

## **Connecting Theory with Practice: Four Change Projects in Faculty Development for Engineering**

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## Introduction

This paper serves as an overarching guide linking four individual panel papers that describe how change makers connect change theory to practice in designing and implementing a change project. It also highlights resources to facilitate this linkage. The topic of change dominates discussions in higher education: change in leadership; change in teaching methods; change in organizational culture; change in processes, regulations, and requirements; change in programs; change in strategic direction; change in outcomes; change in student demographics. The list is near endless. An oft-heard sentiment is that the pace of change is either escalating or needs to escalate. Simultaneously, success stories seem more and more rare. The same problems persist, despite huge financial investments, huge personnel investments, and huge time investments.

More than ever, educators, higher education leaders, and also faculty development professionals must lead change-making efforts. A significant challenge that many change agents face is how to operationalize their theory of change. In other words, when the rubber meets the road, what does a theory-guided, agile, and successful change project look like? The collected papers in this panel session describe four major change efforts at institutions of varying type and mission, with different project goals and guiding theories, and with different levels of staffing and resources. Despite this variability, they collectively highlight lessons learned about connecting change theory to practice that all change agents can benefit from. Understanding their work is a step toward reducing the friction between theory and practice in change efforts and narrowing the gap between the immediate practical decisions that need to be made and the recommendations of change theory or validated change management practices.

This paper begins with a short primer on change theories in order to highlight the implications of choosing a specific guiding theory. We then focus specifically on change project examples that integrate theory and practice, reviewing them in order of project maturity. By connecting these examples to the existing literature in change practices and major change efforts in STEM education, we highlight commonalities in successes and challenges. Our attention then turns to assessment and how it can facilitate the implementation of a change theory in a change effort. We end with a comprehensive look at lessons learned on the part of panel contributors, extracted from their individual reports, and provide a handful of recommendations. Material supporting this panel of five papers (including additional resources and the panel session activities) is archived at <http://bit.ly/ChangeTheorytoPractice>.

## Primer on Change Theories

Discussions about change in higher education increasingly center on theories of change. In change efforts, a theory of change describes the why, how, who, what, with whom, when, and so on of a change effort. More specifically, it is a model that describes a desired future state, the current state, actions that cause a change to occur, and the relevant features of the system being changed. A theory of change links these items to create a strong picture of how the change will happen, how the outcome will be attributed to the change activities, and even exactly what

change activities need to occur. Theories of change are most well-known in the for-profit sector. For example, John Kotter's leading change model (Kotter, 2014) is regularly acknowledged as the authoritative work in change management. Similarly, Harvard Business Review regularly publishes articles focused on change management (see the excellent collection HBR's Must Read On Change Management, 2011). However, not all agree that business-oriented models are appropriate for higher education. These models have been adopted, adapted, and even rejected in the not-for-profit (Rosenbaum, More, & Steane, 2017), higher education (Buller 2014), and government sectors (Huerta Melchor, 2008; Ostroff, 2006). Though these scholars might reject business models of change, they nevertheless recognize the critical need for a specified theory of change. Connelly and Seymour (2015) put it best "Theories of change matter because they are usually implicit, and what remains unseen cannot be questioned." As change work becomes an integral part of higher education, the need for explicit models of change is also becoming a more integral part of the work of change agents.

For example, a change effort directed at increasing adoption of research-based instructional practices (RBIPs) might follow a diffusion of innovation change model (Rogers, 2003). The change agents would identify likely members of the adoption groups (e.g., early adopters or late majority) and create opportunities for each group to identify or demonstrate relative advantage, compatibility, ease of use, trial run opportunities, and positive outcomes - all elements of the diffusion of innovation model. At each stage, the work would be evaluated against the model and the project's desired outcomes. In contrast, that same change effort could adopt the Strategic Doing approach of collaborative, iterative, and agile work (Morrison, 2012). The change agents would implement work that is immediately responsive to current conditions, constantly reevaluate individuals' needs and challenges, and generate solutions and end-points unimagined at the beginning of the change effort, with would-be adopters as co-generators of the process. Again, at each stage, the work would be evaluated against the model and the project's desired outcomes. In both cases, the project could be a wild success or a dramatic flop, but the change agents will know why the outcome occurred. By having a theory of change to guide their work, change agents generate the information that leads to more successful future efforts.

