

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

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Abstract

The purpose of this paper is two-fold. We first explore the question *how might we rigorously and completely study organizational change in response to postsecondary education improvement interventions?* We identify the need for a multi-theoretical research model that allows us to more rigorously describe the potential for organizational change at the start of an educational change intervention in higher education and to document change over time. To accomplish the first purpose, we set the stage by describing characteristics of educational change interventions targeting formal postsecondary education organizations. Next, we detail findings from a targeted literature review concerning: (a) the nature of formal postsecondary education organizations upon which we grounded our ontological perspective of these organizations, and (b) literature on organizational change that contributes to an epistemological perspective for researching postsecondary educational change interventions. In response to this literature review we then propose a multi-theoretical research model that remedies noted ontological, epistemological, and methodological limitations to studying change in postsecondary education organizations, better attending to the multi-dimensional, multi-level organizational phenomena and factors we determined to be important. We then describe our research model's usefulness by addressing the following question: *how can we study the potential for organizational change at a research university with respect to a campus-based STEM improvement initiative?* 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 change. These factors underlie many postsecondary education improvement interventions' theories of action and take into consideration the context in which postsecondary initiatives are situated. Finally, we reflect on the practicality of our research model towards informing and revising an intervention's theory of action, as well as its feasibility for other efforts to improve and study related change in postsecondary education organizations.

Introduction

Interventions to improve postsecondary teaching and learning

In response to public opinion, as well as research in postsecondary education, the US continues efforts to strengthen postsecondary education to better meet the needs of students and society. One means for improving education is through interventions aimed at changing educators' teaching practices, as well as their larger organizations, namely the structures and routines that affect students' experiences in classroom. These interventions include a range of designs, including comprehensive initiatives and accountability policies^[1] meant to foster change to teaching practices, related organizational structures and routines, or both. These include disciplinary and institutional accreditation policies, federal and state laws, initiatives between and across campuses supported and coordinated by various funders and stakeholders, conceptual tools like those promoting educator inquiry on teaching practice (e.g., the scholarship of teaching and learning), and tools, such as those that provide educators with student data to inform practice (e.g., student evaluation forms and data from student response systems).

Although lagging behind K-12 efforts, interventions targeting postsecondary education organizations (PEOs) are becoming more numerous and those focused on the disciplines collectively referred to as *STEM* (science, technology, engineering, and mathematics) are particularly well funded^[2, 3]. 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. Many of these interventions

take aim at faculty teaching practices and seek to foster practices based on evidence from educational research. Such *evidence-based instructional practices* (EBIPs) include educator reflection on teaching practice^[4], the facilitation of cooperative learning^[5] and active learning techniques^[6].

Assumptions underlying postsecondary change interventions' theories of action

Our interests are inspired by efforts on our own campus to improve postsecondary STEM education and to study an intervention that has this ambitious goal as its reason for existing. We briefly detail this postsecondary education intervention to demonstrate typical aspects of theories of actions underlying many interventions underway that aim to improve postsecondary education. Our intervention focuses on a large, public research university in the Pacific Northwest. The comprehensive initiative we are tasked to study has, as its main goal, the greater prevalence 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. Students also attend lab, recitation, discussion groups, or studios, structures that accommodate fewer students. For example, in some courses, students may attend a lecture, a studio and a lab over the course of one week. Primarily non-tenure line faculty members teach the lecture sections in science and mathematics, but this is not as common in engineering. Graduate teaching assistants typically facilitate the learning in the smaller-class-size course structures.

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^[7] by bringing together the people with pertinent teaching and content knowledge and people with positional administrative power; this goal is grounded upon a distributed leadership model^[8]. Our change initiative is based on a theory of action that posits that prevalence of EBIPs will increase as educators participate in both disciplinary and interdisciplinary learning communities in which they learn about and are supported to implement these practices. Implicated strategies for our initiative is the support of learning communities already emergent at the start of the project and the creation of new communities, allowing for educators to come together to share resources and knowledge regarding teaching and learning. In addition, our theory of action includes as a strategy synergizing with other STEM education improvement interventions on campus, and the construction and modification of other organizational structures that influence students' experience in 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 enhanced autonomy in both their teaching practices, as well as any decision-making regarding attempts to change the teaching and learning in their classrooms [7, 12]. As well, we assume that faculty have *critical agency*^[9], that is they are capable of leading STEM education transformation by capitalizing on and challenging organizational norms to facilitate meaningful change^[10, 11].

Our postsecondary STEM education initiative shares many similarities with other interventions currently underway. A general assumption exists that most postsecondary educators have not been afforded development as pedagogues prior to assuming their roles as postsecondary educators. These practices require skills and knowledge that most postsecondary educators do not develop while earning advanced degrees, mostly from research universities^[11, 12]. Another assumption is that educators, as learners themselves, construct and hold cognitive *schemas* of knowledge, constructed via their experiences. Ultimately, these schemas are accessible in and also impact social situations, allowing knowledge, attitudes and behaviors – with respect to teaching and learning – to be recognized distributed throughout an organization^[13]. In this paper, we will frequently discuss these *schemas*, or the cognitive frameworks

on which individual agents makes sense of experience. Schema allow us to fill in gaps as we are perceive our world, as well as make note of inconsistencies, which can be a source of learning. Many postsecondary education improvement interventions have central to their theory of action that educators can revise their schemas regarding teaching and learning through their interaction with other educators, who come together to share resources and knowledge regarding teaching and learning. Such resources and knowledge can then be taken up as indicated by the increased use of evidence-based teaching practices.

