Increasing Student Success in STEM: Summary of A Guide to Systemic Institutional Change

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Summary of A Guide to Systemic Institutional Change

By Susan Elrod and Adrianna Kezar
THE NEED FOR A SYSTEMIC MODEL FOR INSTITUTIONAL CHANGE IN STEM

For the past 20 years, numerous reports have called for change and reform of undergraduate education to improve student learning, persistence, and graduation rates for students in STEM. However, by many measures the recommendations in these reports have not been widely implemented (Seymour 2002; Handelsman, et al. 2004; Fairweather 2009; Borrego, Froyd and Hall 2010). Aspirational student success goals in STEM have been set most recently by the President’s Office of Science and Technology (PCAST) recent report, Engage To Excel: Producing One Million Additional College Graduates in Science, Engineering, Technology and Mathematics (2011). The report states that STEM graduation rates will have to increase annually by 34% to meet this goal.

Many change efforts have been started but few have reached the transformational level of entire programs, departments, or colleges in the STEM disciplines. There is growing recognition that reform in STEM is an institutional imperative rather than only a departmental one. Student advising, faculty professional development, student research mentoring, academic support programs, STEM-focused articulation agreements, external partnerships with business and industry related to internships and other research experiences, and other critical areas are often overlooked within reform efforts. These areas are central to student success. For example, the Meyerhoff Scholars Program at the University of Maryland, Baltimore County combines specific academic, social, and research support interventions that have resulted in dramatic improvements in graduation of minority STEM students (Lee and Harmon, 2013).

In order to facilitate more institutional-level STEM reform, we created a model that provides both a process and content scaffold that campus leaders can use to plan, implement, and evaluate change efforts in undergraduate STEM education beyond redesign of a single course or isolated program. Further details regarding the model have been published in a guidebook for campus leaders who have convened (or will convene) teams comprised of faculty members, department level leaders, student affairs, appropriate central administration officers, institutional research and/or undergraduate studies offices (Elrod and Kezar, 2016).

We have learned from our own work as both researchers and practitioners that institutional change is best executed when a cross-functional team works together. In order for institutional changes to be enacted, support of leaders at different levels across campus is critical—grassroots faculty leadership, mid-level leadership among department chairs and deans, and support from senior leaders in the administration.

Other multi-campus and institutional focused STEM education reform projects have begun with a similar goal of providing a model for more systemic and sustainable improvements in STEM learning and student success. For example, the Association of American Universities (AAU) launched a major initiative with eight member campuses to implement reform in undergraduate STEM education (http://aau.edu/policy/article.aspx?id=12588). Their project centers around the application of an approach by campus leaders that is comprised of three elements: pedagogical reform, appropriate scaffolding and support for faculty to carry out pedagogical reform, and cultural change. Similarly, the American and Public Land-Grant Universities (APLU) has developed an analytical rubric to help campus leaders make improvements in science and mathematics teacher education programs (http://www.aplu.org/page.aspx?pid=2182). A new network of change agents and researchers is emerging, called the Accelerating Systemic Change Network (http://serc.carleton.edu/ASCN), which aims to generate knowledge about change and address key questions regarding institutional change.

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These projects are manifestations of the change in direction of STEM reform and suggest why the new model we offer is a timely addition to the landscape of resources that campus leaders can use to create change. We also note that while the model was developed in the context of STEM reform, it has broader applicability for any institutional systemic change project.

**The Project**

The model was developed in a project working with 11 campuses in California—five California State Universities (East Bay, Fullerton, Long Beach, Los Angeles, San Diego, San Francisco), The California State University Chancellor’s Office; three private liberal arts colleges (W.M. Keck Science Department of Claremont McKenna, Pitzer and Scripps Colleges, University of La Verne, University of San Diego); and, one research university (University of California, Davis) to create institutional level STEM reform efforts.

With the generous support from the W.M. Keck Foundation, we developed an initial institutional change model that we introduced to campuses in 2011. We then began working through the model with them, identifying their vision, obtaining data to better understand their students and specific challenges, and examining possible interventions. We provided webinars, regional gatherings, quarterly check-in calls, and annual meetings of project teams to help them continue their change efforts and work through the model.