Theories of change differ in multiple dimensions. A theory of change should address key questions like (adapted from Kezar, 2001): What are the forces driving change? What's the why? What is the degree of change being sought? In other words, is it evolutionary or transformational? What levels of relationship are influenced? What is the relevant time scale for the change? What aspects of the organization are the focus? Does the change seek to influence structures, human resources, symbols, or politics (Bolman & Deal, 2017)? Is the change proactive or reactive? How are process and outcomes described? Is the change effort active and inclusive of the recipients of change or accomplished by a few individuals acting on behalf? These questions highlight the underlying differences in change theories. For example, the change project described in the panel paper by Morelock, Walther, & Sochacka (2019) uses complex systems theory to guide the change effort. In this approach, components of a system (for example, individuals in a department) and the relationships among components are explored for both unique and emergent properties. Leverage points for change are identified, both internal to the system and external (for example, creating physical spaces that promote relationship development among faculty). Panel contributors Morelock, Walther, & Sochacka (2019) hypothesized that change in teaching practices would result from new relationships among

faculty around engineering education. In contrast, the work reported by panel contributors Nelson & Hjalmarson (2019) relies on the diffusion of innovation model. This approach focuses on individuals participating in a system, and their willingness to adopt and advocate an innovation. Change agents promote knowledge acquisition, decisive action, implementation of the innovation, and commitment to the innovation on the part of adopters. These examples illustrate how the theory of change adopted or created for a change effort dramatically influences the perspectives and processes the change agent uses.

As our understanding of the drivers and barriers to change increase, so too does our understanding that an intentional approach to change is necessary for success. As a consequence, change agents should adopt or build a theory of change in advance of change work. These decisions made in advance direct the activities of the change agents and recipients of change, and confirm that the right work is being done and the wrong work is being avoided.

### **Integrating Theory and Practice: Overview of Four Contexts**

This panel paper integrates the lessons of four panelist papers whose authors, institutions, goals, and change theories can be found in Table 1. This section presents a narrative that compares and contrasts the approaches of the four panelist papers to integrate theory with practice in their change projects. For a more detailed description of each context, we refer readers to each panelist paper, which can be accessed at <http://bit.ly/ChangeTheorytoPractice> .

**Table 1:** Overview of the contexts of the four panelist papers

<b>Contributors</b>	<b>Institution</b>	<b>Goal</b>	<b>Change Theory Used</b>
<b>Margherio et al. (2019)</b>	Multiple	Explain the team formation experiences of thirteen RED grant change project teams.	Kotter’s Leading Change Model
<b>Morelock, Walther, &amp; Sochacka (2019)</b>	University of Georgia	Create, operate, and communicate an engineering educational development program focused on fostering social capacity around teaching & learning.	Complex Systems Theory
<b>Harris (2019)</b>	University of Wisconsin-Madison	Engender institution-wide adoption of a new learning management system.	Kotter’s Leading Change Model
<b>Nelson &amp; Hjalmarson (2019)</b>	George Mason University	Create and sustain teaching development groups across six STEM departments.	Diffusion of Innovations Theory

How change agents adopt change can vary dramatically. For example, in a research context, use of theory can be premeditated and straightforward, particularly when a theory is specifically designed to address a particular aspect of a change project. One panel contributor team (Margherio et al., 2019) presents such a context in their analysis of early team-building experiences across thirteen NSF RED (REvolutionizing engineering and computer science

Departments) grant awardee teams. To examine these thirteen change projects from the lens of an outsider looking in, they used the six characteristics of guiding coalitions outlined by Kotter (2012) to conduct a post-hoc analysis of team-building experiences. By using theory as a means to explain events that occurred in the past, these authors were able to apply theory as a means to understand change project contexts without the need to adapt it in-the-moment as events unfolded. This approach was particularly valuable as a means to make sense of complicated team formation experiences through a retrospective lens and connect the studied teams' experiences to broader team-building narratives.