Such strategies are meant to accommodate the reality that the organizational *culture* in postsecondary organizations impedes educators' efforts in learning and adopting evidence-based student-centered active learning practices^[2, 3]. By *culture* we mean the explicit and implicit ideologies, norms, values, and behaviors that are normative within organizations^[14]. The culture of postsecondary education in the US is largely thought to devalue teaching and provide few affordances to improve teaching and learning. In fact, attention to culture is critical when researching and evaluating postsecondary interventions, including those meant to improve postsecondary STEM education. Therefore, many of these initiatives target culture within their *theory of actions*, that is, an intervention's underlying assumptions, about both what and how to change^[2, 3]. According to Collins^[15], who reviewed theories of actions underlying national postsecondary STEM education improvement interventions

When we look across many recent STEM education improvement initiatives, a general theory of action emerges that involves the following assumption, strategies, and intended outcomes: 1) Evidence shows that student-centered active learning instructional practices help all undergraduates to learn disciplinary content and processes at a deeper level; 2) If we change the culture in postsecondary STEM education organizations (e.g. departments, colleges) to recognize educating students well is equally valuable to generating disciplinary knowledge and related publications and external funding, educators will more likely attempt to learn and use student-centered active learning practices; 3) These changes will be evident in faculty members' changed teaching practices, as well as underlying mental constructs regarding teaching and learning (schema), their commitments and motivation to teaching and teaching improvement, alongside equally important changes to organizational routines (e.g., tenure discussions) and artifacts (e.g., promotion policies).

Underlying these general theories of action is the need to change individual faculty members' schema, their teaching practices, as well as organizational routines regarding teaching and structures, such as policies governing teaching work, at the organizational level. With respect to these theories of action, it is important that education researchers and evaluators use models of inquiry that attend to organizational culture, and the organizational and individual norms, beliefs and behaviors that are implicated by the culture.

Studying change in postsecondary education organizations

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^[16], reward structures^[17, 18], as well as larger departmental and disciplinary culture^[19], especially at research-focused universities where there is enhanced privileging of research over the other work of faculty. Interventions are often intended to both work around and change these shared ideologies, norms, values and behaviors, that is, the *organizational culture*. While this body of research has been illuminating, there is a notable lack of attention to the

complicated phenomena underway in complex education organizations and interacting with education interventions^[20]. Specifically, the body of research exploring and detailing change in response to postsecondary STEM education improvement interventions lacks evidence of change across various intervention theories of action and adequate attention to the interrelated structures and phenomena implicated by interventions and the complex organizations they are targeting.

Research studies concerning K-12 interventions and change are more numerous. These studies can inform studies of educational change in postsecondary settings. In the K-12 context, researchers focus on how educators interpret and construct implications of interventions within unique organizational contexts. They conclude that education interventions, such as policy, are often not adopted and implemented as those that create them intended, partially due to the fact that successful realizing of intervention goals often require coordinated work across multiple levels and units within organizations, all of which implicate additional factors impacting the success of interventions, including the larger culture, information sharing, storage, and related decision-making, and individual cognition and desire for autonomy^[21, 22]. The most robust K-12 research focusing on change in response to education improvement intervention is appropriately situated within organizational theories that synthesize knowledge about how organizations are structured, behave, are created, change, and endure, both internally and in response to the larger contexts in which they are situated.

We have argued that researchers interested in organizational change in PEOs might consider research concerning organizations in other educational sectors, although we cautioned against an overreliance on change research concerning organizations too disparate in their structure and functioning from PEOs. While many research frameworks and findings from research on organizations sectors, such as such as business or government, provide insight into educational change, these findings are only so applicable towards informing change in postsecondary education. Simply put, PEOs are peculiar beasts, as we will soon detail.

Overall, we contend that multiple stakeholders (e.g., funders, change agents, researchers) require more rigorous exploration into postsecondary education interventions, attending to postsecondary organizations from a *systems perspective*. This perspective requires a researcher to view postsecondary organizations holistically; that is, considering the organization as a whole made up of constituent parts and per their *complexity* and acknowledging that organizational functioning and change is based on interwoven processes and structures. We now turn to detailing a targeted literature review that backs these assertions, as well as that helps to implicate a more robust research model for exploring postsecondary education interventions and related change.

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 education improvement interventions?
2. Using our research model, how can we study the potential for organizational change at a research university with respect to a campus-based STEM improvement initiative?

Towards constructing a robust research model to study our campus intervention, we conducted a targeted literature review concerning organizational change research from a variety of theoretical frameworks published since the 1980s. These decades produced significant research. We were particularly interested in documenting change in response to planned interventions, change to both to organizations and the practitioners working in these organizations.

