. J., & Wieman, C. E. (2011). A thoughtful approach to instruction: Course transformation for the rest of us. *Journal of College Science Teaching, 40*(4), 24–30.

Chasteen, S.V. & Code, W. J. (2018). *The Science Education Initiative handbook*. Pressbooks. https://pressbooks.bccampus.ca/seihandbook/

Cook-Sather, A., White, H., Aramburu, T., Samuels, C., & Wynkoop, P. (this volume). Moving toward greater equity and inclusion in STEM through pedagogical partnership. In K. White, A. Beach,

N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 15). Pressbooks.

Dolan, E. L., Lepage, G. P., Peacock, S. M., Simmons, E. H, Sweeder, R., & Wieman, C. (2016). *Improving undergraduate STEM education at research universities: A collection of case studies*. Association of American Universities. https://www.aau.edu/sites/default/files/STEM%20Scholarship/RCSA2016.pdf

Fairweather, J. (2008). *Linking evidence and promising practices in science, technology, engineering, and mathematics (STEM) undergraduate education* [Status report]. National Research Council Workshop, Washington, DC. https://www.nsf.gov/attachments/117803/public/Xc–Linking_Evidence–Fairweather.pdf

Finkelstein, N., Greenhoot, A. F., Weaver, G., & Austin, A. E. (this volume). A department-level cultural change project: Transforming the evaluation of teaching. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 14). Pressbooks.

Halasek, K., Heckler, A., & Rhodes-DiSalvo, M. (this volume). Transforming the teaching of thousands: Promoting evidence-based practices at scale. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 20). Pressbooks.

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952–984. https://doi.org/10.1002/tea.20439

Jones, F. (2017). Impact assessment of a department-wide science education initiative using students' perceptions of teaching and learning experiences. *Assessment & Evaluation in Higher Education, 42*(5), 772–787. https://doi.org/10.1080/02602938.2016.1188057

Jones, F. (2018). Comparing student, instructor, classroom and institutional data to evaluate a seven-year department-wide science education initiative. *Assessment & Evaluation in Higher Education, 43*(2), 323–338. https://doi.org/10.1080/02602938.2017.1343799

Kezar, A. (2014). *How colleges change: Understanding, leading and enacting change*. Routledge.

Klein, C., Lester, J., & Nelson, J. (this volume). Leveraging organizational structure and culture to catalyze pedagogical change in higher education. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 19). Pressbooks.

Moradi, M., Liu, L., Luchies, C., Patterson, M. M., and Darban, B., 2018, Enhancing teaching-learning effectiveness by creating online interactive instructional modules for fundamental concepts of physics and mathematics. *Education Sciences, 8*(3), 109–123. https://doi.org/10.3390/educsci8030109

Nelson, J. K., & Hjalmarson, M. A. (this volume). Discipline-based teaching development groups: The SIMPLE framework for change from within. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 18). Pressbooks.

Roberts, J. A., Olcott, A. N., McLean, N. M., Baker, G. S., & Möller, A. (2018). Demonstrating the impact of classroom transformation on the inequality in DFW rates ("D" or "F" grade or withdraw) for first-time freshmen, females, and underrepresented minorities through a decadal study of introductory geology courses. *Journal of Geoscience Education, 66*(4), 304–318. https://doi.org/10.1080/10899995.2018.1510235

Salomone, S., Dillon, H., Prestholdt, T., Peterson, V., James, C., & Anctil, E. (this volume). Making teachers matter more: REFLECT at the University of Portland. In K. White, A. Beach, N. Finkelstein, C. Henderson, S. Simkins, L. Slakey, M. Stains, G. Weaver, & L. Whitehead (Eds.), *Transforming Institutions: Accelerating Systemic Change in Higher Education* (ch. 17). Pressbooks.

Strubbe, L. E., Stang, J., Holland, T., Sherman, S. B., & Code, W. J. (2019). Faculty adoption of active learning strategies via paired teaching: Conclusions from two science departments. *Journal of College Science Teaching, 49*(1), 31–39. https://doi.org/10.2505/4/jcst19_049_01_31

Tagg, J. (2012). Why does the faculty resist change? *Change Magazine: The Magazine of Higher Learning, 44*(1), 5–14. https://doi.org/10.1080/00091383.2012.635987

TRESTLE. (2020). *TRESTLE*. www.trestlenetwork.org

Wieman, C. (2017). *Improving how universities teach science: Lessons from the Science Education Initiative*. Harvard University Press.

