Studying Organizational Change and Learning: Rigorous Attention To Complex Systems Via A Multi-theoretical Research Model

Abstract

A growing body of research explores how education interventions meant to transform STEM faculty teaching practices are “taken up” by postsecondary educators and their organizations. We drew on intervention-specific literature, and that pertaining to studying change in organizations writ large, to explore how might we rigorously and completely study organizational change in response to postsecondary STEM education improvement interventions? In response to a targeted literature review, we detail the design of a multi-theoretical research model that remedies noted ontological, epistemological, and methodological limitations to studying change in postsecondary organizations. We ascertain our research model’s usefulness by addressing the following question: What is the potential for organizational change at a research university with respect to a campus-based STEM improvement initiative? The initiative we study is towards greater adoption of evidence-based instructional practices (EBIPs) in large enrollments introductory STEM courses via faculty disciplinary and interdisciplinary collaborations. We describe the data and analytical methods that allow us to ascertain the relative prevalence and strength of certain factors indicative of potential for organizational learning, underlying theories of action of many STEM education improvement initiatives. We reflect on the feasibility of applying the theoretical lenses to study and improve other initiatives to improve and study postsecondary STEM education.

Impetus for Our Research:

Attempting Rigorous Study of Complex Postsecondary Systems and Change

Our research questions are prompted by an interest in understanding a campus-based postsecondary STEM education improvement initiative. The initiative we examine targets increasing the adoption and adaptation of EBIPs in large-enrollment, introductory-level STEM courses. Students in the targeted courses attend lectures that vary in size from 80 to 400 students, depending on the discipline. Interactive engagement with frequent formative feedback is the EBIP educators are adopting and adapting in the lectures. However, in these courses, students also attend labs, recitations, discussion groups or studios, structures that accommodate fewer students. In these sections, the initiative encourages cooperative learning in small groups. Primarily non-tenure line faculty members teach the lecture sections in science and mathematics, although this is not as common in engineering. Graduate teaching assistants typically facilitate the learning in the smaller-class-size course structures. The change initiative’s theory of action posits that the adoption and adaptation of EBIPs will increase as educators participate in both disciplinary and inter-disciplinary learning communities. The project either created learning communities or fostered further development of learning communities already emergent at the start of the project. In addition, the theory of action also seeks to synergize with other STEM education initiatives on campus and to build on or modify other organizational structures that influence students’ experience in the introductory STEM courses. Central to this theory of action are assumptions meant to improve postsecondary education, including change.
in knowledge creation, both by individuals and their organizations. The initiative assumes that faculty members have critical agency (Baenziger, 2002), that is they are capable of leading STEM education transformation by capitalizing on and challenging organizational norms to facilitate meaningful change (Bouwma-Gearhart, 2012a, 2012b). The project intends to foster the co-establishment of new routines towards STEM education improvement that build on and attend to the social resources within the institution (Resnick & Spillane, 2006) by bringing together the people with pertinent teaching and content knowledge and people with positional administrative power using a distributed leadership model (Bouwma-Gearhart, Perry, & Presley, 2012).

A growing body of research explores how education interventions meant to transform STEM faculty teaching practices are “taken up” by postsecondary educators and their organizations. Interventions include comprehensive initiatives, accountability policies, and other tools, such as attending to student evaluation of teaching (Coburn & Turner, 2011). A number of organizational factors have been identified as barriers to faculty adoption of evidence-based instructional practices (EBIPs) at the core of many postsecondary STEM improvement interventions. These include norms of governance and autonomy (Eckel, 2000), reward structures (Fairweather & Rhoads, 1995); (Walczyn, Ramsey, & Zha, 2007), as well as larger departmental and disciplinary culture (Austin, 1996), especially at research-focused universities where there is enhanced privileging of research over the other work of faculty. While this body of research has been illuminating, multiple stakeholders (e.g., funders, change agents, researchers) require more rigorous exploration into STEM education interventions, attending to postsecondary organizations from a systems-perspective. Such perspective requires researchers to view postsecondary organizations holistically, that is considering the organization as a whole made up of constituent parts, and per their complexity, acknowledging organizational functioning and change is based on complicated interwoven processes and structures.

**Research Design**

We set out to design and ascertain the efficacy of a research model that could remedy some of the ontological, epistemological, and methodological limitations to studying change in postsecondary organizations, while specifically providing for inquiry into change coinciding with a campus-based STEM education improvement intervention. We proposed two research questions:

1. How might we rigorously and completely study organizational change in response to postsecondary STEM education improvement interventions?
2. Using our research model, what is the potential for organizational change at a research university with respect to a campus-based STEM improvement initiative?