Literature Review: Building The Case For Our Research Model

As noted above, we argue that researchers interested in organizational change in the context of an education initiative might consider change research conducted in organizations in other sectors. However, we noted that it is important to be cautious of an overreliance on change research concerning organizations too disparate in their structure and functioning from PEOs. For this reason, we first review literature to answer the ontological question, “*What is the nature of postsecondary education organizations?*” This review uncovers the ontological perspective of organizations on which our research model is grounded.

Characterizations of postsecondary education organizations: Our ontological perspective

As organizations, PEOs 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^[23]. There are four perspectives upon which our ontological perspective on PEOs is grounded: PEOs are organizations with multiple intersecting levels; PEOs are bureaucracies that behave rationally; PEOs are organized anarchies; and PEOs are complex adaptive systems.

Like other organizations, PEOs 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 PEO^[24-26]. Hereafter, referred to as organizational levels. Considering PEOs 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^[15]. 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 (Accreditation Board for Engineering and Technology, Inc) 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 PEOs 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^[27-30]. When compared with other institution types, the macro-level structure of PEOs makes these institutions even more resistant to change, as the meso-level sub-organizations are particularly good at reconstructing disciplinary ideologies^[31, 32] and effective at socializing new participants in both tacit and explicit worldviews and practices^[33]. 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^[34, 35]. 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 PEOs. However, the notion of bureaucracy underlies investigations into PEO phenomena conducted within a framework of social constructivism as well. For example, studies involving the *socialization* of PEO-related professionals illustrate socially situated replication of bureaucratic features, such as largely uncontested routines and structures and shared, often tacit, mental schemas^[33, 36, 37].

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^[38-40]. 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^[40-42]. 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^[43] within an already *loosely coupled* system in terms of information flow^[44, 45].

Certainly, PEOs exhibit phenomena that are predictable and grounded on rational assumptions; these organizations cluster along a continuum of bureaucracies grounded upon Weber's original notion of the ideal^[46]. There *is* standardization of work, definition of roles within a hierarchy, policies mandating routines framed in assumptions of rationale authority and decision-making. At the same time, inquiry into PEOs also falls into the camp that Heckscher and Donnellon^[47] term post-bureaucratic. While certain aspects of bureaucracy exists, post-bureaucratic PEOs also have distributed leadership and decision-making, redundancy and ambiguity of work and positions, and many individuals and sub-organizations following routines not policy-bound, ultimately allowing for the innovation expected from and desired by these organizations as they attempt to stay relevant^[48].

Still, various researchers have pointed out that the larger fields of research concerning organizational structure, behavior, and change, including that focused on response to educational interventions, continues to be constrained by oversights that limit exploration of organizations in all of their complexity. PEOs, like all social systems, are complex. *Complexity theory*^[49] 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 PEOs assumes agents' individual and collective actions are *unpredictable* and the parts of the institution act as complex adaptive systems^[50] 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 PEOs as complex systems is growing, we contend that much research concerning PEOs, and related change, and much research on organizational change writ large, still pay too little attention to behavioral *complexity*.

Our ontological perspective on PEOs posits that PEOs 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 PEOs include elements that behave as complex adaptive systems. Individual educators are members of several sub-organizations at the meso-level. These sub-organizations may be disciplinary or inter-disciplinary and may or may not intersect (see Figure 1). A PEO is bounded by latent context that includes the organizational culture, that is, beliefs norms and practices. Each PEO resides in an environmental context, which includes postsecondary education in the US and the policies and laws that govern these organizations.

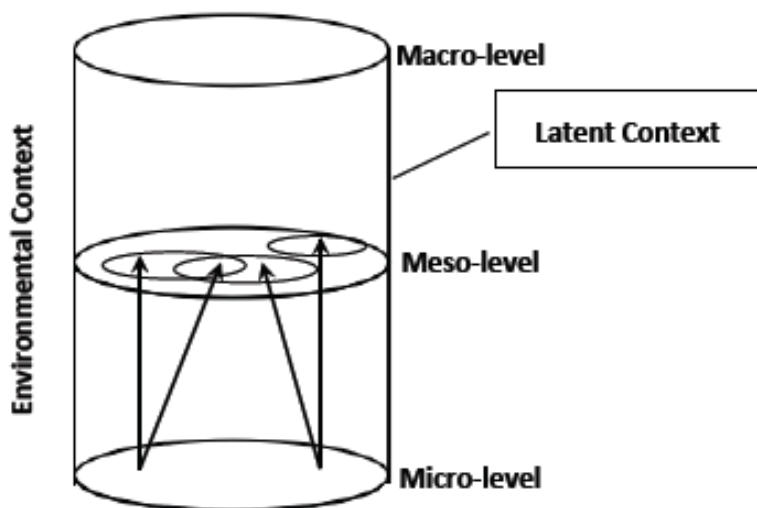


Figure 1: One perspective on institutions of higher education, including organizational levels and context

Researching educational change interventions: Our epistemological perspective

Having attended to our ontological perspective of PEOs, we now turn to some of the epistemological challenges that arise from trying to understand educational change interventions 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.

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^[49, 50]. 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^[21, 22, 51]. 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.