In practice-oriented contexts, change agents can utilize theories in many ways, and may find the relationship with theory is complex even early in a change project's evolution. Another panel contributor team (Morelock, Walther, & Sochacka, 2019) illustrates a broad range of theory utilizations in the early stages of their start-up, college-wide engineering faculty development institute (EFDI). In the two years since the institute's creation, they have used various facets of complex systems theory (Mason, 2009) to generate the institute's goals and values, pragmatically guide institute operations, and reflect upon how to communicate the institute's story to others. In each context, their theory manifested in different ways to meet their changing needs.

The engineering faculty development institute's story is not uncommon. As projects proceed and lessons learned compound to make change agents' relationship to theory more complex, theories being used must often be adapted and morphed. Another panel contributor (Harris, 2019) experienced such a need in their transition to a new learning management system (LMS) at a large, public university. They used Kotter's leading change model (Kotter, 2014) to manage the change project's guiding philosophy and initial plans, particularly with respect to forming cross-disciplinary partnerships that would facilitate widespread adoption of the new system. However, while in the field, some of these philosophies and plans needed to be changed as the change agents learned new lessons.

Sometimes, the realities of a change project require change agents to look beyond their theory for insights. In one such case, another panel contributor team (Nelson & Hjalmarson, 2019) used diffusion of innovations theory (Rogers, 2003) to define the structure of teaching development groups across six STEM departments. They selectively recruited leaders to these six groups on the basis of early adoption of evidence-based teaching practices and used voluntary participation to encourage faculty to make changes at their own pace. Although their theory provided the foundation for their change project, most of their major insights from the project were discovered when asking questions beyond the scope of the theory, such as observing why late adopters of evidence-based practices were attracted to the teaching development groups and how the groups evolved over time.

### **Synthesis of the Four Contexts and Resources from STEM Education Change Projects**

With a theory of change identified a priori, changemakers in the four projects described in this panel were able to identify and implement practices, identify opportunities, address evolving needs of stakeholder groups, and monitor progress towards their goals. In the panel contributors' RED teams analysis and LMS transition projects, the role of interpersonal relationships and group contexts were recognized in their theories of change, and changemakers in these projects

intentionally selected relational practices to support the change outcomes throughout the stages of the project. In the RED project, which currently is in an early stage, the practices of building and strengthening the teams have been part of their guiding coalition's framework from the start (Margherio et al., 2019). The LMS project, which is in its late stage, intentionally built relationships and partnerships with different stakeholder groups in phases, starting with partners (e.g., administrative leaders and faculty developers across units) and later with end-users (e.g., faculty and students). To build buy-in early on with influencers, the project leaders applied more direct approaches and interactions with the partners, who then could use practices specific to the needs of faculty and students in their units (Harris, 2019).

Change projects also can focus on faculty growth and change by developing reflective teachers, increasing awareness of RBIPs, and identifying common goals of the group directly (Henderson, Beach, & Finkelstein, 2011; Borrego & Henderson, 2014) as in the panel contributors' EFDI and faculty-led teaching development groups projects (Morelock, Walther, & Sochacka, 2019). Based on a diffusion of innovations framework, the voluntary teaching development groups were led by faculty early adopters or innovators who influenced departmental colleagues who were open to change (early participants of the project) and those motivated by specific teaching and student needs (later participants). In contrast, the EFDI context integrates the institutional (college office)-led and faculty-driven change practices through its complex systems theory that recognizes the interactions and interdependencies between components and activities across the college in its change strategies.