To address our first research question, we describe a multi-theoretical research model and related foci of research. Given that our theory of action requires our intervention’s designers to be aware of current and evolving realities within our larger institutional- and STEM-specific organizations that could impact our goals, we detail the first stage of research using our model to explore our second research question, What is the potential for organizational change at a research university with respect to...
adoption and adapting evidence-based instructional practices (EBIPs) in large enrollments introductory STEM courses as educators participate in both disciplinary and inter-disciplinary collaborations focused on improving teaching and student learning? We then reflect on our use of our research model, towards informing and honing both our project’s theory of action and its feasibility for other efforts to improve and study postsecondary STEM education.

**Literature Review: Identifying Limitations of Research Concerning Organizational Change In Complex Systems**

Towards constructing a robust research model, we considered organizational change research from a variety of theoretical frameworks published since the 1980s. These decades produced significant research. We were particularly interested in change in response to planned initiatives, change to both to organizations and the practitioners working in these organizations.

In fact, research that examines STEM educational interventions is constrained by limitations of research concerning organizational change writ large, including ontological limitations such as inadequate attention to organizations as complex systems of interrelated processes and structures (Schreyögg & Sydow, 2011; Van de Ven & Poole, 2005), which are influenced by internal and external context and history (Kuipers et al., 2014; Langley, Smallman, Tsoukas, & Van de Ven, 2013). In addition, epistemological limitations have been noted that discount pertinent theory or are too constrained by a single theory (Kuipers et al., 2014; Schreyögg & Sydow, 2011; Van de Ven, 2007; Van de Ven & Poole, 2005). Lastly, methodological limitations include a reliance on anecdotal rather than empirical evidence (Kuipers et al., 2014), lack of documentation of change in real time (Mohrman & Lawler, 2012), and ignorance of time or the relegation of time to a “variable” (Langley et al., 2013). Finally, much organizational research is void of practical recommendations to improve organizations (Mohrman & Lawler, 2012). We noted, as have others, a lack of practical knowledge that could otherwise “help organizations deal with the new challenges they face” (Mohrman & Lawler, 2012, p. 43) by informing organizations’ future development.

In the following, we ground our ontological perspective of postsecondary organizations on this review of the literature and clarify further the epistemological issues of studying these organizations.

**Characterizations of postsecondary organizations: Our ontological perspective**

As organizations, postsecondary organizations can be viewed in terms of more general knowledge about how organizations are created, structured, behave, change and endure. Organizations have been the object of study for decades across diverse fields, such as sociology, psychology, economics, and management. The social sciences, where research on education is generally situated, largely view organizations as entities comprised of individuals acting in coordination to achieve some purpose. Organizations are circumscribed by their autonomy with respect to the environmental context and other organizations, their membership, and their norms and routines, including those of how members interact (Hackman, 1985). There are four perspectives upon which our ontological perspective on postsecondary organizations is grounded: postsecondary
organizations are organizations with multiple intersecting levels; they are bureaucracies that behave rationally; they are organized anarchies; and they are complex adaptive systems.

Like other organizations, Postsecondary organizations include a **micro-level**, a collection individual agents who make up an organization, a **macro-level** that represents the organization as a whole, and the sub-organizations at the **meso-level**, composed of departments, disciplines, and colleges or schools within an IHE (Fumasoli & Stensaker, 2013; Rafferty, Jimmieson, & Armenakis, 2013; Rousseau, 2011). Hereafter, referred to as organizational levels. Considering Postsecondary organizations from the perspective of the different organizational levels is especially timely as more education interventions in higher education have as a goal the systemic and comprehensive change to educators’ practices and their organizations across macro-, meso- and micro-level entities with many interventions targeting multiple levels (Collins, 2016). Such interventions acknowledge the relationship between organizational activity on these three levels and many assume change cannot be realized at one level without also targeting the interactions between levels. Those with more macro-focus include interventions spanning all postsecondary disciplines, such as federal policies like the Obama administration’s Postsecondary Institutions Rating System and national programs such as the Lumina Foundation’s Achieving the Dream initiative. Those spanning more of the meso- and micro-levels can be interdisciplinary, but often focus on a discipline. These include, for example, accreditation policies such as ABET for engineering and the NSF-funded Partnership for Undergraduate Life Science Education (PULSE), which supports Fellows to transform life science departments in a way that leads to improvements in undergraduate teaching. The change initiative we are studying attends to all three levels of the institution.