Study of education interventions, thus, must attend to a variety of intended, as well as unplanned, “levels” of impact. Yet studies investigating organizational change in higher education have predominantly considered the university as the unit of analysis, a macro-level analysis^[24]. In fact, researchers studying educational change in PEOs have called for more attention to the understudied meso-level of disciplines, departments, programs, and the schools and colleges within a university setting^[52]. Fumasoli & Stensake^[24] 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 PEOs. 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^[53]. Research detailing the adoption of EBIPs in higher education diagnose macro- and meso-level barriers to adoption, including norms guiding governance and autonomy^[16], reward structures^[17, 18] and departmental/disciplinary culture^[19]. As we will argue, our multi-theoretical research model allows for exploration of how the various organizational levels within PEOs 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^[10, 11]. Still, methodologically robust research tracing such affordances to the level of actual teaching pedagogical practices is rare. Bastedo^[54] 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.

Advocating for a multi-theoretical model

Overall, we found was a notable lack of research that provided insight into examining postsecondary educational interventions, largely due to constraints that would not allow us to attend to our ontological and epistemological assumptions and commitments concerning organizational change and the study of this, writ large. In fact, organizational theorists collectively noted these limitations. Ontological limitations included inadequate attention to organizations as complex systems of interrelated processes and structures^[55, 56], influenced by both internal and external contexts, and change to these contexts, over time^[57, 58]. Epistemological limitations included discounting of pertinent theory or are too constrained by a single theory^[55, 56, 58, 59]. In addition, with respect to our intend to study our campus intervention with rigor, methodological limitations included a reliance on anecdotal rather than empirical evidence^[58], lack of documentation of change in real time^[60], and ignorance of time or the relegation of time to a “variable”^[57]. Finally, much of the organizational research we reviewed was void of practical recommendations to improve organizations^[60]. We noted, as have others, a lack of practical knowledge that could otherwise “help organizations deal with the new challenges they face”^[60] by informing organizations’ future development. Mohrman and Lawler^[60] advocate for teams of researchers of organizations and change should formulate and attend to answering questions regarding theory (that is,

What is the relationship...?) and questions regarding practice (that is, *How do we design...?*). Inquiry into these questions should be done in close collaboration between researchers and change agents to elicit better understanding of PEOs and potential for feeding of research conclusions back to PEOs towards continuous improvement^[61]. Such arrangements offer opportunity to illuminate both theoretical and practical knowledge^[62].

We assume PEOs are complex. In addition, the education intervention that is our focus implicates additional complexity to which to attend, including understanding the goals and implied strategies within sub-organizational disciplinary units and uncovering the structures and routines that might be similar (e.g., educators' roles and practices, decision-making authority, and promotion norms). In fact, each sub-organization is itself inherently complex. Thus, we sought theory and methodologies that could provide insights into multiple phenomena involving multiple elements (e.g., agents, and sub-organizations) and the interactions between these elements, but, most critically, for these elements' interrelated evolutions and adaptations, especially with respect to individual educators' and their organizations' *learning*. Indeed, we needed a research model that could account for constantly changing organization(s) partially due their continual re-organization around new goals making them ever more complex, open as a system, and thus potentially influenced by, and influencing, an intervention (and other environment influences) in novel, unpredictable ways.

We looked towards pertinent theory to help make research model decisions. 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, meaning potentially informing practice; in our case, this would equate to helping intervention leaders/change agents to improve postsecondary STEM education. Again, we found others arguing for better exploration of organizational complexity note that some researchers are dismissive of pertinent theory or too constrained by single theory^[58, 59], resulting in epistemological and methodological limitations^[55, 56]. Thus, we found ourselves aligning with other theorists who have argued for research models grounded on multiple theories to explain and predict organizational phenomena^[55, 56], including research on PEOs^[63, 64]. 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^[65]. Complexity theorists, specifically, have advocated for the use of various theories to explore organizations^[66]. However, multi-theoretical models remain underemployed by higher education researchers,^[67].

Findings: Our Emerging Research Model

The model we propose emerged from our need to understand a system that includes individuals (their schemas, knowledge construction, 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 largely draw from methodologies from the cognitive and social sciences: (a) organizational social cognitive and sensemaking theories from business^[68, 69], (b) perceived affordance theory from psychology^[70-73], (c) cultural models theory from

anthropology^[74, 75], and (d) organizational learning theory from sociology^[76]. We argue that a research model from these various theoretical perspectives allows us to explore organizational change and attend to a wide range of pertinent phenomena assumed to be relevant with respect to many modern postsecondary education interventions.

Organizational social cognitive theory: Exploring individual cognition and knowledge construction as schemas impacted by social environments and activities

Social cognition theory has its roots in social psychology, and draws heavily on cognitive psychology in attempting to understand the cognitive processes, namely information processing, storage, and retrieval, that underlie socially situated phenomena, largely based on the idea of socially constructed schemata. *Organizational* social cognition theory, largely out of business studies, illuminates how individual agents interpret and act within an organization^[68] and how, specifically, different types of highly organized knowledge schema are used to interpret and act^[77]. Lord and Foti^[77] 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. Ultimately, schema are what individuals rely on to make sense of their world. These schema categories cannot be too precise, and often work in tandem, when an individual agent encounters experiences (data from the environment) and must accommodate new experiences into preexisting schema structures or revise these structures. Organizational social cognitive theory, 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 organizations of which they are part.