In addition to the contexts discussed in this and the four associated panel papers (Harris, 2019; Margherio et al., 2019; Morelock, Walther, & Sochacka, 2019; Nelson & Hjalmarson, 2019), four large-scale, long-term initiatives are highlighted here to provide example models and resources for the development, implementation, and assessment of change projects (see Appendix B). These examples have goals of sustainable change to widespread implementation of evidence-based and student-centered instructional practices in STEM and are in late stages (Table B.1). The frameworks and models developed in the AAU Undergraduate STEM Education Initiative (AAU), Project Kaleidoscope (PKAL), Vision and Change in Undergraduate Biology (V&C), and Science Education Initiative (SEI) focus on change at the department and/or institution levels (AAAS, 2011; AAU, 2015; Carey, 2015; Chasteen et al., 2015). The frameworks and models in these examples helped identify key components and strategies at the outset, with the enacted practice of these frameworks evolving over time to attain outcomes of sustained change in teaching using EBIS and in the culture around student learning. Key resources for changemakers and participants in change projects may be found from the implementation of these frameworks and models, which have resulted in guidebooks, analysis of applications of the frameworks across institutions, and lessons learned (Austin, 2018; Chasteen and Code, 2018; Chasteen et al., 2015; Elrod and Kezar, 2016; Kezar, 2018a).

### **Lessons Learned from the Four Contexts**

The four panelist papers (Harris, 2019; Margherio et al., 2019; Morelock, Walther, & Sochacka, 2019; Nelson & Hjalmarson, 2019) include several insightful lessons learned related to the use of theory in academic change project. We believe these insights to be a key contribution of this panel project to the extant faculty development literature. We found three lessons learned

spanning across multiple panelist papers; interested readers can find a variety of more project-specific lessons learned in the individual panelist papers.

One such lesson learned was that use of theory is not something that happens at a static point in a change project; it is an ongoing negotiation throughout the life of the project. One of the panel contributor teams (Margherio et al., 2019), using Kotter's characteristics of guiding coalitions, found that the characteristics manifested differently throughout the teamwork process across multiple change projects, and thus were ever-present factors in team dynamics. Another panel contributor (Harris, 2019) characterized three roles theory can play throughout the lifecycle of a change project: (1) to generate the project's mission, values, and initial philosophies; (2) to guide the project's operation; and (3) to reflect upon the project and communicate it to others. Use of theory to generate a project's initial philosophies was echoed by another panel contributor team (Morelock, Walther, & Sochacka, 2019).

Another common theme across panelists' lessons learned was the need to adapt one's use of theory to the continually evolving needs of one's faculty. Two of the panelist papers (Margherio et al., 2019; Nelson & Hjalmarson, 2019) noted that the faculty needs evolved as their projects continued, and that adapting their initial theory-informed principles and philosophies had to change accordingly so that the authors could continue supporting the faculty community as a whole. Another panelist paper (Morelock, Walther, & Sochacka, 2019) provided an example of using one's theoretical philosophy to inform how to adapt to roadblocks caused by changing faculty needs, particularly in being willing to forestall interesting projects in the name of better serving faculty members' new needs.

Finally, our panel contributors noted that relationships—either among faculty, among change agents, or between key partners—were a critical element that should be considered in academic change theory. One panel contributor (Harris, 2019) discussed cultural and relational changes as being more complex than technological changes in a learning technology change project, and noted that strategic relationship- and trust-building interactions between faculty developers and key partners across campus were essential to project success. Another panel contributor team (Morelock, Walther, & Sochacka, 2019) used a theory positing that the formation of new relationships around a desired goal lies at the core of systemic organizational change, and thus creating spaces for new relationships to take shape was one of the primary goals of their change project. In contrast, another panel contributor team (Margherio et al., 2019) found that the theory they used failed to take into account the importance of interpersonal relationships in team performance that they observed in their study.