The formal structure of modern Postsecondary organizations is grounded on bureaucracy, using academic departments as building blocks, the result of over a hundred years of departmental and disciplinary boundaries developing hand-in-hand (Clark, 1995, 1996; Geiger, 2004; Veysey, 1965). When compared with other institution types, the macro-level structure of Postsecondary organizations makes these institutions even more resistant to change, as the meso-level sub-organizations are particularly good at reconstructing disciplinary ideologies (Fanghanel, 2009; Moser, 2007) and effective at socializing new participants in both tacit and explicit worldviews and practices (Tierney, 1997). For example, status is conferred to faculty members by departmental, disciplinary, or college boundaries that dictate a certain framing of both faculty scholarship and teaching (Holley, 2009; National Academies, 2005). This framing helps explain the focus on departments and disciplines, sometimes broadly conceived as STEM, when strategizing education interventions. The notion of bureaucracy underlies rationalist investigations that attempt to explain and predict phenomena in Postsecondary organizations. However, the notion of bureaucracy underlies investigations into IHE phenomena conducted within a framework of social constructivism as well. For example, studies involving the **socialization** of IHE-related professionals illustrate socially situated replication of bureaucratic features, such as largely uncontested routines and structures and shared, often tacit, mental schemas (Gioia & Poole, 1984; Harris, 1994; Tierney, 1997).
Within a disciplinary-based bureaucratic model, decision making, problem solving and goal setting are highly influenced by the disciplinary departments privileged to make many influential decisions through processes perceived as complicated and tenebrous, overseen by committees or department heads (Clark, 1983; Hewton, 1982; Rutherford, Fleming, & Mathias, 1985). Such activities are often described as organized anarchy. In an organized anarchy, administrators (e.g., provosts, deans and chairs) have limited authority with respect to determining problem-solving strategies and outcomes, since these strategies and outcomes are evolving, inconsistent and indeterminate within an organization. There are also different levels of participation and effort among the various individuals, units, and levels that make up the organization (Cohen & March, 1974; Davies & Morgan, 1982; Rutherford et al., 1985) These findings are key to understanding challenges to education improvement efforts in higher education; it is difficult for interventions to diffuse throughout the larger system, due to organizational units comprised of autonomous decision makers and actors with limited ability to communicate and collaborate across disciplinary silos (Bouwma-Gearhart, Perry, & Presley, 2014) within an already loosely coupled system in terms of information flow (Orton & Weick, 1990; K.E. Weick, 1976).

Postsecondary organizations, like all social systems, are complex. Complexity theory (Cilliers, 1998) considers how elements of an organizational system interact nonlinearly with one another and with the greater environment In addition, complex systems are self-organizing and this order emerges as elements of the systems interact within the systems and adapt to its environment. This perspective of Postsecondary organizations assumes agents’ individual and collective actions are unpredictable and the parts of the institution act as complex adaptive systems (Holland, 2006) with a large number of agents and components that interact nonlinearly; these systems also adapt, and in the case of social systems, adaptation is learning. While acknowledgement of Postsecondary organizations as complex systems is growing, we contend that much research concerning Postsecondary organizations, and related change, and much research on organizational change writ large, still pay too little attention to behavioral complexity.

Our ontological perspective on Postsecondary organizations posits that Postsecondary organizations have intersecting elements operating on different organizational levels, some of which behave bureaucratically in order to maintain a status quo and others that interact in unpredictable ways within an organizational anarchy, suggesting that Postsecondary organizations include elements that behave as complex adaptive systems. Individual educators are members in several sub-organizations at the meso-level. The sub-organizations may be disciplinary or inter-disciplinary and may or may not intersect (see Figure 1). An IHE is bounded by latent context that includes the organizational culture, that is, beliefs norms and practices. Each IHE resides in an environmental context, which includes postsecondary education in the US and the policies and laws that govern these organizations.
Researching educational change initiatives: Our epistemological perspective

Having attended to our ontological perspective of Postsecondary organizations, we now turn to some of the epistemological challenges that arise from trying to understand educational change initiatives from an organizational change perspective: attending to various organizational levels and their interactions; tracing the impact of education interventions on educators’ practice; and attending to organizational complexity. We then address the utility of a research model that is grounded on several theories.