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 (of *significance*) in a particular situation. *Person schemas* are used to categorize people into particular types. Again, these schema are often mutually co-constituted as agents accommodate new experiences. 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. *Script* or *event schema*, and *person-in-situation* schema are also often mutually co-constituted. 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. Scripts are derived from daily routines (activities performed with significant fidelity and regularity), allow us to understand frequently recurring experiences and inform us of how to act in a particular related, but often somewhat novel, situation. For example, an educator develops scripts for responding to different types of student questions in a learning environment and can rely on these scripts with significant fidelity even as the content of student questions change. Finally, *person-in-situation-schemas* are used to interpret another's actions. For example, an educator may have a person-in-situation-schema, that allows her to interpret an administrator's decision about a policy regarding her work, assuming the administrator intends to promote ever-increasing productivity and efficacy across teaching, research, and service without corresponding commitments to providing additional resources to faculty to achieve these things. We attend to each of these types of schema will emerge from our analyses of interview transcript with the educators.

Perceived affordance theory: Exploring the interplay of agent cognition and the objects and properties of the external environment impacting agent action

Norman's theory of perceived affordances^[73], from the field of psychology, builds on Gibson's^[78] original ideal of *affordances* as objects as properties of or within the environment external to the individual agent with potential to be perceived directly by agents who recognized these objects as *action possibilities*, assuming agents possess certain capabilities to allow them such recognition. Norman later honed the *theory of perceived affordances*^[73], clarifying that agents draw on experiences, knowledge, values, beliefs and goals to perceive certain contextual objects as affordances. Greeno^[71,72] added to perceived affordance theory by elaborating on the relationship of 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"^[72]. Critical to perceived affordance theory, affordances, by their nature, are neither properties of environment or agents alone, but rather context-specific relationships between particular attributes of agents and unique features of environmental situations^[79], or "combinations of the user's experiences and knowledge of semantic, cultural, logical and physical constraints, which direct our perception and affordances of objects"^[73].

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*^[79,80] are properties possessed by an actor that provide a framework to make sense of and act on affordances in their environment. Although Greeno^[72] argues that affordances have a more complicated role in interacting with agents' mental schema, Glenberg & Robertson^[70] 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.

As with organizational social cognitive theory, 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. As with organizational social cognitive theory, the theory of perceived affordances helps situate agents' sensemaking within the environments that agents function within. While organizational social cognitive theory, like other theories based on social schema theory, places emphasis on the activation, processing, storage and storage of knowledge schemas internal to the agent, the theory of perceived affordances is decisively more attentive to the qualities and objects of the external environment, and how the interplay of these with agent effectivities impact agent action. The theory of perceived affordances 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^[72] 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: Exploring culturally situated and distributed meanings, actions, and routines

An undertaking by scholars working utilizing the theory of cultural models, mostly anthropologists, is to understand how cultural or organizational knowledge is organized and how meanings are co-constructed across people and, ultimately, "represent the world, create cultural entities, direct one to do certain things

and evoke certain feelings”^[74]. Also emerging from cognitive anthropology^[75], the theory of cultural models moves us well beyond consideration of individual agent cognition in response to objects and properties of the environment to consideration of how a person interprets her or his world and learns to act in culturally appropriate ways, as well as adds to cultures engaged in routines; as such, cultural models can be representative, constructive, directive or evocative in terms of what they may reflect or influence in an organization.

Cultural models theory allows us to investigate why an educator’s schemas develop, in light of organizational (macro-level) or disciplinary (meso-level) context in which s/he works, as well as why schemas become more encoded and shared between the members of an organization. In addition, this theory – in conjunction with social cognitive theory and affordance theory – provides a lens for understanding organizational members’ actions with respect to teaching and learning. 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, cultural models theory allows exploration and noticing of new cultural entities that may be *created* in an organization. For example, ‘active learning’ is an entity for which many modern educators are creating meanings. Researchers might trace and try to document how and why related schemas emerge within organizational contexts; for instance, the meaning of active learning created by educators teaching large-enrollment introductory mathematics courses is likely different from those created by engineering educators or psychology professors. Instructional leaders might take this knowledge to steer strategies towards more distributed and normalized associated definitions and practices. Important for our research model, uncovering meaning systems provides insights into both how individual agents perceive and make sense of their cultural worlds, and means to understand shared cultural meanings systems by uncovering interacting meaning systems of individuals within an organization.

Organizational learning: Exploring knowledge creation, movement, repository, and use within an organization in light of routinized objects and actions and as indicators of organizational change

Organizational learning is a theory utilized most often in sociology, and illuminates how individuals collectively may perceive, respond, and contribute to knowledge within an organization^[81]. An organization *learns* as its members undertake tasks in which knowledge is created, retained, or moved within or beyond the organization^[76]. According to Argote & Miron-Spektor^[76], this knowledge “can manifest itself in changes in cognitions or behavior and include both explicit and tacit or difficult-to-articulate components” (p. 1124).