Wieman, C., Deslauriers, L., and Gilley, B. (2013). Use of research-based instructional strategies: How to avoid faculty quitting. *Physical Review Special Topics—Physics Education Research, 9*(2), 023102. https://doi.org/10.1103/PhysRevSTPER.9.023102

Conclusion

GABRIELA WEAVER AND ANDREA BEACH

The work for *Transforming Institutions* began a decade ago, with the planning of the first conference subsequently leading to a volume that brought together narratives of the ongoing work of initiatives presented at that and subsequent conferences. Changes in higher education as well as in the socio-political landscape since that time have brought into sharp relief some of the underlying issues driving the work presented in that first volume. It is clearer now than ever that in order for change to take place at our institutions of higher learning, the fundamental processes of those institutions and of the higher education sector overall must be examined.

As discussed in the 2015 volume (Weaver et al., 2015), transformation efforts were, at that time, beginning to shift from classroom-based to program-based and, in some cases, to institutional efforts. Change agents recognized that a substantial body of evidence existed in support of student-centered teaching methods, which laid a foundation for transformation efforts. The work of educational transformation was becoming more rigorously theory-based, utilizing knowledge from other sectors. For example, theories of organizational change from the business sector began to be integrated into frameworks for institutional change in higher education, as can be seen in the work of Kezar (2013) and the AAU (2013). At the current time, change frameworks are increasingly expected in funding proposals and published research. They are being applied not only to institution-level change, but also to networks of institutions and academic organizations working jointly on transformation efforts. For example, the Networked Improvement Communities (NIC) framework (Bryk et al., 2011), is one way to achieve the simultaneous engagement of both leadership- and course-level actors. Networking was an important methodological proposition introduced in the previous volume, and is discussed at length in this book as critical to sustaining and institutionalizing change.

We have seen institutional change initiatives in STEM education progress, expand, and become more numerous over the last half decade. So, too, have the efforts to understand and support change. The conversation about change in higher education has become a national one and has generated coalitions to address the work in systemic ways. For example, the Bay View Alliance [BVA] (BVA, n.d.) is a network of 10 (at this time) institutions working together on STEM education institution-level projects; the Accelerating Systemic Change Network [ASCN] (ASCN, 2020) brings together those who are researching systemic change at higher education institutions with those who are making systemic change happen at their individual institutions, with the aim to accelerate change at program and institution levels, and to improve STEM education nationally; the Network of STEM Education Centers [NSEC] (NSEC, n.d.) provides resources for and supports the work of campus-based units that are often at the grassroots level of change. More recently, the National Academies of Science, Engineering, and Medicine [NASEM] created a standing group called the Roundtable on Systemic Change in Undergraduate STEM Education (NASEM, n.d.) intended to support ongoing exploration of the intersections among policy, research, and implementation in STEM Education. In this volume, we see the growth of the national dialogue about STEM education transformation reflected in the new organization of book, with sections titled: *Theories of Change*, *Change across Scales*, and *Change Leaders*. This organization was driven by the increased presence of advanced enactment of change in this volume's chapters, as compared to five years prior, when the much of the book comprised descriptions of programs in the early stages.

The chapters in the section *Theories of Change* offer detailed examples of projects framed by specific theories adapted from organizational and business literature, and initiatives framed by emergent theories developed in the higher education context. Authors in this section also explore the value of applying multiple theoretical lenses to complex change problems and ask important questions: What happens to ideas in an institution? Why do some ideas gain traction and others wither? How do different change theories add interpretive value to data emerging from change initiatives? These chapters go well beyond the descriptive approach that characterized chapters in the prior volume. They describe projects that spread across all four quadrants of Henderson et al.'s (2011) change strategies, and stress the importance of context in planning and enacting change. Henderson and Stains note in their Introduction to this section that change theories do not often address context, and that its presence within all seven chapters points to nuances in change initiatives that have been under-developed but remain important for future theory application and development.