Studies investigating organizational change in higher education have predominantly considered the university as the unit of analysis, a macro-level analysis (Fumasoli & Stensaker, 2013). However, some researchers studying educational change in Postsecondary organizations have called for more attention to the understudied meso-level of disciplines, departments, programs, and the schools and colleges within a university setting (Trowler, Fanghanel, & Wareham, 2005). Fumasoli & Stensaker (2013) called for attention to departmental-level practices as “factors of change…the [potential] link between the micro and macro” (p. 490). Underlying calls for this epistemological focus include perspectives that recognize meso-level structures as key to decision making within Postsecondary organizations. For example, decisions about curriculum and teaching practice are rarely made by individuals working at the macro-level (e.g., university provosts), but typically are made at the departmental level, with these meso-level structures critically impacting, and being impacted by, individual educators (Quinlan & Akerlind, 2000). Research detailing the adoption of EBIPs in higher education diagnose macro- and meso-level barriers to adoption, including norms guiding governance and autonomy (Eckel, 2000), reward structures (Fairweather & Rhoads, 1995; Walczyk et al., 2007) and departmental/disciplinary culture (Austin, 1996). As we will argue, our multi-theoretical research model allows for exploration of
how the various organizational levels within Postsecondary organizations impact one another.

Some research focuses on individual educators. Findings from this research suggest potential affordances that may alleviate barriers to change in postsecondary education. Notable affordances include particular factors that may serve as motivation to improve practice, such as monetary or teaching awards, peer pressure, as well as threats to professional ego (Bouwma-Gearhart, 2012a, 2012b). Still, methodologically robust research tracing such affordances to the level of actual teaching pedagogical practices is rare. Bastedo (2012) has argued that education researchers’ over-focus on structure and function has resulted in “a retreat from educational practice itself” (p. 10). Our epistemological perspective considers the importance of educators making changes on the micro-level.

Attention to the complexity of educational organizations is important for developing, implementing, and researching education interventions and associated organizational change, since educators may respond to change initiatives in unintended ways (Cilliers, 1998; Holland, 2006). This argument has been made especially relevant by those researching K-12 interventions, who have noted limited impact of interventions due to overlooking organizational complexity, including that influenced the unpredictable interactions of individual educators working on the micro-level (see (Coburn, 2001), (J.P. Spillane, 2012), (James P. Spillane, Reiser, & Reimer, 2002)). However, a focus on organizations as complex has not addressed two limitations to organizational change research in general. First, there is a need to document and explain the products of organizational change, such as organization routines and structures and individual practice. Second, there is the need for elaborate processes inquiry and organization-specific implication per unique contexts.

Advocating for a multi-theoretical model
A theory’s usefulness is two-fold, in particular when considering theories to study education interventions and associated change. A theory must be able to illuminate phenomena of interest, that is, explain and predict. Yet it is also should be practical. In our case, it better helps the change agents working on our project to improve postsecondary STEM education.

Various theorists have argued for models grounded on multiple theories to explain and predict organizational phenomena (Schreyögg & Sydow, 2011; Van de Ven & Poole, 2005), including research on Postsecondary organizations (Kezar, Carducci, & Contreras-McGavin, 2006; Kezar & Dee, 2011). Those arguing for better exploration of organizational complexity note that some researchers are dismissive of pertinent theory or too constrained by single theory (Kuipers et al., 2014; Van de Ven, 2007), resulting in epistemological and methodological limitations (Schreyögg & Sydow, 2011; Van de Ven & Poole, 2005). The field of organizational studies speaks to multiple audiences and draws on multiple other fields’ “utility” theories, towards explaining and predicting complicated social and cultural organizational phenomena (Corley & Gioia, 2011). Complexity theorists, specifically, have advocated for the use of various theories to explore organizations. Dooley (1997) highlights the need for researchers with an ontological perspective that features of Postsecondary organizations behave as CAS to adopt theories that account for what he presents as the main phenomena implicated by
complexity: (1) agents’ perceiving aspects within their environments, (2) their construction of and use of schemas, and (3) means for schema and other information processing and movement through an organization, and specifically inter-agent interactions. However, multi-theoretical models remain underemployed by higher education researchers, (Lewis & Kelemen, 2002).

Finally, Mohrman and Lawler (2012) observe that organizational research often overlooks the connections to and implications for practice: "We need to apply, extend, modify, and combine theories to craft research that yields knowledge that will help organizations deal with the new challenges they face” (p. 43). Mohrman and Lawler advocate for teams of researchers of organizations and change should formulate and attend to answering questions regarding theory (what is the relationship...?) and questions regarding practice (how do we design...?). Inquiry into these questions should be done in close collaboration between researchers and change agents to elicit better understanding of Postsecondary organizations and potential for feeding of research conclusions back to Postsecondary organizations towards continuous improvement (Penuel, Coburn, & Gallagher, 2013). Such arrangements offer opportunity to illuminate both theoretical and practical knowledge (Cobb & Jackson, 2011).