Argote & Miron-Spektor’s perspective on organizational learning situates the organization within three contexts: an environmental, a latent, and an active context. For instance, research may examine an education organization 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. For example, of focus may be a postsecondary, Land Grant institution of higher education with a strong research mission with certain other characteristics and structures (e.g., department climate, spaces for teaching and learning). The *members* of an organization may be the educators who

facilitate learning in large enrollment introductory STEM courses at this university. The *tasks* these educators undertake may include teaching, making decisions about curriculum, and making decisions about promotion and tenure. Pertinent teaching-related *tools* of these educators may be student response systems, document cameras and course management systems. See Figure 2 for elaboration.

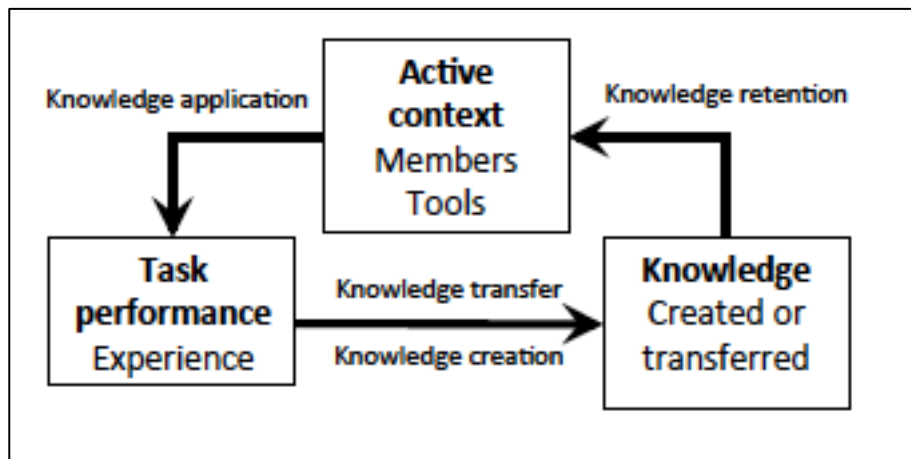


Figure 2: A model of organizational learning (adapted from Argote & Miron-Spektor^[76]). An organization *learns* as its members undertake tasks in which knowledge is created, moved, or retained.

Within this theory, it is assumed that learning begins with experience, implicating both the micro-level of individual agent and meso-level of organization. The current state of organizational knowledge is applied as the organizational members undertake tasks using tools. For instance, members may experience activities meant to improve teaching by participating in instruction-related learning communities, trying new instructional practices in their classroom, or by engaging in action research concerning their instruction. As educators work on these organizational tasks, experience is gained and knowledge is created and stored in individual agents with the potential for co-construction and movement of knowledge within the organization when the tasks are either undertaken collectively or are done in relation to tasks or tools that convey (effectively move) others' knowledge to the agent independently engaged in a task. 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 is 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 learning is a theory that helps to understanding organizational change per the movement and storage of knowledge across individual agents and relevant structures, building on the micro-focused theories of agent-situated knowledge activation and creation (organizational social cognitive theory) and agent-environment interactions (perceived affordances theory). A key difference between the theory of perceived affordances and organizational learning is organizational learning's focus on the meso-level in exploring knowledge, and its dynamics, across an organization, ultimately in light of routinized objects and actions. Organizational learning theory, like cultural models theory, focuses more on the interplay of individuals and organizations, with focus on the construction and influence of shared schema. Yet, over cultural models theory, which ultimately relies on capturing of individual agents' meanings, organizational learning theory definitively highlights more obvious, and potentially less subjective,

indicators of organizational change, that being knowledge that can be traced and evidenced in forms less reliant on self-report. For instance, organizational knowledge can be embedded as organizational routines and artifacts, such as policies [82]. According to Feldman and Pentland [82], organizational routines are “repetitive, recognizable patterns of interdependent actions, carried out by multiple actors” (p. 95). For instance, as educators at a university learn how to develop assessments to measure students’ progress to articulated learning outcomes, this knowledge might be reflected as actual *performative* aspects of routines the educators undertake to document student learning for evaluating programs and for accreditation, versus *ostensive aspects*, or the subjective perceptions and related schema of diverse actors, similar to a group’s cultural meanings/models [82]. While not all enactments of a routine will be performed in the same way by the same agent, an organization may be said to “have learned” if enough performances resemble the ostensive aspect, or prototype, of the routine. Additionally, new knowledge can become embedded in routines when a particular performative variation is “taken-up” by agents, assumed to be beneficial or a variation is mandated.

Taken together, we believe our research model, with its multi-theoretical basis, allows us to study the complexity of implicated and interrelated phenomena, including numerous objects/structures, processes/activities, and organizational levels. A graphic depiction of our research model is below (Figure 3).

