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Joel Smith – joelms@cmu.edu
Lauren Herckis – lrhercki@cmu.edu

EXECUTIVE SUMMARY

This research was motivated by an interest in making implementation of evidence-based innovations in instruction using technologies easier for and more attractive to university faculty. Many who have worked in the field of technology enhanced learning (TEL) over the last 30 years has experienced a frustrating dichotomy. One the one hand, the increasing collaborations among faculty content experts, learning scientists, and technologies have produced significant innovations in instruction with measurable improvements in learning. On the other hand, many (if not most) of these innovations have relatively short lives and seldom propagate beyond the research, development, and initial implementation stages. As a substantial body of literature sited in this report documents, even demonstrably effective, evidence-based TEL instructional innovations face significant roadblocks to widespread implementation and sustainability.

Carnegie Mellon is a university with a particularly rich history in research and development of TEL and other instructional innovations. It has also experienced a surprising lack of adoption and sustainability of many of these demonstrably effective innovations. Although previous studies have revealed some of the roadblocks to TEL implementation that we have observed at Carnegie Mellon, our sense was that complex factors that inhibit broader adoption remained unidentified, factors often referred to only in general terms as "institutional and cultural factors." For this reason, we were motivated to adopt research methods that have typically not been brought to bear in this domain – mixed qualitative and quantitative methodologies from the field of anthropology – to add to the current understanding of what gets in the way of evidence-based innovations in instruction in higher education.

We sought to understand the culture of Carnegie Mellon on its own terms, with an aim to understand, assess, and constructively critique. There are implications embedded in this research for both this institution and for others, though the singular nature of ethnographic efforts is a caution against generalization of the particulars. An investigation conducted at a single institution can teach us how to read the lay of the land and how to understand relationships between different types of landmarks, figures, and structures. The import and intersections of these relationships can and should be meaningfully extrapolated to inform our understanding of other landscapes. The particulars of relationships identified through these methods, however, are unique to the people, and places, and moments themselves. We look forward to a time when the kind of research reported here is a more widespread and regular feature at other colleges and universities so that that similarities and differences across institutions can be more fully understood.

This report describes the research methodologies, the results of the research, and some policy and process recommendations that would seem to follow from the results. Our section entitled "An Anthropological Approach to Understanding the Adoption and Use of TEL Resources in Higher Ed" explains the mixed-methods research approach designed and implemented by Dr. Lauren Herckis, one of the principle investigators. This research revealed factors operating in the development of and transfer to TEL-based innovations that both validate findings of previous students *and* identify causes of failures in implementations that have previously either not been identified or, perhaps, have been underappreciated in terms of the degree to which they affect outcomes. To be doubly clear, our research and results were *not* directed at the

instructional effectiveness of instructional innovations. Instead, our focus was on the dynamics of *efforts to implement TEL-based instructional innovations for which there is already evidence of effectiveness*. Our goal was a better understanding of problems in *implementation*.

Simply put, we used a range of research strategies including faculty surveys, ethnographic studies, and semi-structured interviews. The latter were conducted with both faculty and professional staff who support faculty efforts in instruction and technology-based innovations in instruction.

Our section entitled "Results" reports what we learned about roadblocks *and* affordances to the implementation of evidence-based TEL strategies at Carnegie Mellon. As we say in that section, key findings focus on relationships: the relationship between faculty and their craft, the attempts of individuals to manage numerous tasks which require amongst them a tremendous breadth of expertise, the downstream effects of organizational and institutional structures on decision-making at multiple organizational levels, and some of the specific ways that institutional silos create unrecognized barriers to effective collaboration. Because of the importance of detail and contextual interpretation, or what Clifford Geertz, referencing Gilbert Ryle, once called "thick description," we urge the reader to take the following report of the results in this executive summary for what it is: a set of pointers to the more detailed accounts in the full report which follows.

A selection of our key findings includes:

- Because effective TEL-based instructional innovations typically involve collaboration among individuals with diverse expertise, roadblocks created by *these specific kinds* of collaborations are significant. For example:
    - Collaborators with different kinds of expertise and interests easily develop disparate understandings of the goals of an implementation *even when there is apparent agreement on explicit statements of the goal*.
    - Unrecognized miscommunications among collaborators lead to disagreements about a surprisingly wide range of key pieces of an implementation, e.g. about "what went wrong" in a particular instance of the use of a learning module.
    - The variation in priorities of the participants in particular projects often fail to map to the time available for the implementation, with resulting failures of coordination of efforts necessary to bring projects to completion.
    - Participants in such collaborations engage in constant renegotiations of their role in the project.

