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8

Applying the CACAO Change Model to Promote Systemic Transformation in STEM

Anthony Marker, Patricia Pyke, Sarah Ritter, Karen Viskupic, Amy Moll, R. Eric Landrum, Tony Roark, and Susan Shadle

CONTEXT

Since its inception in the Middle Ages, the university classroom can be characterized by students gathered around a sage who imparts his or her knowledge. However, the effective classroom of today looks vastly different: First-year engineering students not only learn basic engineering principles, but are also guided to consider their own inner values and motivations as they design and build adaptive devices for people with disabilities; students in a large chemistry lecture work animatedly together in small groups on inquiry-based activities while an instructor and teaching assistants circulate and guide their learning; students learning differential equations practice explicit metacognitive skills while problem-solving in class. Even though educational research, especially research that is targeted at STEM disciplines, demonstrates what most effectively engages students and supports their learning, many of today's classrooms look much like they did a century ago, with a professor delivering a primarily one-way lecture and students passively sitting in seats bolted to the floor. At this juncture in history, colleges and universities face a public call to engage a more diverse representation of students in effective learning, persistence, and degree attainment, and to do so economically and efficiently. It is essential that institutions draw upon methods demonstrated to effectively increase student learning and success. Educational researchers have thoroughly explored the "basic" science in this area, and a body of literature documents effective evidence-based instructional practices, hereafter referred to as EBIPs.

Although EBIPs are well documented, we know far less about how to shift faculty practice and institutional culture to catalyze widespread adoption of these practices. "Applied research" is the current frontier, as propagating EBIPs has proven remarkably challenging, whether across institutions, across campus, or even down the hall in the same department. The National Science Foundation (NSF), a driving force and primary sponsor of STEM education research,

has called for wider propagation of EBIPs. NSF's solicitation for the Widening Implementation and Demonstration of Evidence-Based Reforms (WIDER) program notes that "Despite the myriad advances in STEM teaching and learning know-how, it is the sense of policy makers and practitioners (and evident in accounts published in articles in academic journals) that highly effective teaching and learning practices are still not in widespread use in most institutions of higher education" (NSF, 2013, para. 67).

For this reason, identifying and assessing effective change strategies has moved to the forefront in STEM education, as evidenced by increasing scholarship activity in this area. Higher education researchers are exploring networks and other organization-level dynamics, such as "mutual adaptation and social movements [that] create ownership, sustainability, depth of adoption and spread" (Kezar, 2011, 241). Discipline-based education research has been a focus (National Research Council, 2012), and disciplinary societies are investing in propagating EBIPs. For example, since 2002 the American Physical Society and The American Astronomical Society have joined with the American Association of Physics Teachers to support, with NSF assistance, training on effective teaching for new physics faculty (AAPT, 2014). Similarly, the American Chemical Society and Research Corporation for Science Achievement provide Cottrell Scholars Collaborative (CSC) workshops for new faculty to "promote transformative change through the exploration of new pedagogies and the dissemination of proven methods. . . ." (CSC, 2014, para. 1). In geosciences, the On the Cutting Edge professional development program managed by the National Association of Geoscience Teachers (NAGT) has provided training and resources for early-career and experienced instructors through virtual and in-person workshops since 2002 (NAGT, 2015). In a special issue on transforming STEM education, guest editors for the *Journal of Engineering Education* noted that the prevailing focus of STEM educators has been on course- or curricula-level changes, and suggested new discussion "has laid some foundation for others to take the next steps and fully launch into systemic inquiries, studies and analyses of the complexities of educational transformation" (McKenna, Froyd, & Litzinger, 2014, 189).