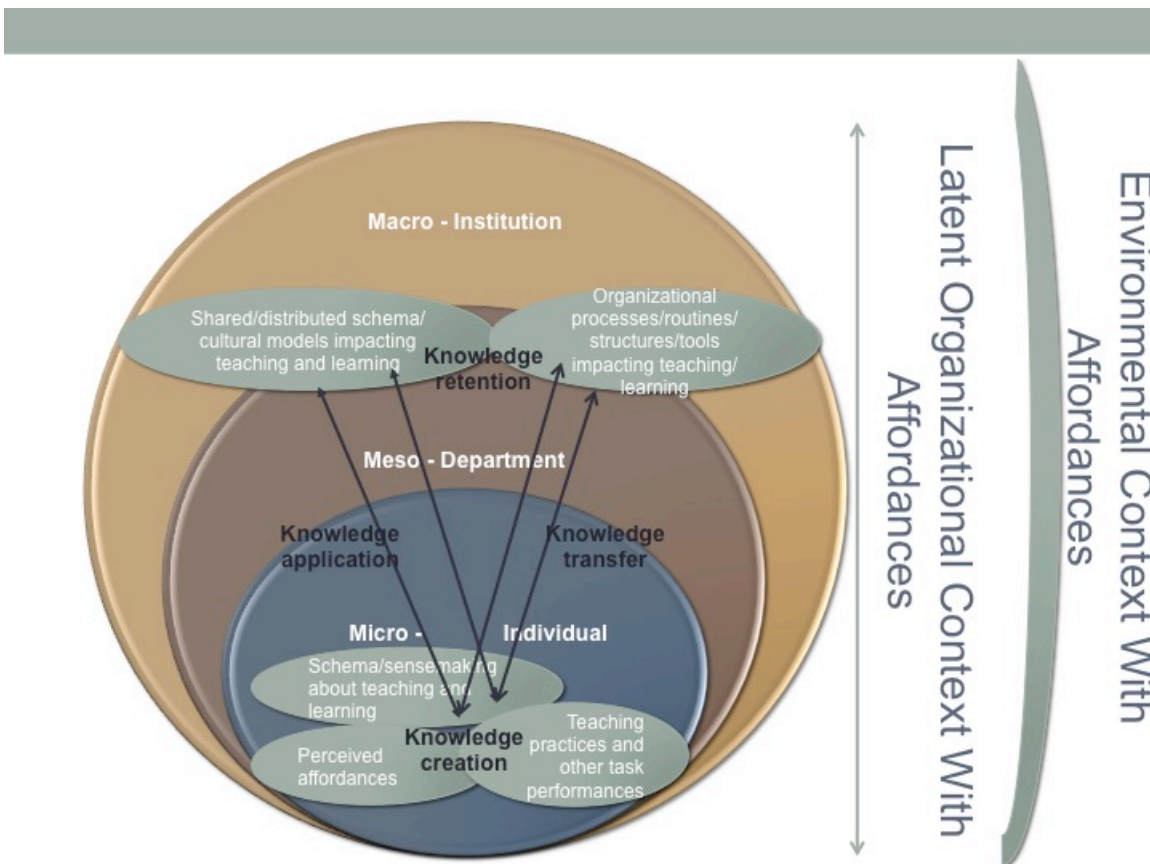


Figure 3: Proposed research model to study postsecondary organizational change, with its multi-theoretical basis and implicated, interrelated phenomena, objects/structures, processes/activities, and organizational levels

Data Sources and Ongoing Analysis Using our Model as a Tool

Our ontological point of view of postsecondary organizations and the theoretical perspectives that make up our analytical model allow us to make sense of the various data collected to document change. 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, 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)^[83] and educators’ participation in a variety of learning communities were also conducted. 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

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

Table 2: Summary of data collection strategies and analytic lenses

Data Source	Organization level(s)	Elements of model
Survey: Definitions of teaching practices	Micro	Cultural models
Semi-structured interview with educators	Micro, meso and the interaction between these levels	All
Semi-structured interview with administrators, including department chairs, vice provosts and center directors	Meso, macro and the interaction between these levels	All
Survey: Network data	Meso	Organizational learning (through social network analysis)
Survey: Department climate	Meso, macro	Collective sensemaking, Perceived affordance theory

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. The interviews queried educators' teaching practice and aspects of the department climate for supporting conversations around teaching and student learning. The interviews also uncovered information about department level routines and structures that are related to decision-making about curriculum and teaching. The interviews are analyzed using codes defined by the theoretical perspectives in our analytical model, such as schema, organizational routines and affordances. Subcodes for schema come out of this analysis and subcodes are compared across units and many subcodes merged. Enhanced focus is given to summarizing the routines, structures and perceived affordances that might impact changes to teaching and student learning in each organizational unit as potential for organizational change.

The survey included items that asked educators to provide definitions of *active* and *cooperative learning*, items that measured department climate, selected from one subscale of a previously developed faculty teaching climate survey^[84] and items adapted from a survey developed for the Mathematical Association of America's Characteristics of Successful Programs in College Calculus¹ that gauge the extent to which educators value certain teaching practices and the frequency of the use of these practices.

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^[85]. 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 climate² 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.

Summary

The four theories underlying our research model describe the mechanisms through which a person interprets and interacts in and on the world, in our case, within the PEO in which the change initiative we study is being undertaken.