- Projects that are guided by a champion for that project who can deal with the complex communication issues are more likely to succeed. A collaboration that isn't guided by such an individual or process that addresses the kinds of nuanced miscommunications and misunderstandings described above is unlikely to produce a successful implementation of a TEL instructional intervention.

- Faculty identities feature teaching as a strong and sometimes primary component, even at a research-intensive university like Carnegie Mellon.

- Faculty typically form a very strong mental model of what constitutes quality instruction in their discipline, *based on their own personal educational experiences*.

- This model a) is rationally constructed from their own positive learning experiences with one of their instructors and b) is difficult to displace, *even with evidenced-based alternatives*.
    - We found these mental models of "good teaching" can be grouped into four, not mutually exclusive categories of preferred approaches to good teaching: relational, content-focused, measurable, and practical.
    - The models are associated with personal feelings about what it means to be a good teacher in one's discipline.
    - If advice about how to teach conflicts with these personal feelings about good teaching, faculty are likely to reject it even if it comes from scientific studies of effective instruction and improved learning.
    - Conversely, faculty are more likely to adopt new ways of teaching which are compatible with the specific tenets at the core of their instructional identities.

- The importance of being a "good professor" contributes to risk-averse teaching strategies and creates tension around the already-fraught subject of evaluation.
    - Faculty are very reluctant to make changes in instruction that constitute a risk to student satisfaction.

- One reason evidence-based TEL innovations don't spread is risks that faculty perceive to be associated with participating in such implementations. There are at least the following perceived risks:
    - Diminishing student satisfaction.
    - Wasting student time.
    - Displaying lack of competence if technology fails when using it in an instructional setting.
    - Suffering professional setback or even loss of employment because of a diminution in student satisfaction or a display of what is perceived by others as a lack of competence.

- Implementations of instructional innovations with TEL in an instructional context engage different cycles of a complex system that are out-of-sync. Typically, these cycles don't "match up" in a way that would make implementations of evidence-based TEL innovations easier for faculty.
    - One cycle involves each individual faculty member's journey on an academic career and the associated personal professional development.
    - Another cycle involves the institutions choices about how to fund and deploy resources (e.g. teaching centers) to support faculty teaching.
    - Another cycle involves the technological infrastructures available to faculty and support staff to create TEL innovations.
    - Another cycle involves changes in available technologies that is largely beyond the control of educational institutions and of faculty.

- Personal networks of support for implementation of innovation can be more important to faculty than the institutional resources.

- Faculty are aware of misalignments among three different views about the importance of their teaching:
    - The university's position on the importance and nature of quality teaching in the institution's mission statement.

  - Their departments position on the importance and nature of quality teaching as reflected by how teaching is views and supported in the department.
  - Their personal views on quality teaching.

A failure of these three views to align affects faculty's willingness to engage in instructional innovations.

POLICY AND PROCESS RECOMMENDATIONS

The body of this research report does not contain such recommendations. It is intended to be a report of *research findings*. However, in this executive summary, we suggest some recommendations that we are considering at Carnegie Mellon and which seem to follow fairly naturally from our findings. Here are some suggestions:

- TEL development projects and "hand-offs" of a successful implementation to new implementers should both include processes for exposing, discussing, and understanding the particulars of the intervention and its utility for effective instruction. If an effort to implement a previously successful technique is staffed by individuals with widely varying models of quality instruction, this research suggests its chances for success and sustainability are low. If an effective TEL intervention developed by a group with well-aligned models of good instruction is handed off to a new instructor with very different views about quality teaching, it also is unlikely to survive the transition.

- An implementation project needs a champion or some clearly defined processes for managing the complex communication and renegotiation of roles of the kinds described in this report.

- An open recognition that however much we might prefer measurable learning gains to be the dominant factor motivating faculty, they may not be. It is important to acknowledge and manage the fact that student satisfaction and other aspects of student experience are very important to faculty, and to manage how this fact will affect efforts in TEL implementations. Specifically, managing student satisfaction through initial implementation that are bound to encounter problems seems vital.