Our intention was to assist campuses in their STEM reform efforts but also study the campuses to see what worked in the model and what proved challenging. For example, initially we had them start with the vision and then collect data, but right away it became clear they could not develop a vision without reviewing the data. Thus we made modifications to the model on an ongoing basis as we saw what worked for campuses and what became difficult or not helpful. The goal by the end of the project was to develop a more comprehensive model that would help move campuses forward as well as understand common challenges to help future campuses avoid them. We also wanted to understand the value of having a model or guide to help enable organizational learning toward sustained change in undergraduate STEM education.

Our approach in this project was based on practices of organizational learning. Within this approach to change, information gathering and data analysis play a central role in helping individuals to identify directions and appropriate interventions for making strategic progress. Participants in any organizational learning planning process foreground the data, reflection, dialogue, and non-hierarchical teams learning and developing innovative approaches. This means having campus teams look at data related to student success in order to determine the specific challenges and problems and to orient themselves towards a vision for change.

But an organizational learning model also focuses on learning throughout the change process. The model is focused on facilitating organizational learning, but it also incorporates key ideas from other research on change such as the need to address politics, developing buy-in and a shared vision, and understanding the power of organizational culture and helping campus leaders unearth underlying assumptions and values that might create resistance to change.

**The Keck/PKAL Model**

The Keck/PKAL model for institutional systemic change increasing student success in STEM is illustrated as a river, indicating the dynamic, flowing nature of change (Figure 1).

The process shown in Figure 1 begins at the upper left and proceeds toward the lower right with the colored boxes representing the practical steps that need to occur along the way. Leadership is critical for starting the process, and leaders must be identified and cultivated early in the process. These leaders may be from the central administration, department, division, or college. External experts and/or...
partners may also play a critical early leadership role (board of trustee member, K–12 partner). Faculty members who are early adopters/disrupters already engaged in course redesign or DBER (discipline-based educational research) or are champions (influential faculty leaders) are common early leaders for change in STEM. These individuals make up important members of an initial team to get the project started.

The process also requires a significant readiness assessment component to gauge campus climate, capacity for change, and resources required for program development. Some resources (particularly time for faculty leaders to devote to planning and initial analysis) are extremely helpful during this phase. Internal special project funds or external grant funds are important sources of seed funding to launch initial project planning and pilot testing.

And finally the process leads to action, implementing the planned strategies that lead to desired results. The process of change takes time and, in particular, it takes time to develop a vision and common language about people’s views. Without early discussions about vision and goals, project progress can be delayed or derailed due to lack of shared understanding.

We are confident that our work helped identify the key barriers and challenges, which will make future efforts easier. The specific steps and elements in the model are listed and described below (Table 1). They describe the points and processes in the “river” of change.

The river analogy is apt, not only because of the flowing nature of a river, but because a river is a dynamic, changing structure. The flow (change process) encounters obstacles (challenges presented by certain aspects of the change process) that may result in an eddy where the flow circles around the obstacle until it can break free. For example, formation of a robust vision is best informed by analysis of institutional data to ground the vision in reality; however, many campuses do not have good data collection and analysis systems readily available. In a “reform eddy” teams “peel out” or pause while the obstacle is investigated and further analyzed before they are able to get out of the circular flow and continue further downstream.

Travelers on the river may enter at various points or “put out” at certain locations to rest and regroup. New travelers may enter and join a party already on a journey down the river. Indeed, we observed teams starting at different points, changing membership, or even stopping
out for periods of time because of competing institutional or departmental priorities. Teams can also paddle up or downstream, although the general flow will be ultimately to go downstream toward action and success. For example, teams who are in the process of determining whether or not they are ready for implementation of a particular strategy may find that they are lacking critical resources or expertise that is required in order to be successful. They may need to revisit other opportunities that could be leveraged in a different strategy or even collect more data to refine their challenge and vision.

It is extremely helpful to identify where you are, based on campus context, expertise, leadership, etc. and envision what you think will work for you. However, wherever you start, we believe you must address all the elements at some point or time.

**Implementation of the Model**

While we don’t have space in this article to review how to use the entire model, we provide information about one element so that readers get a sense of what the steps entail. Because establishing a clear vision is a critical step in the change process, it seemed appropriate to focus on this step first. A vision in this Model means that the campus has a well-defined statement that describes their collective vision for improving STEM student learning and success. The vision includes clear goals for efforts as well as specific outcomes and measures.