The authors within the *Change across Scales* section offer a series of studies that were not possible to offer in the first volume, which in itself is a testament to the rapid evolution of thinking about undergraduate STEM change—both among change makers and among funders. All of the initiatives described in the seven chapters were funded, either wholly or partially, by the National Science Foundation or the Howard Hughes Medical Institute. All involve significant collaboration, whether initiatives were initially planned at a multi-institutional scale or grew to that level. That a full third of this volume is able to focus on such networked projects speaks to the very rapid success of researchers and funding agencies in thinking beyond the intra-institutional levels that characterized prior STEM education research. These chapters provide early blueprints for very large-scale change efforts that will be needed to fully realize the "new normal" that Slakey and Gobstein proposed (2015). They manifest the intentional shift that Finkelstein noted in the Introduction of this volume.

The works within the final section, *Change Leaders*, also address an aspect of change not explored in the prior *Transforming Institutions* volume. Chapters explore the power of students as leadership partners in change efforts, the shared support and accountability offered by learning community models of change, the necessary leadership roles needed to make them successful, and the key role that discipline-based educational specialists have taken within complex instructional transformation initiatives. Collectively, the chapters paint a portrait of leadership from every level needed to build sustained change over time. The mix of developing and mature initiatives offers readers multiple entry-points to considering questions of leadership across the arc of change—early development, building to scale, and institutionalization.

The works in this volume clearly demonstrate a broadening and deepening of thinking about how to implement and study transformative change in undergraduate STEM teaching and learning. The spectrum of initiatives represented across the chapters shows the dramatic growth that has occurred over the past decade. What this volume lacks, however, is representation of a diversity of contexts when we think about STEM teaching and learning outside of bricks-and-mortar, research-oriented, traditionally delivered undergraduate education. There are few comprehensive, liberal arts, or minority-serving institutions represented, no community colleges, no adult learners, no online, hybrid, or alternative schedule courses. It is impossible to talk about transformative change in undergraduate STEM education when the discussion is missing the bulk of institutions that educate our undergraduates. Furthermore, there is change happening at those institutions that offers additional and important perspectives to the national conversation on higher education transformation. Broadening the contexts and the student groups we include in our research and change-making enterprises in the next decade is critical.

A central question of the first volume of *Transforming Institutions* was whether the use of student-centered teaching practices could become the "new normal" in the near future, if ever. One goal we had as we began this volume was to reflect on that question and appraise the landscape along that metric. However, that is now only one of many questions we are asking as we synthesize the work of the scholars contributing to this volume. At the time of completion of this volume, near the end of 2020, our country and the globe have been through tremendous tests of resiliency, compelling deep reflection and adaptability by individuals and organizations at all levels. In some ways, the resulting shifts have been catalytic for the types of changes that education researchers and change agents have been continually pursuing prior to this time, though making only incremental progress. In other ways, however, unaddressed deficiencies and injustices of our higher education system—and society as a whole—have been amplified and brought to center stage. Foremost among these are issues of equity, ranging from access and inclusivity for traditionally underrepresented people to heightened awareness of systemic racism and the policies, practices, and structures that sustain it.

Those same policies, practices, and structures, regrettably, are inherent in this country's system of higher education, and those of other countries with similar structures. Higher education institutions of today have emerged from a legacy of knowledge discovery and dissemination that was elitist by design and developed in an era when inequality was not questioned. Addressing the deficiencies and injustices of our system, then, requires nothing short of a full reexamination of the "ways of doing" and the "ways of being" in our institutions through a lens of equity, inclusion, and diversity. Many of the change efforts represented in this and the prior volume of *Transforming Institutions* have been grassroots initiatives, and have often struggled to become institutionalized. This begs the question of whether these institutional legacy structures are able to support higher education in becoming what is needed for today's society.

It is incumbent on all of us to make changes where changes can be made, or to rebuild the structures entirely where changes would be only makeshift, palliative efforts. It is not enough to create programs that simply adorn the edifices that exist, only to have a new seismic societal shift remind us of the flaws we left in place. We argue that "*structural renewal*" must be at the core of our efforts to achieve the "new normal" envisioned by Slakey and Gobstein (2015). This is a time of lessons and an opportunity to apply what we are learning in meaningful ways. The editors and authors of this volume, and all of those who have contributed to the ongoing work of transforming institutions, believe that the core mission of our work is to ensure that all students can access and succeed in

STEM higher education. Indeed, that the flourishing of human society depends on it. As such, we consider our work only a beginning and hope it will be a call to action for every reader.