¹ <http://www.maa.org/programs/faculty-and-departments/curriculum-development-resources/national-studies-college-calculus/cspcc-project-description>

² Organizational *climate* should not be confused with organizational culture, although both are of interest to researchers attempting to study and facilitate organizational change. In particular, we usually think about climate being more understood by individual agents and reflected in their perceptions, as well as affording more immediate actions [86]. For example, an educator perceives that her department is welcoming of efforts to improve her teaching, allowing her to speak of her extensive teaching professional development activities engagement without fear of recourse. In many studies of postsecondary education organizational change, researchers will ultimately be interested in agents' perceptions and impact of organizational climate for improving teaching and learning. To measure this, we selected items from one subscale of a previously developed faculty teaching climate survey by Knorek [84].

Ongoing Analysis

In order to answer our second research question, *how can we study the potential for organizational change at a research university with respect to a campus-based STEM improvement initiative*, interview transcripts and qualitative data from the faculty survey were 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 intend to analyze and present findings in light of various theoretical lenses and implicated questions.

In this paper, we largely focus on methods that allow us to explore department context, in relation to individual educators and the larger organizational (institutional) contexts, uncovering the potential for organizational learning, opportunities for collective sensemaking and concerted action, educators' cultural models, and understanding affordances for change. Given the complexity of our organizations, we have determined that analysis and presentation of findings will be enhanced via departmental-level case vignettes. Towards presenting our findings about the current state of the system, in a way that both speaks back to our analytical conceptual-model and answers our research question, we frame these department level cases around questions grounded in our theoretical perspectives and answered using the summaries and claims from the previous analyses of the interviews, as well as the educators' responses to selected survey questions as a way to ground claims from the interviews in broader data set of survey responses. The questions that are being used to construct the cases are provided in Table 3.

Two researchers are co-constructing cases of two departments, documenting that they are exhausting the data and previous analyses when answering each question. Once this is complete, the cases will be written based on the answers to the questions and the process each researcher used to generate the case will be merged and documented, so that they can construct the remaining independently. Once the cases are complete, the research team will use these cases as a final set of 'data' generated to answer the research question by looking within and across the cases to best understand the current state of the system.

In consideration of our research model, we believe that these vignettes will serve to answer our question concerning the potential for organizational change by examining the ways ideas become shared (using sensemaking as the mechanism for generating knowledge and organizational learning to explain how this knowledge moves within the postsecondary institution) within an organization comprised of structures and routines (in this case, a science department at a large research university), how educators in the department collectively make sense of concepts (cultural models), and how ideas held by agents do or do not translate into individual and collaborative actions and decisions. In addition, the story also explains how one department interacts with other STEM department and with the institution as a whole.

Table 3: Analytical questions being used to construct the department-level cases in future analysis

<p><i>Context</i></p> <ol style="list-style-type: none">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? <p><i>Organizational learning</i></p> <ol style="list-style-type: none">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? <p><i>Collective sensemaking and concerted action</i></p> <ol style="list-style-type: none">6. What organizational routines hold the potential for collective sensemaking and subsequent actions and decision making around teaching practice and student learning? <p><i>Educators' cultural models</i></p> <ol style="list-style-type: none">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"? <p><i>Affordances for change</i></p> <ol style="list-style-type: none">8. What are perceived affordances and barriers to enacting new teaching practices, and/or making other changes that impact teaching and student learning?
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Concluding Remarks

In this paper, we argued for a multi-theoretical research model that can predict and explain organizational change in postsecondary education organizations in the context of an education change initiative. This model attends to the ontological, epistemological, and methodological challenges uncovered in the pertinent literature. We believe we have created a research model that supports the development of a practical theory to be used by others working on similar initiatives. The model we put forth was grounded on a review of literature on organizational change writ large, and in postsecondary education specifically. This targeted review informed both our ontological perspective on formal PEOs, our epistemological perspective on studying change in postsecondary education, and related methodological strategies.

Our multi-theoretical research model remedies noted ontological, epistemological, and methodological challenges to studying change in postsecondary organizations. Our work attends to concerns with how education research suffers from adequate detail regarding *design*,^[86], including that of research models guiding research. We detailed and critiqued common research models concerning organizational change and heeded the calls of others arguing for consideration of multiple theoretical frameworks to inform exploration of organizational phenomena, including those concerning postsecondary education^[63, 87].

Specifically, we believe our research model will allow us to investigate the potential and realization of organizational change at our university, in light of an intervention meant to improve teaching and learning. We hypothesize that our model will allow us to ascertain relative prevalence and strength of certain factors indicative of potential for organizational learning, a key necessity for our initiative's success. Still to be determined, however, is whether such data can inform project leadership of the current and evolving state of the organization and its various constituents and processes, ultimately towards intervention improvement. We already have some insight into individual and collective schemas regarding teaching practices, structures (disciplinary and inter-disciplinary social networks that concern 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 leader goals. Project leadership may then revise 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. As highlighted in Henderson, Beach, & Finkelstein^[20], 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. Still to be determined is whether such attention to organizational complexity over time is ultimately worth the resources it commands.

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