### **Assessing the Implementation (Practice) of Theories of Change**

Assessment produces or indicates value, reports on the impact of projects, and helps guide within-context implementation of theoretical change models through all stages of a project. However, the high need for assessment in change projects is often paired with a low prevalence of formal assessment activity (Beach et al., 2016). To avoid this, a structured approach to assessment should be used from the very beginning, and conducted as an integral component of the entire project. During planning, assessment of “readiness for change” is critical (Reeves, 2009; Lehman, Greener, and Simpson, 2002; Combe, 2014; Lynch & Smith, 2016). Moving

through the project, assessment plans should be mindful of Banta et al.'s (1996) principle of assessment stating that "Assessment requires attention to outcomes, but also and equally to the experiences that lead to those outcomes". To do this, Hall (2013) argues that direct assessment of the extent of implementation in change projects is essential. Hall recommends applying three diagnostic dimensions of the Concerns Based Adoption model in a change project:

- Stages of Concern (SoC) address the personal side of change,
- Levels of Use (LoU) describe the different behavioral profiles of non-users and users,
- Innovation Configurations (IC) represent the possible operational forms of the change.

While a theory of change built in advance of change work directs the activities of the change agents, assessment confirms that the right work is being done and the wrong work is being avoided. It also can help to answer the question of why is or isn't a change project working. Addressing these issues productively requires an appropriate mindset for assessment. A growth-oriented assessment mindset seeks only to improve performance without judging the change agents or participants (Jensen, 2007). This approach is reinforced by using the **SII** model of assessment feedback (Wasserman & Beyerlein, 2007) where identifying **Strengths** (i.e., using evidence to confirm that the right work is being done) is the first step in assessment feedback. This is accompanied by identifying opportunities for **Improvement** that include specific action plans, and documenting **Insights** or lessons learned.

Several lessons about assessing change projects can be taken from our 4 panelist contexts. First, the fluid nature of group composition in a change project necessitates more than documenting the frequency and content of formal meetings. For example, "Interviews with group participants helped to tease out the different ways in which they ... continued to communicate." (Nelson & Hjalmarson, 2019). Next, creative assessment approaches are needed to address less tangible outcomes, such as assessing increased excitement around engineering teaching and learning during a project where simple headcounts at events are not sufficient. This led to a search for "new assessment techniques [such as social network analysis] to better capture the connectedness among engineering faculty as a result of their participation" in a change program (Morelock, Walther, & Sochacka, 2019). Similarly, theories of change may not account for all aspects of change. Assessment plans allowing for exploration of unexpected issues through open ended techniques need to be included in order for these elements to be discovered. Then, reporting on these items to the implementation team must occur in a timely fashion so that they can be attended to. For example, Margherio et al. (2019) found interpersonal relationships were missing in Kotter's framework, yet they underlie and amplify all characteristics of a guiding coalition. Thus assessment of "team building activities and getting to know each other on a personal level" became important. Assessment adaptations like these are facilitated when "the expertise of the social scientists and education researchers help discern which change strategies have supporting evidence and fit the context, in addition to what is reasonable for planning, implementation, and evaluation" (Margherio et al., 2019).

## **Conclusions and Recommendations**

As the accompanying four panelist papers demonstrate, effective change projects happen through a blend of intentional approaches to design and adaptable approaches in operation, where theories of change can play crucial roles in shaping both. Theory provides a means for change



agents to benefit from the collective wisdom of past change initiatives captured in the literature, and provides a structured way to generate projects and adjust course in the face of adversity. The four panelist papers exhibit multiple possible approaches to the use of theory in an academic change process. Looking across these cases and their lessons learned, we propose a handful of recommendations for change agents looking to implement change projects rooted in theory:

1. Select a theory of change that aligns well with your context and your modes of operation as a faculty developer. Our four panelist papers present a variety of change project contexts and theories of change to act as a starting point.
2. Derive a set of guiding principles or an initial philosophy for your change project. Your approaches to change will inevitably change to match the changing needs of faculty and other key partners; having guiding principles or an overarching philosophy will help steer you in productive directions as you face roadblocks without locking you into a single mode of operation based on your chosen theory.
3. Focus on developing relationships among your change agent team (if applicable) and among the faculty and key partners that are part of your change project. Robust relationships between actors played an important role in all four of the panelist cases, suggesting that they are essential to effectively engendering change.
4. Assess change as it occurs. Assessment is crucial to ensure that your change efforts are having the impact you intend, and for communicating the success of your change project to others. Theory can help define variables of interest and direct your assessment efforts.

In selecting an appropriate theory of change and drawing from the lessons learned from the four panelist contributor teams, we are confident that faculty developers can generate change projects that run smoothly and yield effective, observable results.

### **Panelist Papers**

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Nelson, J., & Hjalmarson, M. (2019). Insights into the Nature of Change and Sustainability in an Ongoing Faculty Development Effort. Proceedings of the 2019 ASEE Annual Conference Exhibition, Tampa, FL.

Harris, E. (2019). Change management in the transition to a new learning management system. Proceedings of the 2019 ASEE Annual Conference and Exhibition, Tampa, FL.

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## **Appendix A: Participant Activities During the Panel Session**

### **Activity 1: Workshop-style application of theories to participant context**

Title: Theory To Practice - Taking it Home

Why is this activity helpful for the learner?

Even when applying the same concept and with the same intentions, each context is unique. Therefore, thinking through critical pieces of a change project for your own context, and practicing sharing your ideas in a friendly environment before interacting with actual stakeholders, can be of great help in getting a project off the ground.

Time allotted: 20 minutes

Learning objective(s): By the end of this activity, participants will be able to

- choose a change theory and map its overarching framework to desired change in their own context
- articulate a variety of readiness characteristics to explore on one's own campus
- respond to potential concerns that might be raised, based on interaction with a colleague

Performance criteria:

- complete the change theory framework table using specific information from your own context to create a high level skeleton plan
- wear the hat of multiple likely change agent leaders on your campus in responding to a brief readiness assessment
- summarize your change project plan and readiness assessment results in 90 seconds or less for a partner
- respond thoughtfully with at least one strength, and either one area for improvement or one insight about your partner's plan

Instructions to participants:

- Private think time
  - choose a change theory
  - fill in the framework template with information for your context
  - respond to at least 2 of the items on the readiness assessment instrument
- Pairing
  - summarize your change project plan and readiness assessment response with your partner in 90 seconds or less
  - listen to your partner's summary
  - provide feedback to your partner using the SII format: at least one strength, and either one area for improvement or one insight about your partner's plan
- Sharing
  - be prepared to share the most valuable piece of information you discussed with your partner

Facilitation:

- walk around to individuals to offer feedback on documenting their ideas on the change theory application template and/or readiness assessment feedback form
- show a timer so participants can see how much time is being allotted for them to do the activity
- offer ideas for very small change projects common to our field that could help people at least learn to apply the change theory even if they don't have an idea of their own for a change project.

Sharing participant results:

- oral sharing from perhaps 2-4 pairs. Won't have time for many
- no assessment data is needed other than discussing how the activity went after we are done (what did people get stuck on, how far did they get, etc.)

Resources needed (course/other materials):

- 1 pg change theory application template worksheet (one for each theory presented in our paper)
- 1 pg readiness assessment instrument questions worksheet

Reflection/self-assessment prompt for closure:

- please take 30 seconds to write down the most salient information to you from sharing with your partner and listening to others share the most valuable thing they learned.

**Activity 2: Breakout Conversations - World Cafe Format**

Title: Change Project World Cafe - Leveraging Our Collective Experience

Why is this activity helpful for the learner?