CACAO CHANGE FACILITATION MODEL

At Boise State University, we are engaged in a project that seeks a complex, systemic solution to widespread adoption of EBIPs. This ambitious three-year project aims to identify and reduce institutional barriers to EBIP adoption across more than a dozen departments. The project was initiated in response to the NSF WIDER invitation to propose and test models to effectively support

broader propagation of EPIBs and to achieve an ultimate outcome of increasing student success. Our project, WIDER PERSIST—Promoting Education Reform through Strategic Investment in Systemic Transformation, asks: Can we apply a change facilitation model from the business world to implement EBIPs more widely throughout a higher education institution? The facilitation model we chose recognizes instructional practice as only one element of the instructional climate. Other elements include institutional policies on workload and tenure and promotion, department traditions, social networks, institutional structures such as centers for teaching and learning, and faculty associations, institutional leadership, facilities, resources and other variables. Another key element of this model is that it is consistent with and allows us to leverage pedagogical transformations already underway.

The model, Dormant's **C**hange, **A**dopters, **C**hange **A**gent, **O**rganization (CACAO) model (Dormant, 2011), is a synthesis of Rogers' work (2003) on the diffusion of innovations (passive) and the work of Kotter (1990) on the purposeful implementation of designed changes (active). Dormant's model does the important work of helping us integrate and apply these concepts. She combines the approaches suggested in Rogers' work, which tends to look at change from the bottom or middle and up, and Kotter's work, which looks at change from the top down, into a single model. The model enables people using it to develop customized and purposeful change plans that take into consideration the:

- Benefits and drawbacks of the change itself
- Audience (adopter) characteristics
- Stages people go through in accepting or rejecting a change, and appropriate strategies for each stage to smooth adoption
- Leadership support and social networks that allow the group to find the right change champions
- The change agent's relationship to the change
- The creation of a well-rounded change team that is both proactive and responsive

The CACAO model provides a series of steps and strategies to guide a team toward achieving a particular change. We describe how we have applied several specific aspects of the model and our year one results. The four dimensions around which the model is organized are Change, Adopters, Change Agents, and Organization:

Change: First, the model dictates the value of collecting information about how adopters view the change. Dormant specifies the need to examine five characteristics. This examination, when complete, provides a profile that

illustrates how likely adopter groups are to resist the change, and the areas in which resistance is likely to occur. As a result, the change profile provides a way of anticipating and mitigating resistance by developing strategies that make the most of the change's strengths and counteract the change's weaknesses. Those characteristics are:

Relative Advantage: the extent to which the change offers adopters advantages over the old way of doing things
Simplicity: the extent to which adopters can understand the change
Compatibility: the extent to which the change is consistent with adopter past practices
Adaptability: the extent to which adopters can adapt the change to fit local conditions
Social Impact: the extent to which the change will have little or no impact on existing social relations of the adopters.

Adopters: Second, the model looks at the stages of adoption that intended adopters typically go through when considering whether or not to implement a change. It specifies the importance of matching strategies to stages, and then provides specific strategies to most efficiently address each adoption stage (Table 1). The model further suggests that different adopter sub-groups, in this case different academic departments and groups within departments, are likely to be in different stages of adoption, mandating tailored strategies for each group.

TABLE 1. Strategies to Support Adopters

For adopters entering this age	Strategies to support adopters in this stage
Awareness	Advertise (brief)
Curiosity	Inform (detailed)
Mental Tryout	Use demonstrations
Hands-on Tryout	Provide training
Adoption	Provide support

Change Agents: Third, the model offers prescriptions for putting together an effective leadership team that includes members with expertise as organizational sponsors, content experts, change experts, grant experts, data collection and analysis experts, communication experts, training experts, and others as various needs arise.

Organization: Fourth, the model helps elucidate how to identify and manage layers of organizational hierarchy and then leverage networks of people for different roles during change implementation. The model identifies as particularly

valuable people who can fulfill the roles of leadership sponsors, early acceptable innovators, opinion leaders, and traditionalists as groups that can potentially provide separate perspectives and valuable contributions. Identifying people who fit these roles and then using their contributions when and where they can most benefit the project is a crucial aspect of the change model.