This vision is most powerful when it is constructed by a diverse team of leaders—faculty and staff from STEM departments and throughout the institution—and is aligned with campus priorities or initiatives for undergraduate learning or success that have support from the central administration, deans, and department chairs. Guiding questions to help leaders in thinking about their vision include:

1. Is the vision articulated in a way that will be clear to internal and external groups who we may need to communicate with and get support?
2. Is our vision aligned with institutional goals and priorities?
3. Who is already engaged in STEM education program improvements and what ideas are they enthusiastic about moving forward?
4. What are the key data trends that should guide your vision of student success?
5. What assets do you have that can be capitalized on for creating a vision?

From observing the 11 campus teams we learned that developing a vision or goals takes longer than expected. Spending the time to talk as a team and come up with a common language is an important part of vision development. Most teams believed that they could develop a vision in a couple of meetings, but this turned out to be a false assumption. Creating a vision, particularly if a campus has not had conversations about STEM student success, usually requires an extended period of conversation over six to eight months or several retreats where people read some common documents, reports or research on the issue, or explore campus data together.

Most campuses also learned that vision creation involves a careful landscape and capacity analysis. This landscape analysis includes understanding current work on campus that supports student success, exploring data that might help understand gaps in programming or existing successful programs, as well as understanding the history related to STEM reform efforts. The analysis helps teams to consider appropriate goals given their history, current efforts, and trends in student success revealed by the data that they previously may not have been aware of (e.g., graduation gaps between majority and minority students).

Many campuses started their work believing they had created a vision, but as they encountered other information that surfaced during their process, for example, about past efforts in another department or data across several programs (as opposed to just their own), they either broadened or reconsidered their vision. For example, faculty members may have different perspectives on student success because they are focused on a narrower range of programs than the dean of undergraduate studies who looks across all programs.

Ultimately, the vision process is not just about developing the direction but also a common language that everyone understands. This is important so that people can communicate clearly and buy in can be created amongst team members and others in order to build enthusiasm and broader support for the change. Campus teams mentioned that being flexible with the vision and allowing it to change over time as new ideas or opportunities emerge was important.

Getting teams to think beyond a narrow vision, for example, seeing undergraduate research as the sole intervention, also took time. We asked teams to consider the many opportunities there are to improve STEM education, sometimes outside their departments, and to consider a range of opportunities that they might leverage in shaping their vision of STEM student success. Some examples of the range of opportunities include:

- K–12 partnerships, dual credit coursework, and outreach that might assist with recruitment
- Developments in evidence-based teaching practices (e.g., POGIL, PLTL, SCALE-UP, Classroom-Based Undergraduate Research Experiences (CUREs), etc.; Project Kaleidoscope’s Pedagogies of Engagement website, National Academies, 2012); use of other High-Impact Practices (Kuh, 2008), such as learning communities, service learning, and undergraduate research
- STEM specific orientations, Summer Bridge, and other summer programs
- Advising practices and partnerships with Student Affairs
- Tutoring and Supplemental Instruction programs
- Curricular alignment and mapping exercises
- Assessment of student learning and progress
- Faculty professional development programs
- Transfer agreements, partnerships with community colleges, and reverse transfer policies
- Mentoring opportunities, both peer and faculty
- Peer learning approaches, study groups and clubs
- Remediation, both English and Math, also reconsidering Math requirements
- Partnerships with industry or business for research but also career connections, including internships and co-ops
- Differential tuition policies
- Facilities that support active learning; hybrid classrooms and uses of technologies

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Campuses in the project were largely successful in developing vision statements to guide their work. Here are some examples.