Diversity of experience and perspectives enriches both dialogue and solutions. Here, we will take advantage of the diverse experience of participants to provide additional ideas for you to help frame your change project.

Time allotted: 20 minutes

Learning objective(s): By the end of this activity, participants will be able to

- add 2-3 questions or ideas to enrich the thinking represented on your initial change project framework worksheet
- integrate multiple perspectives around several key questions that can guide change projects

Performance criteria:

- respond thoughtfully to the facilitator prompts guiding discussion in the cafe, for the benefit of the group
- add relevant ideas to the change theory framework worksheet you completed earlier

Instructions to participants:

- Choose a cafe table
- Listen for the discussion prompts offered by your facilitators at each table
- Offer responses to the prompts that can be tied to specific details in contexts you have experienced
- Work with your group to share your top insight gained from the conversation
- Move to the next table when prompted

Facilitation:

- walk around to groups to intervene on processes that might be impeding good group dynamics, or to rephrase prompts to direct conversation in a useful direction
- show a timer so participants can see how much time is being allotted for them to do the activity
- leave enough time for each facilitator to share the top insight(s) produced at their table

Sharing participant results:

- oral sharing from each table facilitator - just their top 1-2 insights depending on time.
- no assessment data is needed other than discussing how the activity went after we are done (how easily did participants begin responding to the prompts, how engaged were they, etc.)

Resources needed (course/other materials)

- 1 pg change theory application template worksheet from earlier
- 1 pg readiness assessment instrument questions worksheet from earlier

Reflection/self-assessment prompt for closure

- Session assessment form

## **Appendix B: Key resources of Change Theories to Practice**

In addition to the contexts discussed in this and the four associated panel papers (Harris, 2019; Margherio et al., 2019; Morelock, Walther, & Sochacka, 2019; Nelson & Hjalmarson, 2019), four large-scale, long-term initiatives are highlighted here to provide example models and resources for the development, implementation, and assessment of change projects. These examples have a goal of sustainable change via widespread implementation of evidence-based and student-centered instructional practices in STEM (Table B.1). These frameworks were developed and used to effect change not only in one department but across one or multiple institutions and disciplines. The frameworks developed in the AAU Undergraduate STEM Education Initiative (AAU), Project Kaleidoscope (PKAL), Vision and Change in Undergraduate Biology (V&C), and Science Education Initiative (SEI) focus on change at the department and/or institution levels. Through the frameworks, individual participating departments or institutions design change projects that are specific and relevant to their own contexts, with common goals around evidenced-based teaching across projects within the initiative. The scope of PKAL, V&C, and AAU includes national organizations (e.g., AAU, AAC&U, AAAS) as leaders guiding the efforts, with the capacity to convene and coordinate stakeholders across institutions and organizations, and support through funding from federal agencies and private foundations. In contrast, the SEI was a model originally developed and supported within an institution and was implemented at two institutions (University of Colorado Boulder and the University of British Columbia).

The frameworks and models in these examples identified key components and strategies for change at the outset, with the enacted practice of these frameworks having evolved over time to attain the goals of sustained change in teaching using RBIPs and in culture around student learning. PKAL and V&C are long-standing initiatives, with histories of activities over 30 years for PKAL and over 12 years for V&C. As they grew, capacity building, support structures, and networks grew. While an early focus of PKAL efforts and project funding was the implementation of the framework and its components with a set of eleven institutions and systems in California (Carey, 2015), PKAL has grown to include PKAL Regional Networks and meetings across the U.S., PKAL Leadership Institutes, and a PKAL guide to document effective practices of the model for sustained STEM undergraduate education change (Elrod and Kezar, 2016). V&C also leveraged networks to expand curriculum and pedagogy change across the biology community, such as PULSE and ongoing regional and national disciplinary meetings. AAU started with a funded cohort and then quickly included a network of AAU institutions when interest grew (Kezar, 2018a), with AAU leading in coordinating the STEM Network (Kezar, 2018b). SEI spanned over ten years and resulted in resources broadly disseminated and propagated to assist instructors in adopting RBIPs, Discipline-Based Education Specialists (DBESs) in supporting instructional changes, leaders in implementing departmental change, and measuring shifts to increased active learning (Smith et al., 2015; Chasteen and Code, 2018). Key resources for changemakers and participants in change projects may be found from the implementation of these frameworks and models, which have resulted in guidebooks, analysis of the applications of the frameworks across institutions, and lessons learned (Austin, 2018; Chasteen and Code, 2018; Chasteen et al., 2015; Elrod and Kezar, 2016; Kezar, 2018a).