CHANGE ANALYSIS: DEFINING AND UNDERSTANDING THE CHANGE

In the first year of our project, we have worked to define the change we seek and have worked with adopters to lay the groundwork for successful institution-wide change in the subsequent years of the project. One of the first tasks of the leadership team on our project was to define and communicate the intended change by developing a vision statement. This was important for two reasons: First, it provided a target against which to judge progress; and second, it served to guide task and strategy prioritization. The goal, in the case of the WIDER PERSIST project, was to increase the rate of implementation of EBIPs among university STEM faculty by directly supporting faculty and changing the culture surrounding teaching practices. By focusing on changes in the instructional culture, the project is able to encourage systemic changes, rather than strategies that simply change individual faculty behavior. Although cultural change requires a slower adoption process, it ultimately encourages sustainable practices in the long-term. Our WIDER PERSIST leadership team expressed the vision as an "end state," a new norm toward which the campus could collectively progress. The vision is that:

> The culture of teaching and learning at Boise State University 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, and
> - teaching evidenced and informed by meaningful assessment.
>
> We believe the fulfillment of this vision will enhance our learning-centered culture and result in increased student achievement of learning outcomes, retention, and degree attainment; especially among underrepresented populations.

In order to both introduce the proposed change to faculty and to collect information from them about their view of the goals, we undertook extensive data collection early in the first year of the project. Doing so has informed the development of departmental change profiles; these profiles assisted us in evaluating progress and prioritizing decisions. As described earlier, when we introduced the CACAO model's four dimensions of change, change profiles provide information about perceived strengths and weaknesses of the change that might lead adopters to resist or embrace adoption. To this end, we held 17 one-hour focus groups with the staff and faculty of academic STEM departments, as well as with groups of department chairs and deans, ultimately involving a total of 194 participants. During the focus groups, participants were introduced to the vision and completed a questionnaire in which they identified and listed factors that either supported or opposed the change for each of five characteristics of change adoption (Table 2). Participants were given 5–7 min per characteristic to independently record their thoughts, which were then discussed as a group.

TABLE 2. Change Protocol: Faculty Discussion Group of the Strengths and Weaknesses of the End Etate (Vision)

Factor	Discussion Prompt
Relative Advantage	1a. Ways in which this end state is advantageous to me/my department 1b. Ways in which this end state is disadvantageous to me/my department
Simplicity	2a. Features of our current environment & practice that make this end state easy/simple to attain and/or maintain 2b. Features of our current environment & practice that make this end state hard/complex to attain and/or maintain
Compatibility	3a. Ways in which the end state is compatible with what I already do 3b. Ways in which the end state is incompatible with what I already do
Adaptability	4a. In what ways might the end state allow for flexibility and individual choice (while still achieving the vision)? 4b. In what ways might the end state limit flexibility and individual choice in order to achieve the vision?
Social Impact	5a. How will the new end state positively impact my relationships (with colleagues, with students, with administrators, etc.)? 5b. How will the new end state negatively impact my relationships (with colleagues, with students, with administrators, etc.)?

We collected data from the faculty focus groups, which resulted in the compilation of a qualitative dataset with 1,755 drivers (positive factors) and 1,605 restrainers (negative factors) for change. The faculty results provided us with a universal set of characteristics as well as data to develop profiles and priorities for individual departments.

After our team collected the data, four researchers independently coded the barrier data according to an organizational change analysis model intended to identify the root causes of performance gaps between current practices and our envisioned goal, Gilbert's (1978) Behavior Engineering Model (BEM). The BEM (Table 3) is a 2 x 3 matrix which divides the causes for performance gaps into two main sources (rows), those originating in the environment, and those originating with the user.

For each of those sources, the model provides three types of causal areas (columns): information, instrumentation (tools), and motivation. Causes appearing in the environment are more directly under control of university leadership and can be easier to address compared to those that reside in individual adopters. Our team further categorized the causes that surfaced during our analysis as 18 commonly perceived themes (Figure 1). The majority of these themes have to do with issues of time, alignment to current assessment and metrics, classroom autonomy, resources, research-teaching balance, and institutional reward. These barriers align well with those that other research studies have previously identified and documented (Brownwell & Tanner, 2012; Henderson & Dancy, 2007; Walczyk, Ramsey, & Zha, 2007). Importantly, having the local data for our institutional context has provided the WIDER leadership with information we have used to begin devising appropriate support strategies for adopters by removing obstacles. These themes also provide fodder for discussion within departments about the barriers that impact local EBIP adoption.