- An institutional effort is needed to align university-level statements about teaching with department-level statements, institutional policies, and structural support for teaching faculty. Such alignment affects faculty willingness to implement new teaching practices.

- Our most general policy suggestion is directed at higher education in general as well as at individual institutions. This study is about factors affecting successful *implementations* of TEL interventions that are evidence-based to start with. The problem we sought to better understand is *the translation of results from research on instructional effectiveness into classroom practice*. We believe this is quite similar to a problem recognized 25-30 years ago in medicine: results from research on effectiveness of treatments were not being translated to clinical practice to the degree hoped. In response, the medical community, led by the NIH, embarked on an effort to study implementation practices. This has grown into an ongoing enterprise within the

medical community know as "implementation" or "translation" science. That is, medicine recognizes that achieving widespread, successful implementation of known effective treatments requires them to study the broad range of contexts, practices, beliefs, etc. that affect the application of scientific results to clinical practice. The results produced by our limited efforts at understanding implementation roadblocks and affordances at Carnegie Mellon combined with the history of success of these efforts in medicine suggest that *higher education would benefit greatly from the development of a similar ongoing practice of implementation science for evidence-based educational tools and practices.*

FULL REPORT

MOTIVATION AND BACKGROUND

Questions on Campus

The motivation for this project was grounded in something of a paradox: faculty and teaching support professionals at Carnegie Mellon have been at the forefront of learning science for decades, developing evidence-based educational technologies, and taking pains to apply principles of learning engineering in the practice of teaching. Exemplifying this tradition, and the aegis under which the project described here took place, the Simon Initiative is a cross-disciplinary effort named for the late Nobel and Turing Award laureate and CMU professor Herbert A. Simon with a mission to leverage the research, technology, and human resources of Carnegie Mellon toward measurable improvement of educational practice. Great scientific strides and incredible ingenuity have sparked the innovation of proven tools and technologies for many years at CMU. Anecdotes about students learning more, in less time, with the help of dynamic new technology-enhanced learning (TEL) resources are recounted with tremendous enthusiasm. And so, the question was posed: With all of this ingenuity, enthusiasm, and research to back it up, why don't we see even demonstrably effective TEL approaches spreading much more widely and quickly at the university? Why aren't all kinds of academic efforts dramatically boosted—or even incrementally boosted— by innovative applications, cutting-edge technologies, and results from the learning sciences?

The sweeping promise of TEL resources in general has been described in industry publications, research, and articles for mass consumption. Proliferating innovations designed to improve educational experiences for faculty, students, and institutions have long promised to radically change the postsecondary landscape: Students will be able to learn more, faster. Marginalized populations will gain access to world-class educational opportunities. Faculty around the world will effortlessly and instantly deliver innovative, inspirational experiences, supported by technologies barely imaginable only a few years ago. Of course, there are the skeptics, and some educators are dismissive of the suggestion that technological tools might hold a transformative power to enhance learning.

Firm believers in the power of TEL resources to improve teaching and learning collaborated to initiate the project described in this report and solve the mystery. Funded by the Carnegie Corporation of New York, this two-year effort, entitled "Understanding and Overcoming Institutional Roadblocks to the Adoption and Use of Technology-Enhanced Learning Resources in Higher Education" had twin goals of 1. Explicating institutional roadblocks to instructional innovations using TEL and 2. Identifying potential policy levers and strategies to facilitate the

adoption and use of TEL resources in higher education. That project, and its outcomes, are described in this internal report.

A Background for Understanding the Adoption and Use of TEL Resources in Higher Ed including Some Results from Prior Research

The literatures which touch upon the adoption and use of technology in higher education are too many to review comprehensively here. They span science of learning, the nature of technological innovation, the challenges of implementation, policy environments, organizational behavior, theories of change and change management, anthropology of higher education, and other disciplinary approaches to the problem space.