### Research Model Development

The model we propose emerged from our need to understand a system that includes individuals (their knowledge and actions), the creation and movement of knowledge necessary for change within particular cultural and organizational contexts, and also attends to the dynamic interaction between the different levels of the organization, as well as between its members (educators, department chairs or administrators) at each level. In this section, we first describe the theoretical components of a model that we posit will allow us to investigate how an organization changes as a result of an educational change initiative.

The adopted frameworks comprising our research model are borrowed from various disciplines: (a) organizational social cognitive and sensemaking theories from business (Sims & Gioia, 1986; Karl E. Weick, Sutcliffe, & Obstfeld, 2005), (b) perceived affordance theory from psychology (Glenberg & Robertson, 1999; Greeno, 1994, 1998; Norman, 2013); (c) cultural models theory from anthropology (D'Andrade, 1984; Quinn & Holland, 1987), and (d) organizational learning theory from sociology (Argote & Miron-Spektor, 2011). Developing a research model from these various theoretical perspectives allows us to explore organizational change and attend to a wide range of pertinent phenomena. Cultural models theory helps explains how educators make sense of organizational culture and how these cultural models can also affect the organizational culture at either the meso- or macro-level. Organizational social cognitive and sensemaking theories explore the connection between individual cognitive and concerted action in organizations. Organizational learning theory provides insight into the repositories of organizational knowledge created through either individual or concerted action, such as organizational routines and practices regarding teaching and teaching innovations (James P. Spillane & Zoltners Sherer, 2011).
Organizational Social Cognitive Theory: Collective Sensemaking

Organizational social cognition theory explains how an individual interprets and acts within an organization (Sims & Gioia, 1986) and how highly organized knowledge structures of schema are used to interpret and act (Lord & Foti, 1986). Lord and Foti describe four types of schemas used to interpret and act in the world: self schema, person schema, script or event schema, and person-in-situation schema. Self schemas are organized among the dimensions that form one’s identity and are used to sift information, according to the dimensions that are important to oneself in a particular situation. Person schemas are used to categorize people into particular types. These categories cannot be too precise, because they may have to accommodate new examples into a schema. For example, an educator sees a group of 18- and 19-year-olds on campus and interprets these people as students. Later in her own classroom, an unfamiliar woman in her 40s sits with a notebook near the front of the classroom and, in this case, the educator’s schema of student bends to accommodate this perception. Schemas of particular interest to understand how people act include scripts for an individual’s actions and person-in-situation schema to help an individual interpret other’s actions; of course, these two types are mutually co-constituted. Scripts are derived from daily routines, allow us to understand frequently recurring experiences and inform us how to act in a particular situation. For example, an educator develops scripts for responding to different types of student questions in a learning environment. Finally, person-in-situation-schemas are used to interpret another’s actions. For example, an educator may have a person-in-situation-schema, which allows her to interpret a department chair’s decision about a policy regarding her work. We expect that each of these types of schema will emerge from our analyses of interview transcript with the educators.

Perceived Affordance Theory

Norman’s theory of perceived affordances (2013), stemming from the field of cognitive psychology, builds on Gibson’s (1977) original ideal of affordances as objects within/properties of the environment that can be directly perceived directly and immediately recognized by agents as action possibilities, if agents possess certain capabilities to allow them such recognition. Norman honed a theory of perceived affordances (1988; 1999), arguing that agents draw on experiences, knowledge, values, beliefs and goals to perceive certain contextual objects as affordances. Thus, afforadnces, by their nature are neither properties of agents or the environment alone but are relational ‘combinations of the user’s experiences and knowledge of semantic, cultural, logical and physical constraints, which direct our perception and affordances of objects’ (Norman, 2013). Greeno (1994, 1998) added to perceived affordances theory by tying it firmly to situated cognition and action, arguing that agents’ perception of affordances can increase agents’ likelihood of performing actions. For Greeno, affordances are “qualities of systems that can support interactions and therefore present possible interactions for an individual to participate in” (1998, p.9). Critical to this assumption is recognition of affordances as not properties of the environment alone, but rather context-specific relationships between particular attributes of agents and unique features of environmental situations (Chemero, 2003).
The theory of perceived affordances, in its concern with agent cognition, brings researcher focus to the micro-level, that being of the individual agent, interacting with the greater environment, including the social structures of which they are part. The theory of perceived affordances helps situates agents’ sensemaking within the environments that agents function within. Affordances, like other aspects of the larger environment perceived and experienced by agents, have potential to impact agent learning. In further considering the interdependence of affordances and agents’ pre-standing attributes, the concept of actors’ competencies is helpful. Actor competencies, or effectivities (Chemero, 2003; Shaw, Turvey, & Mace, 1982) are properties possessed by an actor that provide a framework to make sense of and act on affordances in their environment. Although Greeno (1998) argues that affordances have a more complicated role in interacting with agents’ mental schema, Glenberg & Robertson (1999) assert that affordances can ultimately even serve as building blocks for mental models. Agents, in turn, may draw on mental models to perceive affordances as action possibilities.