1 References

Accelerating Systemic Change Network. (2020). *Accelerating systemic change in STEM higher education*. Accelerating Systemic Change Network. https://ascnhighered.org/index.html

Association of American Universities. (2013). *Framework for systemic change in undergraduate STEM teaching and learning*. Association of American Universities. https://www.aau.edu/sites/default/files/STEM%20Scholarship/AAU_Framework.pdf

Bay View Alliance. (n.d.). *Bay View Alliance*. https://bayviewalliance.org/

Bryk, A., Gomez, L., & Grunow, A. (2011). *Getting ideas into action: Building Networked Improvement Communities in education*. Carnegie Foundation for the Advancement of Education. https://www.carnegiefoundation.org/wp-content/uploads/2014/09/bryk-gomez_building-nics-education.pdf

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952–984. https://doi.org/10.1002/tea.20439

Kezar, A. (2013). *How colleges change*. Routledge.

National Academies of Sciences, Engineering, and Medicine. (n.d.). *Roundtable on systemic change in undergraduate STEM education*. The National Academies of Sciences, Engineering, and Medicine. https://www.nationalacademies.org/our-work/roundtable-on-systemic-change-in-undergraduate-stem-education

Network of STEM Education Centers. (n.d.). *Network of STEM education centers*. https://serc.carleton.edu/StemEdCenters/index.html

Slakey, L. & Gobstein, H. (2015). Toward a new normal. In Weaver, G. C., Burgess, W. D., Childress, A. L., & Slakey, L. L. (Eds.) *Transforming Institutions: Undergraduate STEM education for the 21st century* (pp. 485–496). Purdue University Press.

Weaver, G. C., Burgess, W. D., Childress, A. L., & Slakey, L. L. (Eds.) *Transforming Institutions: Undergraduate STEM education for the 21st century*. Purdue University Press.

About the Editors

Kate White is the Assistant Director for Language Learning Services in the Student Success Center at Temple University. She served as the ASCN Research Director from 2018 to 2020, and as a Postdoctoral Research Associate in the Center for Research on Instructional Change in Postsecondary Education at Western Michigan University. Her research interests include institutional change, team-based change, evidence-based teaching and learning, environmental effects on learning, bilingualism, interactional competence, and second language teaching and learning. She earned her Ph.D. from the Ohio State University (2015) in Slavic linguistics and second language studies.

Andrea L. Beach is Associate Dean for Academic Services in the College of Education and Human Development, Professor of Higher Education Leadership, and Co-Director of the Center for Research on Instructional Change in Postsecondary Education (CRICPE) at Western Michigan University. Her research centers on organizational change in higher education, support of innovation in teaching and learning, faculty learning communities, and faculty development as a change lever. Her research has been supported by over $6M in federal and foundation funds. She is Co-PI of the Accelerating Systemic Change Network (ASCN), a national network of higher education change researchers and change agents, sits on the National Academies of Science, Engineering and Medicine roundtable on the future of undergraduate STEM, and was an American Council on Education Fellow in 2018-19.

Noah Finkelstein is a Professor of Physics at the University of Colorado Boulder and conducts research is in physics education, specifically studying the conditions that support students' interests and abilities in physics – developing models of context. In parallel, he conducts research on how educational transformations get taken up, spread, and sustained. He is a PI in the Physics Education Research (PER) group and a co-director of CU's Center for STEM Learning. He co-directs the national Network of STEM Education Centers, is building the STEM DBER-Alliance, and coalitions advancing undergraduate education transformation. He is involved in education policy serving on many national boards, sits on a National Academies' roundtable, is a Trustee of the Higher Learning Commission, is a Fellow of the American Physical Society, and a Presidential Teaching Scholar for the University of Colorado system.

Charles Henderson is a Professor at Western Michigan University (WMU), with a joint appointment between the Physics Department and the WMU Mallinson Institute for Science Education. He is the Director of the Mallinson Institute and co-Founder and co-Director of the WMU Center for Research on Instructional Change in Postsecondary Education (CRICPE). His research program focuses on understanding and promoting instructional change in higher education, with an emphasis on improving undergraduate STEM instruction. Dr. Henderson's work has been supported by over $9.5M in external grants and has resulted in many publications (see https://sites.google.com/view/chenderson). He is a Fulbright Scholar and a Fellow of the American Physical Society. Dr. Henderson is the senior editor for the journal Physical Review Physics Education Research and has served on two National Academy of Sciences Committees: Undergraduate Physics Education Research and Implementation, and Developing Indicators for Undergraduate STEM Education.