The nature and administration of higher education are a source of much reflection and analysis (e.g., Berg and Seeber 2016; Blum 2016; Bowen, 2013; Collini 2012; Donoghue 2008; Featherman 2014). The nature of teaching and learning in post-secondary contexts has been the focus of learning science, education research, and discipline-based education research, all of which seek to empirically define the ways that students learn and how best to teach concepts and skills to students of all kinds (e.g., Ambrose et al 2010; Foster, Bower and Watson 2002; Nilson 2003; Wieman 2017). This rapidly expanding field of inquiry has been matched by increasing recognition at high levels of interest on campuses and off. In 2012, the President's Council of Advisors on Science and Technology (PCAST) recommended that post-secondary educators "catalyze widespread adoption of empirically validated teaching practices" (AERA 2012). The proliferation of campus centers for teaching excellence and other kinds of support for faculty suggest a growing institutional will to bring evidence-based tools and strategies to the classroom.

The credibility of "evidence-based" claims and their route to implementation is tied to culturally-bound methods, facts, and disciplines. Complex conditions surround the uptake of innovations including the nature of the new scientific knowledge, information about the contexts in which data about evidence-based approaches are put into practice, and the associated rhetoric (e.g., Biagioli 1999; Hackett et al 2007; Downey and Dumit 1997; Eglash 1999; Jasanoff et al 1995; Latour 2005; Reid and Traweek 2000; Sismondo 2003). The processes of conducting research and developing concepts based on this research are fraught: they necessarily involve peer review and evaluation, as well as collaboration with colleagues, sometimes collaboration across disciplinary and institutional boundaries. Each such interaction carries challenges which have been explored in the broader literatures (e.g., Balakrishnan et al 2011; Chillana et al 2015; Cummings and Kiesler 2005; Ren et al 2008). The factors necessary to successfully shepherd a concept to realization of prototypes, and eventually to user-ready products, requires attention to a suite of factors most fully explicated in the business and marketing literatures (e.g., Cooper 2016; Wilkinson and De Angeli 2014). The social implications and cascading cultural effects of creation and sustained incorporation of technological innovation has been thoroughly explored in archaeological contexts, where anthropologists attend to the entire person-centered behavioral chain which engages with a concept, tool, or practice in a meaningful way from its origin through its abandonment (e.g., Bédoucha 2002; Kovacevich 2015; Lemmonier 2002; Quilici-Pacaud 2002; Skibo and Schiffer 2008; Winterton 1994).

The implementation of evidence-based instructional tools and strategies can be complex, and their translations from research conditions to sustained use in postsecondary instruction has been uneven. As a result, many tools and practices which have been proven effective are not widely used in instructional contexts (Folkestad and Haag 2002; Gannon-Cook et al 2009; Parthasarathy and Smith 2009; Reid 2012; Scheines et al 2005; Spodark 2003; Zemsky and Massy 2004). This gap persists in large part because of our limited understanding of the institutional and cultural factors embedded in implementation strategies and processes that hinder or promote the adoption of new instructional tools and practices. The organizational and administrative landscape can be challenging to disentangle and more challenging to navigate, and competing goals may further complicate administration and policymaking (e.g., Bate 1997; Bowen 2013; Rousseau 1990; Simon 1997; Spector 2008; Tierney 1988). Efforts to implement evidence-based instructional tools and practices are often guided by the uncoordinated and unreported efforts of researchers, universities, and commercial enterprises, leaving each new effort to reinvent the wheel. Organization-level research has special infrastructural requirements and challenges, but can return key insights into the effective implementation of tools and practices that rely on collaboration between multiple facets of the organization (Cortina and Landis 2013). Organizational factors influence the acceptance of—or resistance to—innovative practices, as well as the development of the new practices required to effectively and consistently maintain them (e.g., Barwick et al. 2009; Chamberlain et. al. 2008; Glisson, Schoenwald et. al. 2008; Proctor et. al. 2007).

Individuals and groups vary in resistance to or fetishization of technology (Hornborg 2017; Latour 1993, 2010), and in perception of technological innovations as the politically and morally neutral products of human ingenuity which can serve as effective solutions to social problems (Adas 1989, 2006; Marsden and Smith 2005; Friedel 2007; Headrick 2010). At the intersection of culture and materiality, a body of anthropological theory has recently explored the social, political, and economic relationships symbolized by, enacted through, and reconceptualized as technology (e.g., Hornborg 2014; Ingold 2000; Latour 1996; Pfaffenberger 1992). The appropriate role of educational technology in postsecondary contexts is the source of considerable debate. Expectations of students (Elmore 2010), efforts of administrators (Pittman and Edmond 2016), and institutional trajectories (Reid 2014; Spodark 2003) vary widely. Faculty expectations of new educational technologies rarely align with these to permit rapid adoption at scale (e.g., Orr and Pennington 2009; Parthasarathy and Smith 2015). This discussion takes place in a larger context of tremendous variation in the organization, goals, and priorities of institutions of higher learning (Boyer 1990; Braxton, Luckey and Helland 2002; Collini 2012; Twigg 2010), which in many ways obviates any effort to characterize *the* "role" or "utility" of "technology in higher education", when each of these categories is so dependent on context.