**Table B.1: Summary of large-scale education change initiatives**

<b>Initiative</b>	<b>Vision and Change in Undergraduate Biology (V&amp;C)</b>	<b>Project Kaleidoscope (PKAL) STEM Education Effectiveness Framework</b>	<b>Science Education Initiative (SEI)</b>	<b>AAU Undergraduate STEM Education Initiative</b>
<b>Goals</b>	Improve teaching and learning of undergraduate biology nationwide	“Develop a comprehensive, institutional model to help campus leaders plan and implement evidence-based reforms geared toward improving student learning and success in STEM into scalable and sustainable actions” (Elrod 2015)	“Change departmental teaching practices and culture, aiming for a majority of faculty in departments to use and sustain research-based instructional practices” (Chasteen & Code 2018), with emphasis on active learning	“To influence the culture of STEM departments at AAU institutions so that faculty members are encouraged and supported to use teaching practices proven by research to be effective in engaging students in STEM education and in helping students learn.” (AAU)
<b>Scope</b>	Undergraduate biology discipline broadly	11 California-based institutions and later more institutions and multiple regional networks	Two institutions (University of Colorado Boulder The University of British Columbia) with 6 departments + 1 pilot at each institution	Eight institutions with 39 departments total and STEM Network (AAU member institutions)
<b>Framework and components</b>	Recommended specific actions: “integrate core concepts and competencies throughout the curriculum; focus on student-centered learning; promote a campus wide commitment to change; and engage the biology community in the implementation of	Establish vision, examine landscape and conduct capacity analysis, identify and analyze challenges and opportunities, choose strategies/interventions and leverage opportunities, determine readiness for action, implementation,	Framework and components: Discipline-Based Education Specialists (DBES), department grants. Funded by institutions.	Framework with the components of pedagogy, scaffolding, cultural change, available. Institutional grants available

	change” (AAAS 2011)	measure results, disseminate results and plan next steps. Institutional grants available		
<b>Theories of change</b>	(Not explicitly stated) elements of Kotter’s guiding coalitions - leadership (national and institutional), networks, diffusion of innovations	Individual projects at institutional level rather than departments (context of local vision and challenges)	(Not explicitly stated) diffusion of innovations via Discipline-Based Education Specialists (DBESs)	Open-system theory of change with multiple theories: institutional theory/influence, networks, organizational learning, culture change, political theories, systems theory
<b>Who’s involved</b>	Professional and funding organizations (AAAS, HHMI, NIH, NSF, USDA), campus leaders, faculty	Campus leaders, chairs and deans, faculty, AAC&U PKAL center, funding organizations	Initiative leaders, department chairs, DBESs, faculty	STEM Network of AAU member institutions, AAU
<b>Implementation and Practice</b>	PULSE (Partnership for Undergraduate Life Sciences Education) and meetings to guide department-level implementation of recommendations, Vision & Change Rubrics	Empower faculty and leaders through PKAL Leadership Institutes, PKAL regional networks & meetings, PKAL guide (Elrod & Kezar, 2016), PKAL strategic plan (AAC&U, 2017)	Disseminate results and products (COPUS, handbook for leaders and DBES)	Added STEM Network to broaden reach, reports (role of organization, status update)