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

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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.

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?

Table 1. Change Agent Questions Related to Change Characteristics

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.

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.

Stage	Strategies suggested by CACAO Model	Examples of Application During PERSIST
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.

Table 2. Change Agent Strategies Related to Faculty Adoption Stages

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.*

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)

CICS Item	2014 Survey Results M (SD)	2018 Survey Results M (SD)
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)

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

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

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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

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