The theory of perceived affordance also highlights norms and practices in human systems in understanding agent interactions with affordances and action (possibilities and actual) in light of them. Norms and practices in human systems are what Greeno (1998) termed as constraints to action. Agents’ action possibilities are also, thus, constrained by more standard patterns of action they experience and are part of. Such constraints, such as organizational routines they are involved in (described more below) ultimately, act as actors’ attunements to environmental affordances.

**Educators’ Cultural Models**

Cultural models theory allow us to investigate how an educator’s schemas develop within the organizational (macro-level) or disciplinary (meso-level) context in which s/he works, as well as how these schemas become shared between the members of an organization. In addition, this theory – in conjunction with social cognitive theory – provides a lens for understanding organizational members’ actions with respect to teaching and learning. The theory of cultural models emerged from cognitive anthropology (Quinn & Holland, 1987). One undertaking by scholars working in these traditions is to understand how cultural or organizational knowledge is organized and how meanings are co-constructed across people. The “meanings represent the world, create cultural entities, direct one to do certain things and evoke certain feelings” (D’Andrade, 1984, p. 88), that is, cultural meaning systems are representative, constructive, directive or evocative; they explain how a person interprets her or his world and learns to act in culturally appropriate ways. With respect to the culture surrounding teaching practices at a research university, a faculty member’s meaning for lecture, for example, might represent the status quo in so far as lecture is what the primary mode of teaching large-enrollment courses is called by the organization. Referring to part of a course structure a ‘lecture’ and another part a ‘lab’ may direct a faculty member to act in certain ways in lecture, but in different ways in lab as the term lecture might be evocative for faculty members, who have constructed meanings for it, such as lecture as a practice that is one-directional and does not actively engage students. Finally, new cultural entities are created. For example, active learning is an entity for which many educators are creating meanings, and the meaning of active
learning created by educators teaching large-enrollment introductory courses is likely different from that created by cognitive psychologists. It is important to note that meaning systems are how an individual perceives and makes sense of his or her cultural world, and the way to understand shared cultural meanings systems is to understand individual meaning systems.

**Organizational learning**

Organizational learning is a theory from cognitive and social psychology research that illuminates how individuals learn within organizations, including how they may perceive, respond, and contribute to knowledge within an organization (Levitt & March, 1988). An organization *learns* as its members undertake tasks in which knowledge is created, retained, or moved within or beyond the organization (Argote & Miron-Spektor, 2011). According to Argote & Miron-Spektor, this knowledge “can manifest itself in changes in cognitions or behavior and include both explicit and tacit or difficult-to-articulate components” (p. 1124).

This perspective on organizational learning situates the organization within three contexts: an environmental, a latent and an active context. In our case, the organization we examine is situated in the environmental context of institutions of higher education in the US. The organization is also situated in a latent context, which includes culture (that is, distributed beliefs, norms and practices) of teaching at a land grant institution with a strong research mission; perceived psychological safety (e.g., department climate), and structures (e.g., spaces for teaching and learning). The *members* of the organization in which we are interested are the educators (including graduate and undergraduate teaching assistants), who facilitate learning in large enrollment introductory STEM courses. Some of the *tools* these educators use are student response systems, document cameras and course management systems. The *tasks* these educators undertake include teaching, making decisions about curriculum, and making decisions about promotion and tenure.

Within this theory, it is assumed that learning begins with experience. The current state of organizational knowledge is applied as the organizational members undertake tasks using tools. On our project, members may gain experience by participating in learning communities, trying things out in their classroom, or by engaging in action research. As educators work individually or collectively on these organizational tasks, experience is gained and knowledge is either created, or created and moved within the organization when the tasks are undertaken collectively. Knowledge is then embedded or stored within the active, latent or environmental context of the organization. In the active context, knowledge is stored within individual educators’ schemas or within schemas shared among several educators, or within the tools they use to conduct the tasks that constitute their work. In the latent context, knowledge in embedded within the educators’ cultural models and shared schema, educators’ department climate, and within organizational structures, such as available spaces for teaching and learning.