TABLE 3. Behavior Engineering Model

	Lack of Information	Lack of Tools	Lack of Motivation
Causes originating in the **Environment**	✓ Data ✓ Expectations ✓ Feedback ✓ Clarity	✓ Resources ✓ Technology ✓ Space (classrooms) ✓ Tools ✓ Support ✓ TAs/Instructional support	✓ Consequences ✓ Rewards ✓ Incentives
Causes originating in the **Person**	✓ Knowledge ✓ Skills	✓ Physical capacity (incl. time) ✓ Mental capacity ✓ Flexibility ✓ Resilience	✓ Motives ✓ Affect ✓ Work habits ✓ Drive

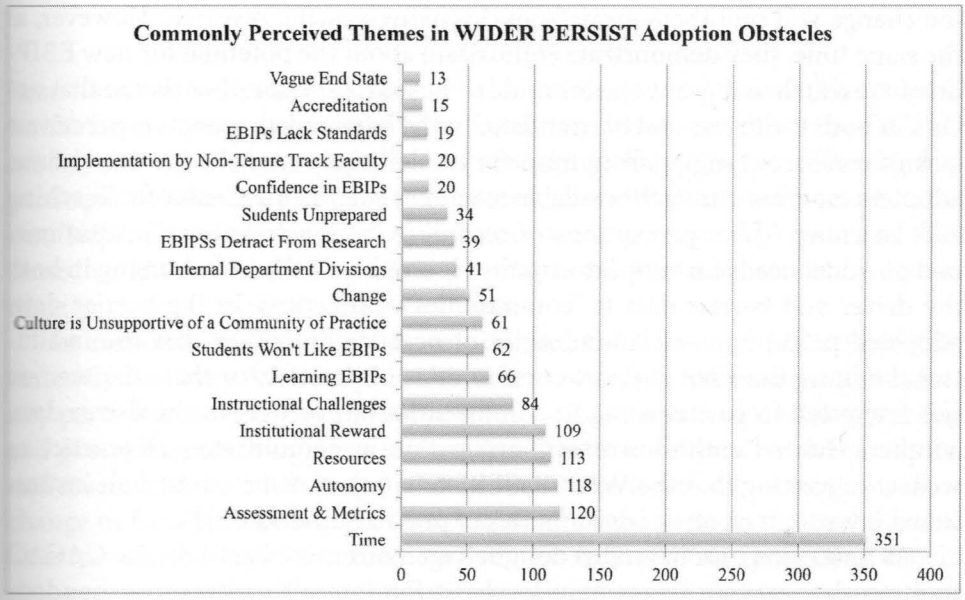

FIGURE 1: Barriers to change. Bars represent total number of faculty comments categorized in that theme.

Fortunately, in addition to change obstacles, there are very often positive drivers that encourage change. Our team is currently in the preliminary stages of analyzing these drivers. As there seems to be less research on drivers in the literature that there is on barriers, this analysis has the potential to contribute methods for accelerating change by supporting such drivers. At this early stage of analysis, the commonly recurring themes are:

- Increased opportunities for research
- Recognition of resources in place, e.g., Center for Teaching and Learning
- Enthusiasm about sharing ideas within and across departments and establishing or continuing development of communities of practice (Murray, Higgins, Minderhout & Loertscher, 2011)
- Improved student outcomes—learning, retention, graduation
- Potential for better prepared students in the classroom (engaged, participatory, and background knowledge) and workplace
- Professional recognition—becoming model departments at the university and national level

Additionally, there are a few themes that occur as both drivers and barriers. For example, potential adopters see "research" as a barrier since implementing

the change will pull them away from discipline-specific research. However, at the same time, they demonstrate enthusiasm about the potential for new EBIP-driven research and grant opportunities. "Resources" is another theme that occurs in both the driver and barrier data. In the barrier data, adopters perceive a lack of resources ranging from monetary to lab equipment. In the driver data, adopters mention currently available resources such as the Center for Teaching and Learning. These perceptions of resources demonstrate both institutional and personal needs for support. Another example of a theme occurring in both the driver and barrier data is "communities of practice." In the barrier data, adopters' perceptions of communities of practice are either that the institutional culture does not support communities of practice, or that adopters are not interested in participating in communities of practice. In the driver data, adopters showed enthusiasm for participation in communities of practice as well as suggesting that the WIDER PERSIST project demonstrated an institutional interest in creating communities of practice around EBIPs.