Scott Simkins is associate professor and chair of the Department of Economics at North Carolina A&T State University. Previously, he served for twelve years as director of the university's teaching and learning center. From 2016-2019, he co-led the Accelerating Systemic Change Network (ASCN) Costs and Benefits of Change in Higher Education working group and joined the ASCN Leadership Team in 2017. His research focuses on the implementation and diffusion of evidence-based pedagogical practices in economics, drawing on discipline-based education research from a variety of STEM disciplines. He has led multiple National Science Foundation-supported economic education research projects promoting and assessing the use of evidence-based teaching practices, including the development of an online *Starting Point: Teaching and Learning in Economics* pedagogy hub for economists, created in collaboration with the Science Education Resource Center (SERC) at Carleton College. From 2009-2019, he served as co-executive editor of *College Teaching*.

Linda Slakey served at the University of Massachusetts Amherst from 1973 – 2006, first in the Department of Biochemistry and Molecular Biology, then as Dean of the College of Natural Sciences and Mathematics, and then as Dean of Commonwealth Honors College. She supported teaching and learning initiatives throughout the University, with particular attention to faculty development, engaging undergraduate students in research, and the support of research on how students learn. From 2006 through 2011 she was Director of the Division of Undergraduate Education at the National Science Foundation. At present she has a consulting practice focused on bringing about a shift in the culture of undergraduate teaching from one in which lecture is an accepted dominant form toward one characterized by personal and institutional expectations of more student-centered teaching practices.

Marilyne Stains is an associate professor in the Department of Chemistry at the University of Virginia. Her research focuses on characterizing the extent, nature, and factors involved in the gap between instructional practices in science college classrooms and discipline-based education research. She is specifically interested in 1) developing new methods to characterize instructional practices in STEM college classrooms, 2) exploring how faculty and teaching assistants think about their teaching, 3) identifying individual, departmental, and institutional factors that influence instructors' instructional decisions, and 4) characterizing the impact of different types of pedagogical professional development programs. She has received funding from the National Science Foundation, including a CAREER award (2016). In 2019, she was awarded the Presidential Early Career Award for Scientists and Engineers (PECASE) and the American Chemical Society Women Chemists Committee Rising Star Award.

Gabriela Weaver serves as Professor of Chemistry at the University of Massachusetts, Amherst. Previously, her role was Vice Provost for Faculty Development and director of the Institute for Teaching Excellence and Faculty Development (TEFD). Prior to coming to UMass, Gabriela served as professor of chemistry and science education and the Jerry and Rosie Semler Director of the Discovery Learning Research Center at Purdue University. In 2019-2020 she held a Fellowship with the American Council of Education, carried out at Boston University. In 2012, she was elected a Fellow of the American Association for the Advancement of Science for distinguished contributions to transforming Science education at the undergraduate level. She has been an author on two chemistry textbooks, and the 2015 book *Transforming Institutions: Undergraduate STEM Education for the 21st Century*, as well as numerous scholarly articles and book chapters. She earned a B.S. degree in chemistry from the California Institute of Technology and a Ph.D. in chemical physics from the University of Colorado at Boulder.

Lorne Whitehead is the University of British Columbia's Special Advisor on Entrepreneurship, Innovation and Research and a Professor in the Department of Physics and Astronomy. He has held several administrative positions including Associate Dean, Dean pro tem, VP Academic & Provost and Leader of Education Innovation. He holds 143 US patents that find application in computer screens, televisions and lighting products and has launched seven spin-off companies. He received a Ph.D. in Physics from UBC and has considerable experience in technological, business and administrative innovation. From 1983 to 1993 he served as CEO of TIR Systems, a UBC spin-off company that grew to 200 employees before being acquired by a multinational corporation.

Abbreviations

A&S: Arts and Sciences

AAAS: American Association for the Advancement of Science

AACU: Association of American Colleges and Universities

AAMC: Association of American Medical Colleges

AAU: Association of American Universities

ABCD: Asset-Based Community Development

AN: Adaptive Network

AOSC: Atmospheric and Oceanic Sciences

APLU: Association of Public & Land-Grant Universities

ASCN: Accelerating Systemic Change Network

ASTR: Astronomy

BFA: Boulder Faculty Assembly

BIOL: Biology

BioTAP: Biology Teaching Assistant Project

CACAO: Specify the (C)hange, Understand (A)dopters, Organize (C)hange (A)gents, and Attend to (O)rganizational structures and cultures.