- “The vision for the … project is to develop a culture in which instructors use evidence-based, scientific approaches to teaching and student learning in classroom, online and laboratory instruction in courses across the curriculum.” (CSU, Fullerton)
- “Our goal for the project was to properly scaffold these skills (learning how to ask questions, formulate hypotheses, carry-out experimentation, analyze data, and present research in lower stakes environments) to improve retention (to 70% after one year and at least 60% after year two) and help prepare our students for the capstone and beyond.” (University of La Verne)
- “Our vision is to contribute “to the advancement of effective STEM education across the CSU, so our diverse pool of STEM graduates, with their unique qualifications and talent, will be prepared to meet the challenges and opportunities in our global society.” (CSU System)

Campuses took different approaches to develop these visions that were consistent with their cultures, opportunities, team expertise, and internal processes. For example, University of La Verne took the opportunity to align their STEM vision with an emerging strategic plan and a new campus president. This allowed them to get institutional resources and support for their ideas. CSU East Bay created an institute that brought together educational researchers and STEM faculty to develop a common vision. Bringing together diverse voices was helpful. They also developed an advisory board to help them with their vision development and were successful in obtaining both external and internal resources to support their vision. The CSU system team held an all-day retreat and brought in a consultant to help them in developing and defining the vision statement. Several campus teams took advantage of grant funding to provide the time and resources to solidify a common vision.

Several challenges to the visioning process were identified by working with campus teams as well. The most common include:

- **Leadership Turnover:** Leadership turnover in the early phases can be particularly disruptive and needs to be engaged with care. At the CSU system, the initial team leader left after the project started, which left the team without a champion to lead the vision discussions. They resolved the issue by continuing to meet and share the leadership role until another leader came on board.
- **Assumption of a Shared Vision:** For many institutions, members of the team will have different ideas about a vision, and these may be implicit or not yet articulated. The CSU system experienced difficult initial meetings until they discovered one issue that they could all agree upon—the value of high impact practices. Once they had agreement around that issue, they decided to look at data related to it, and that helped them move toward a collective vision.
- **Stale or Static Vision:** The CSU Fullerton case study demonstrates that even though they had been working in STEM reform for 15 years, they did not have an updated vision to guide them forward in their current work. Their past project visions led them to falsely believe they knew where to go next, but they had to stop and develop a new vision.
- **A Singular or Top Down Vision:** The CSU Fullerton case also illustrates that when a vision is largely driven by a single individual, such as a dean or department chair, then it may not gain traction until others on the team have the time to understand and buy into it. Similarly, the UC Davis vision emerged from the Provost’s office and, despite the support from administration, it had less faculty buy-in at the beginning that resulted in slow initial progress.

More detailed descriptions of the elements of the Model can be found in the published Guidebook (Elrod and Kezar, 2016). Additional details such as key questions to consider, campus case studies, challenge alerts (mistakes to avoid or pitfalls to be aware of), and timeline considerations are included in the Guidebook. The Guidebook also contains specific tools to help campus leaders and teams plan and manage change initiatives, such as resources to help teams determine how to get started, conduct data analyses, avoid common pitfalls, build effective teams, build leadership capacity, and sustain change. It also includes a readiness survey to help teams determine whether they are prepared to move forward with implementation of their chosen strategies and interventions and a rubric to help campus teams gauge their progress in the Model phases. In addition, detailed case studies from participating campuses are featured on a website (http://www.aacu.org/pkal/educationframework/index.cfm) and in the Spring 2015 issue of AAC&U’s journal, Peer Review.
Challenges in applying the Model to change projects

While the Model provided direction, teams often veered off course using their own implicit change assumptions. For example, campus leaders tended to jump into the process at the implementation stage. They wanted to start by implementing a strategy that they read about in a report or publication or learned about at a conference. This information and the positive impact revealed in the study may motivate change, but it is important to be patient and go back to vision and landscape analysis before jumping into implementation of the latest published student success strategy—it may not fit the campus situation or resources.

It is important to understand campus capacity to implement a strategy and whether the strategy will address local challenges and be consistent with resources, mission, and campus priorities. For example, summer bridge programs may not work for student populations that rely on summer employment to earn money to pay for tuition or other college expenses. Campuses that started this way found that they struggled with purpose, outcomes, implementation, and measuring success and impact. They ended up going back to their vision, refining it, and conducting additional landscape analyses. These campuses often encountered problems with resources, expertise or data collection methods during implementation that caused them to go backwards in the Model to review their readiness. This resulted in significant delays and sometimes a loss of momentum.