As a next step, we have also designed an instrument based on the CACAO framework to explore department-level distributions of faculty across the adoption process. A discussion of this adopter analysis is beyond the scope of this paper and will be reported in future publications. Together, these analyses position the project team to respond to results by addressing barriers and supporting drivers. See Figure 2.

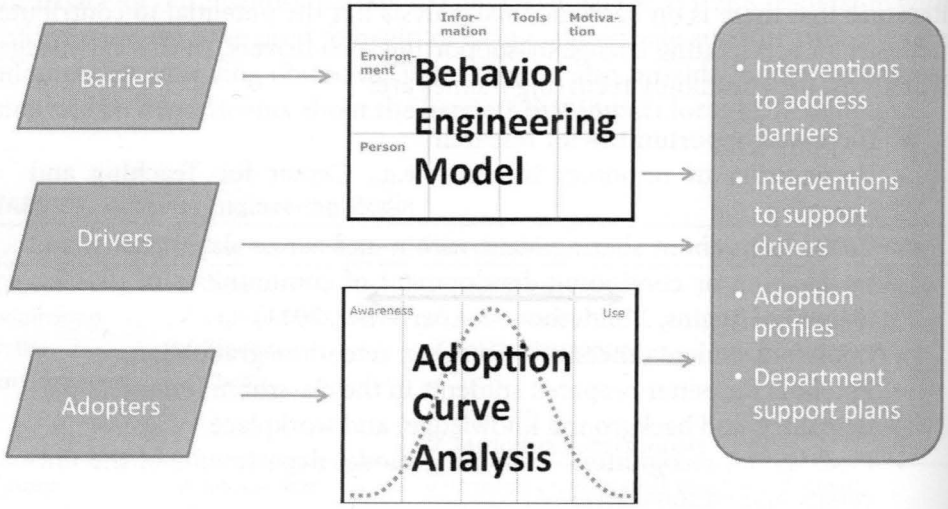

FIGURE 2. Addressing Barriers and Supporting Drivers

RESPONDING TO RESULTS

In an ideal scenario, one might prefer to have collected and thoroughly analyzed results before using them as the basis for action. However, within the CACAO model, data collection is actually part of making change happen. Focus group participants (who are prospective adopters) have demonstrated interest in the next steps. Therefore, it made sense for our team to respond to results as they came in and to refine the analysis as we progressed. We have been and will continue to respond to results in several ways.

In response to early results, we designed the Current Instructional Climate (CIC) survey. We used this instrument to collect information about faculty perceptions regarding the support for various aspects of teaching (valuing and promoting teaching, institutional conditions, unfettered teaching culture, and teaching-research balance) and in the future it will allow us to measure change in faculty attitudes. We constructed all of the items in the survey based on responses (both positive and negative) that emerged from collecting data in change conversations. For example, respondents in our change conversations indicated that the lack of appreciation for teaching in hiring decisions is a barrier to achieving the widespread adoption of EBIPs. In response, we crafted the following item for the CIC, answered using a seven-point semantic differential format: "I believe that the campus culture does not value teaching ability in hiring decisions" to "I believe that the campus culture does value teaching ability in hiring decisions." The instrument is designed to be directly sensitive to the particular barriers and drivers cited by faculty in the change conversations because CIC items were derived directly from faculty member comments. Further, we've administered our CIC instrument along with Western Michigan University's Postsecondary Instructional Practices Survey (Beach, Henderson, Walter & Williams, n.d.), which provides complementary information about how faculty perceive their current teaching practices.

Another way we've used the results is to look carefully at barriers and drivers to achieving our sought-after change. Doing so has allowed our project team to identify strategies that we think will help address particular barriers or leverage specific drivers. Several examples of this approach are summarized below (Table 4).