One focus of research has been the identification of effective tools and practices (Docktor and Mestre 2014; Hattie 2015; Healey 2000; Huber 2013; Lovett, Meyer & Thille 2008; Scheines, Smith, Leinhardt, and Cho 2005; Singer, Neilsen, and Schweingruber 2012); another has focused on the identification of barriers, affordances, and strategies for integration of these proven educational tools and strategies (eg, Foklestad and Haag 2002; Gannon-Cook, Ley, & Warner 2009; Parthasarathy and Smith 2009; Reid 2014; Spodark 2003; Weiman 2007); and a third has delved into extension and optimization of faculty and institutional support (Ambrose et al 2010; Beach et al 2016; Lewis 2015; Orr, Williams and Pennington 2009; Sorcinelli et al 2006; Wieman 2017).

Organizational change is slow, and uneven, and deeply tied to the contextual factors, including characteristics of institutional culture, which can be challenging or impossible for change agents

to identify or act effectively on (Chermak 1990; Collins 1998; Kezar 2014). Change does not come easily to complex organizations (Cameron 1991; Kezar and Eckel 2002; Schein 1985;), and organizational culture in higher education has unique quirks (Bate 1997; Bryk et al 2016; Kezar 2014; Tierney 1988). Theorists have developed archetypes (eg, Bergquist 1992) and approaches to assessing and transforming organizational capacity and readiness for change (eg., Backer 1995; Kotter 1996; Narine 2003; Sathe 1985; Weiner, Amick and Lee 2008), including in education contexts (Adelman and Taylor 1997; Kalman and Bozbayindir 2017; Kondakci et al 2017; Twigg, 2003). Cultural theories of change incorporate structures and systems of values, symbols, ritual, belief, and meaning, as well as traditions, history, identit(y/ies), political and policy environments (Kezar 2014; Schein 1985). Management science models, political models, social cognition models, live-cycle models, evolutionary models, teleological models, and other theories of change provide additional frameworks from which to understand organizational change, and in recent years it has become clear that multi-model theories of change stand to provide the most useful frameworks (Kezar 2014), and that understanding the intersection between different kinds of organizational change is often necessary to identify appropriate levers and to produce the kinds of second-order or deep changes necessary for sustained and pervasive shifts (Kezar 2014). Cultural models of change are most holistic and systems-oriented, but rarely provide the kinds of straightforward instructions or tools desired by theorists of organizational change. These theories of change are interesting but often viewed as impractical, complicating without providing accompanying clarity. The current study serves to further develop cultural models of change while also examining the intersections between cultural and other models of change in the interest of identifying potential policy levers and administrative strategies.

Theorists will continue the work of developing cultural models of organizational change in higher education, though theorizing culture is no simple undertaking. Culture cannot be measured with a yardstick, and dangerous misconceptions can result when brief explorations with good intentions fail to delve deeply into cultural systems. Ethnographic methods were developed by anthropologists with the express design to lay bare elements of complex cultural systems; we learn a great deal about culture through immersion and ethnographic exploration that we cannot through other methods, alone or in concert. This work adds to the existing landscape of insights a mixed-methods approach with a heavy dose of ethnography. A deep dive into the organizational culture of one university, this study employed anthropological methods and theory to holistically examine the populations, relationships, and systems instrumental in the success or failure of individual efforts.