Other common barriers encountered included:

• Faculty beliefs about their roles as “gatekeepers” or as the “sage on the stage” as opposed to “gateways” or as “guides on the side.”
• The need for building faculty expertise and capacity in evidence-based STEM education teaching and assessment methods.
• A misguided belief that a broader circle of faculty and staff have bought into the vision.
• Inadequate incentives and rewards for faculty participation in STEM reform projects.
• A lack of capacity for data collection and analysis in terms of support from centralized offices of institutional research.
• Inadequate planning to secure appropriate buy-in, approval, or support from relevant units, committees, or administrators.
• Inadequate resource identification or realization.
• Unforeseen political challenges, such as tension regarding department “turf,” resource, and faculty workload allocation.
• Shifts in upper level leadership leading to stalled support or redirection of efforts to new campus initiatives (e.g., quarter to semester conversion).
• Changes in team membership because of sabbatical leaves or other assignments.
• Failure to connect STEM reform vision at the departmental level to institutional priorities to get support.

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• Team members’ implicit theories of change that prevent them from engaging in parts of the model that they tacitly don’t believe in.
• Lack of consideration about how students will be made aware of the changes or new programs, as well as the rationale for them. In order for students to fully participate, they need to understand how they will benefit from the changes or new opportunities.
• Failure to examine all the implicit assumptions about the problem, possible solutions, and approaches.

Not considering these barriers can cause serious project delays. Some of these barriers can be identified as the team gets started and thus can be dealt with early; however, some occur unexpectedly during the process. Having a committed campus leader at the helm as well as a diverse and high functioning team can create an environment that will help to alleviate the potential setbacks and interruptions. Leaders, though, must be flexible and adaptable to respond to these developments and continue to focus the team on the goals and desired outcomes.

Implicit biases as barriers to the change process

In the end, we discovered that a model can be used to facilitate change because it outlines important steps and processes that must be addressed in order to lead to successful outcomes. However, we also discovered that using the model is more challenging than we expected. One key barrier was that the most significant reason teams struggled with the model is that they had their own implicit theories of how change happens. For example, a common assumption among STEM faculty is that meaningful change can only happen in departments. If faculty hold this belief, they will resist examining potential levers outside the department that may be important to address, such as mathematics preparation,
success in a prerequisite course in another department, or level of study skills.

Another common assumption we found is that change can’t happen without a large grant or other funding to support faculty buyouts to plan and prepare for change. If teams have this assumption (and it is usually unspoken), then efforts to come together and analyze data will often be sidetracked by discussions about funding limitations. The process may stall completely if grant applications are unsuccessful (Kezar, Gehrke, and Elrod, 2015).

Implicit biases can only be revealed through conversations about beliefs, values, and practices. Therefore, we encourage teams to make their first meeting a discussion about how change occurs and to make their implicit theories explicit. What makes this process hard is that their theories are often unconsciously held. Many people may not be able to articulate a theory of change or understand why they might be struggling with the model. It can help just to have a candid discussion among team members: “What do you think it will take to start an undergraduate research program here?” “Why do you think our underrepresented minority students are not retained at similar rates as majority students?”

If something is implicit, how do you go about changing it? First, we found that the initial discussions of the team should focus on issues around how change occurs including how they think it will occur. What actions should be taken? This allows these implicit assumptions to emerge and be debated as the team develops a common language. Second, we found that as people reviewed case studies of change it challenged their assumptions, and they began to change their views. Thus, we believe the case studies about change included in the publication will facilitate discussions about change processes so that team members can begin to articulate their own theories of change. We also had them start engaging in the change process, and this helped demystify the process and challenge beliefs. We provide excerpts from case studies that we hope help to make the change process more real. Reflecting on cases might help people to make their implicit theories explicit and therefore open to examination and change.

Meeting National STEM Reform Goals

We will not meet the ambitious goals set out national for STEM reform by continuing existing efforts. Research has emerged that demonstrates the importance of a broader vision of STEM reform for student success—moving from programs and departments to an institutional effort. The Keck/PKAL Model offers a tool for helping campuses work through a process to achieve their goals. We appreciate the efforts of our pioneering campuses that explored new territory—literally going where few colleges have gone before. We are convinced that campuses who use this resource and allow themselves to engage in what can be a messy process of change can create sustained and scaled efforts at STEM reform.

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