TABLE 4. Responding to Barriers and Drivers

Barriers	Drivers	Planned Strategy
Time		Provide teaching reductions for course redesigns; provide direct faculty development support
Uncertainty about EBIPs		Offer workshops tailored to EBIPs in particular disciplines; provide discipline-specific references and resources
Resources of classroom or materials		Influence university classroom planning/ renovation process
Lack of incentive and recognition		Provide "toolkit" to tenure and promotion committees
	Interest in communities of practice	Support specific opportunities for inter and intradepartmental conversations around teaching
	Support for the outcome of increased student success	Create a "data team" to work with institutional research in order to help departments better understand how their students are doing within courses and in follow-on courses; support faculty assessment efforts
	Recognition	Create "faculty spotlight" videos to highlight faculty who are effectively implementing EBIPs

LONG-TERM VISION AND NEXT STEPS

As expressed in the vision statement, the ultimate reason for seeking change in instructional climate is to increase student achievement of learning outcomes, retention and degree attainment. To that end, a main focus of the WIDER PERSIST leadership team effort and energy in the first year has been on working with faculty teams to implement EBIPs broadly across departments, working with university leaders to remove barriers and provide support, and putting in place systems for measuring progress. Future work and subsequent publications will describe our data collection and analysis in more detail and address the ways in which our data has been used to drive change. Involving institutions beyond Boise State University is also a major goal of the project, and the team welcomes contact from other institutions interested in applying the CACAO model on their campuses.

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REFERENCES

American Association of Physics Teachers (AAPT). (2014). *Workshop for new physics and astronomy faculty.* College Park, MD: American Association of Physics Teachers. Retrieved from http://www.aapt.org/Conferences/newfaculty/nfw.cfm

Beach, A. L., Henderson, C., Walter, E. M. & Williams, C. (n.d.). *Postsecondary instructional practices survey (NSF #1256505).* Kalamazoo, MI: Western Michigan University.

Brownell, S. E. & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and . . . tensions with professional identity? *CBE-Life Sciences Education, 11,* 339–346.

Cottrell Scholars Collaborative (CSC). (2014). *CSC New faculty workshop.* Retrieved from http://chem.wayne.edu/feiggroup/CSCNFW/cottrell-scholars-collabora.html

Dormant, D. (2011). *The chocolate model of change.* San Bernadino, CA: Author.

Gilbert, T. F. (1978). *Human competence: Engineering worthy performance.* New York, NY: McGraw-Hill.

Henderson, C., & Dancy, M. (2007). Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Physical Review Special Topics: Physics Education Research, 3,* 020102-1–020102-14.

Kezar, A. (2011). What is the best way to achieve broader reach of improved practices in higher education? *Innovative Higher Education, 36,* 235–247.

Kotter, J. (1990). *A force for change: How leadership differs from management.* New York, NY: Free Press.

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

Murray, T.A., Higgins, P., Minderhout, V., & Loertscher, J. (2011). Sustaining the development and implementation of student-centered teaching nationally: The importance of a community of practice. *Biochemistry and Molecular Biology Education, 39,* 405–411.

National Association of Geoscience Teachers (NAGT). (2015). *On the cutting edge: Strong undergraduate geoscience teaching.* Retrieved from http://serc.carleton.edu/NAGTWorkshops/index.html

National Research Council (NRC). (2012). *Discipline-based education research: Understanding and improving undergraduate learning in science and engineering.* Washington, DC: Author.

National Science Foundation. (2013). Widening implementation and demonstration of evidence-based reforms (WIDER). *Program Solicitation #NSF-13-552.* Washington, DC: Author. Retrieved from http://www.nsf.gov/pubs/2013/nsf13552/nsf13552.htm

Rogers, E. (2003). *Diffusion of innovations* (5th ed.). New York, NY: Free Press.

Walczyk, J. J., Ramsey, L. L. & Zha, P. (2007). Obstacles to instructional innovation according to college science and mathematics faculty. *Journal of Research in Science Teaching, 44,* 85–106. doi:10.1002/tea.20119

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