Organizational knowledge is also embedded in organizational routines and policies (Feldman & Pentland, 2003). According to Feldman and Pentland (2003), organizational routines are “repetitive, recognizable patterns of interdependent actions, carried out by multiple actors” (p. 95). As educators at a university learn how to develop assessments to measure students’ progress to articulated learning outcomes, this
knowledge is embedded in the routines the educators undertake to document student learning for evaluating programs and for accreditation. However, Feldman and Pentland also distinguish between the *ostensive* and *performative* aspects of organizational routines. The ostensive aspect incorporates the subjective perceptions and related schema of diverse actors, similar to a group’s cultural meaning systems. The ostensive aspect of a routine needs to be general so that the routine can be performed in diverse settings by diverse actors. In contrast, the performative aspect of an organizational routine is the actions undertaken by particular actors in a given situation. Although a routine is repeated, not all enactments of a routine will be performed in the same way. However, there is enough of a resemblance between performances, using one’s perception of the ostensive aspect or routine prototype, that recognizable patterns of action are evident. The ostensive aspect of a routine tends to be stable and variation lies in the performance of a routine. However, new knowledge can become embedded in routines when a particular variation is assumed to be beneficial or a variation is mandated and the ostensive aspect of the routine adapts to accommodate the variation.

**Data Sources and Ongoing Analysis Using our Model as a Tool**

Our data sources and analysis techniques are multifaceted. The data sources included survey, interview and observational data. The survey queried educators’ teaching practice, their professional networks with respect to teaching and student learning (as opposed to research), and how they perceived their department’s climate with respect to teaching and student learning. Semi-structured interviews were conducted with educators and the administrators who have an impact on teaching and student learning, such as Associate Deans of Academic and Student Affairs. Finally, observations of classrooms teaching, using the Teaching Dimensions Observation Protocol (TDOP) (Hora & Ferrare, 2014), and educators’ participation in a variety of learning communities were also conducted. These data, in conjunction with our research model, allow us to address our second research question: *What is the potential for organizational change at a research university with respect to adopting and adapting evidence-based instructional practices (EBIPs) in large enrollments introductory STEM courses as educators participate in both disciplinary and inter-disciplinary collaborations focused on improving teaching and student learning?* Table 1 provides further detail about the data collection. Table 2 summarizes the data collected during the first year of the intervention. It includes the type of data collected, the organization level – or interactions between organizational levels – we expect these data to address, and the elements of theoretical model we use as a theoretical lens to examine these data.
Table 1: Data collection detail

<table>
<thead>
<tr>
<th>Data Collection Tool</th>
<th>Targeted population</th>
<th>Response rate or number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey</td>
<td>All educators (tenure-line and non-tenure line) in seven STEM units</td>
<td>Overall response rate: 54% (142 submitted surveys) Unit response rate varied from 39% to 77%</td>
</tr>
<tr>
<td>Educator interviews and teaching observations</td>
<td>Educators adopting and adapting EBIPs in six STEM units</td>
<td>18</td>
</tr>
<tr>
<td>Administrator interviews</td>
<td>Administrators in six STEM units and one college, two center directors and one vice provost.</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 2: Summary of data collection strategies and analytic lenses

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Organization level(s)</th>
<th>Elements of model</th>
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<tbody>
<tr>
<td>Survey: Definitions of teaching practices</td>
<td>Micro</td>
<td>Cultural models</td>
</tr>
<tr>
<td>Semi-structured interview with educators</td>
<td>Micro, meso and the interaction between these levels</td>
<td>All</td>
</tr>
<tr>
<td>Semi-structured interview with administrators, including department chairs, vice provosts and center directors</td>
<td>Meso, macro and the interaction between these levels</td>
<td>All</td>
</tr>
<tr>
<td>Survey: Network data</td>
<td>Meso</td>
<td>Organizational learning (through social network analysis)</td>
</tr>
<tr>
<td>Survey: Department climate</td>
<td>Meso, macro</td>
<td>Collective sensemaking, Perceived affordance theory</td>
</tr>
</tbody>
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At the micro-level, the observations of classroom teaching and interviews with observed faculty inform us about the ways faculty members affiliated with the project adopt project-affiliated practices and artifacts. The interviews help us understand the educators’ pedagogical goals, any changes to their perspectives on teaching and student learning, and their decision-making concerning curriculum and instruction, as well as the ways the intervention has influenced these goals, perspectives and decisions. A potential measure of change within the meso-level is the frequency and refinement of educators’ discussions around teaching and student learning, findings which are then triangulated with the findings from micro-level data. The survey responses allow us to explore both the micro- and meso-levels. In particular, these data allow us to examine emerging networks of educators using social network analysis.
The growth and enhancement of these networks is one indicator of change. In addition, the survey and interviews allow us to explore faculty members’ perceptions of departmental climate\(^1\) and the way different climates influence change. Interviews with administrators and center directors uncover meso- and macro-level structures and routines that help us query the potential for organizational change within the organization.