CBMG: Cell Biology and Molecular Genetics

CCE STEM: Cultivating Cultures for Ethical STEM

CCLI: Course Curriculum and Laboratory Improvement

CCT: Cross-course Communities of Transformation

CHEM: Chemistry and Biochemistry

CICS: Current Instructional Climate Survey

CIRTL: Center for Integration of Research, Teaching and Learning

CMNS: College of Computer, Mathematical, and Natural Sciences

CMSC: Computer Science

CODS: Characteristics of Dissemination Success

COVID: (Co)rona(vi)rus (D)isease

CRUSE: Coalition for Reform of Undergraduate STEM Education

CTE: Center for Teaching Excellence

CTL: Center for Teaching and Learning

CU-B: University of Colorado Boulder

CUR: Council of Undergraduate Research

CURE: Course-based undergraduate reserach experience

CV: Curriculum Vitae

DAT: Departmental Action Team

DBER: Discipline-Based Education Researchers

DBES: Discipline-Based Education Specialists

DEI: Diversity, equity & inclusion

DFW: “D” or “F” grade or withdraw

EBEP: Evidence-based educational practices

EBIP: Evidence-based instructional practices

EHR-DUE: Directorate for Education and Human Resources, Division of Undergradate Education (National Science Foundation)

ENTM: Entomology

ExCEL: Excellence x Confidence Equals Leadership

FAQ: Frequently Asked Questions

FAST: Faculty Advocates for STEM Transformation

FIRST: Faculty Institutes for Reforming Science Teaching

FLC: Faculty Learning Community

FSSE: Faculty Survey of Student Engagement

FTE: Full-time employees

GEOL: Geology

GPA: Grade point average

GTA: Graduate teaching assistant

HHMI: Howard Hughes Medical Institute

HN: Hierarchical Network

IE: Inclusive Excellence

ILI: NSF Instrumentation and Laboratory Improvement program

INCLUDES: Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science

IUSE: Improving Undergraduate STEM Education

KU: University of Kansas

LA: Learning assistants

LTO: Long Term Outcome

M: Mean

MATH: Mathematics

MOOC: Massive Open Online Courses

NASEM: National Academies of Sciences, Engineering, and Medicine

NIC: Networked improvement community

NSEC: Network of STEM Education Centers

NSF: National Science Foundation

NSSE: National Survey of Student Engagement

OAPA: Office of Academic Planning and Assessment

P&T: Promotion & tenure

PCAST: President's Council of Advisors for Science and Technology

PERSIST: Promoting Education Reform through Systemic Investments in STEM Transformation

PHYS: Physics

PI: Principal Investigator

PIC: Peer Implementation Cluster

PKAL: Project Kaleidoscope

POD: Professional and Organizational Development

QUBES: Quantitative Undergraduate Biology Education and Synthesis project

RCN-UBE: Research Coordination Network-Undergraduate Biology Education

REALISE: Realizing Inclusive Science Excellence

RED: Revolutionizing Engineering Departments

REDPAR: Revolutionizing Engineering Departments Participatory Action Research

REFLECT: Redesigning Education for Learning through Evidence and Collaborative Teaching

RISE: Research Innovation Service Experiential Learning Institute

SaLT: Students as Learners and Teachers

SEA-Change: STEMM Equity Achievement Change

SEI: Science Education Initiatives

SEISMIC: Sloan Equity and Inclusion in STEM Introductory Courses

SET: Student evaluation of teaching

SIMPLE: Sustained, incremental change, mentoring, people-driven, learning environment

SL: Student leaders

STEP-U: Survey of Teaching Beliefs and Practices for Undergraduates

TA: Teaching assistant

TEFD: Teaching Excellence and Faculty Development

TEval: Teaching Evaluation

TLC: Teaching and Learning Center

TOC: Theory of Change

TPB: Theory of Planned Behavior

TPD: Teaching professional development

TQF: Teaching Quality Framework Initiative

TRESTLE: Transforming Education, Stimulating Teaching and Learning Excellence

TU: Towson University

TUES: Transforming Undergraduate Education in STEM

UBC: University of British Columbia

UMass: University of Massachusetts, Amherst

UTOP: UTeach Observation Protocol

WIDER: Widening implementation and demonstration of evidence-based reforms