**Ongoing Analysis**

In order to answer our second research question -- *what is the potential for organizational change at a research university with respect to a campus-based STEM improvement initiative?* -- the interview transcripts and qualitative data from the faculty survey have been analyzed using codes that derive from our research model of organizational change. In order to present findings about particular sub-organizations within the postsecondary organization, we generated a list of questions that focus the various theoretical lenses on the data. We are using answers these questions to ground vignettes about the five units (either a department or a school) that are impacted by the intervention we are examining. The questions uncover details of the department context, in particular with respect to teaching and learning in large-enrollment introductory STEM courses, the potential for organizational learning, opportunities for collective sensemaking and concerted action, uncovering educators’ cultural models, and understanding affordances for change (see Figure 2).

The construction of these vignettes is currently underway. Preliminary findings indicate the potential for organizational change is closely aligned with educators’ perceptions of the departmental climate for making improvements to teaching that impact student learning. In addition, the potential is greater in departments in which the social connections between the tenure-line faculty members and the instructional faculty are stronger and in which there exists particular organizational structures, such as curriculum committees that focus the large-enrollment introductory courses.

\(^1\) Organizational climate is a construct that is easier to measure than organizational culture. In particular, we usually think about climate affording particular actions (Walter, Beach, Henderson, & Williams, 2014). For example, a person lives in a town that has a climate for farm-to-table dining. In our study, we are interested in a STEM department’s climate for conversations about improving teaching and learning. To measure this we selected items from one subscale of a previously developed faculty teaching climate survey (Knorek, 2012).
**Context**

1. Which educators teach the large-enrollment introductory courses and how are these courses -- and any attendant course structures such as labs, recitations, studio workshops -- assigned to educators?
2. What are the aspects of climate within the department related to teaching and learning?

**Potential for organizational learning**

3. What departmental tasks do educators undertake through which organizational (meso-level) knowledge is created and moved between members of the department?
4. What routines and social networks in the department allow for the movement of knowledge within the department or between the department and other departments?
5. What departmental structures (such as policies) exist or have been created to store organizational knowledge?

**Opportunities for collective sensemaking and concerted action**

6. What organizational routines hold the potential for collective sensemaking and subsequent actions and decision making around teaching practice and student learning?

**Uncovering educators’ cultural models**

7. What are the models and schema educators in the department hold around culturally constructed concepts such as ‘active learning’ and ‘the successful student’ and “departmental membership”?

**Understanding affordances for change**

8. What are perceived affordances and barriers to enacting new teaching practices, and/or making other changes that impact teaching and student learning?

Figure 2: Questions on which to ground vignettes to better understand the potential for organizational change

**Implications**

Our multi-theoretical research model remedies noted ontological, epistemological, and methodological limitations to studying change in postsecondary organizations. Our work attends to concerns with how education research suffers from adequate detail regarding design, (Bell, Hoadley, & Linn, 2004), including that of research models guiding research. We detailed and critiqued some common models and heeded the calls of others arguing for consideration of multiple theoretical frameworks to inform exploration of organizational phenomena, including those concerning postsecondary education (Bess & Dee, 2008; Kezar & Dee, 2011).

Specifically, our research model allowed us to investigate the potential of our research university for organizational change in response to a STEM education.
improvement initiative. Data allowed us to ascertain relative prevalence and strength of certain factors indicative of potential for organizational learning, a key necessity for our initiative’s success. Specifically, these data afforded project leadership knowledge of the current state of organizational knowledge (as individual and collective schemas regarding teaching practices), structures (intra- and inter-disciplinary interpersonal networks concerning issues of teaching and learning), and other factors (individual and collective perceptions of departmental climate and culturally constructed concepts like active learning) that may both support and impede our goal for organizational change. Project leadership revises its theory of action with these realities in mind, demonstrating the efficacy of our research model beyond mere research interests towards continuous related project improvement.

Our research model and implementation example may benefit those attempting to enact and document postsecondary STEM education improvement, such as those present at the annual NARST conference. As highlighted in Henderson, Beach, & Finkelstein (2011), researchers studying postsecondary STEM education improvements often work ignorant of pertinent frameworks and related tools in critical domains, such as organizational theory, and organizational change and learning. We believe use of our model can help remedy these theoretical divides and will be of interest to researchers working in fields concerned with systemic pedagogical innovations, including those of cross-disciplinary focus, as well as those attempting to document and study related organizational change.

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