AN ANTHROPOLOGICAL APPROACH TO UNDERSTANDING THE ADOPTION AND USE OF TEL RESOURCES IN HIGHER ED

The Anthropological Lens

Anthropology is the study of people. This holistic, systems approach to understanding cultural and social contexts, and, in particular, to understanding the roles and relationships of people and groups within those social contexts, can provide a unique perspective on the interactions of people, policy, and the materially constructed world that they inhabit. A suite of methods and theoretical perspectives lend themselves to this endeavor, particularly those which investigate and unpack power dynamics, economies, beliefs, and entangled social relations. Archaeological anthropology takes a material focus to the study of people in their cultural contexts. These material approaches underpin the new maker movement (Ingold, 2013) and have shaped the past decade(s) of theory and practice across a number of disciplines. Application of an anthropological lens, and particularly the incorporation of behavioral approaches to material

culture (eg, Skibo and Schiffer, 2008) in conjunction with ethnographic methods, represent a new approach to understanding the complex interrelationship of policy, practice, and educational technology in higher education (Pabian 2014).

Every effort to intentionally shape teaching and learning in postsecondary contexts consists of a sequence of distinct actions and decisions made throughout a behavioral chain which incorporates the many steps required to conceive, design, develop, adopt, adapt, and employ a technique or tool. Each action and decision made by individuals and groups in this sequence, as well as the sequence or behavior chain itself, is shaped by and in turn shapes properties and performance characteristics of the technique or tool (for examples, see Kovacevich 2015; Ogundiran 2014; Quilici-Pacaud 2002). Implementation efforts designed to affect change at scale necessarily require the coordinated actions of more than one person, group, unit, and team. Even though some individuals or work groups may conduct much of their work independently, they will still come into contact with, and be affected by, other individuals and work groups (Cooper and Foster 1971; Spector 2008; Winterton 1994). Efforts in complex institutions must take into account the influence of these groups upon one another. Consideration of the interrelations of individuals, groups, infrastructure, tools, and the ecosystem in which these elements interact enables the researcher to identify and examine characteristics that may not be measurable from the perspective of individual groups, projects, or actors within a collaborative effort. A frame of analysis which considers the entire behavior chain, without a perspective limited to or centered in a single link in this chain, enables the researcher to discover variables which are interstitial and holistic.

What is often missing in the current literature is a detailed decomposition of macroscopic variables, such as “control of intellectual property,” which play a causal role in generating barriers. In some situations, faculty interest in control of intellectual property is concerned with the degree of open access. In others, it focuses on seeking assurances of attribution of authorship, and in still others, it is related to the long-term rights to royalties. Going beyond the very general policy advice, “Deal with intellectual property issues early in a TEL project” requires ethnographic approaches of the kind described here in order to identify finer-grained causal variables (which contribute to the success or failure of interventions) than are typically found in the existing literature. Dr. Lauren Herckis designed and guided the execution of the mixed-methods anthropological research in this project.

Study Design

Ethnographic methods allow the researcher to paint a realistic and detailed picture of the landscape of goals, motivations, and expectations in which innovative teaching tools and practices are effectively adopted, as well as some of the challenges which projects might face. This work began with several months spent building rapport, becoming familiar with the relevant administrative, policy, and cultural contexts, and conducting unstructured interviews with informants. At the end of this initial period, a fixed multi-phase mixed-methods research design was conceived and initiated, entailing in-depth ethnographic observation of four projects with stated goals for developing and deploying technology enhanced tools for teaching. These efforts were variously described as course transformation, innovation, design, and development efforts. Subject selection was based on (1) inclusion in a grant narrative submitted to the Carnegie Corporation for funding this project; (2) scope of project (3) nature of collaboration; and (4) convenience.

Mixed-methods research has its roots in social and human sciences and has been widely employed across a variety of disciplines and in interdisciplinary research for several decades

(Creswell and Clark 2011). The integration of data collected through the complementary use of various qualitative and quantitative methods provides an opportunity for the development of agile research designs which (1) capture information with substantial breadth and granularity and (2) are responsive to a changing landscape. Nastasi and Hitchcock (2009) argue that mixed-methods research is the only way to explain outcome variations within and across layers of multilevel interventions and across contexts. Mixed-methods research can be used to answer questions or validate findings in contexts where qualitative or quantitative methods alone are insufficient, lacking in statistical power, or limited in scope (Palinkas and Soydan 2012). Mixed methods research offers a suite of ways to conceptualize, plan, collect, analyze, integrate, and interpret data (Creswell and Clark 2011). Mixed methods approaches are well-suited to take advantage of available rich sources of data relevant in the analysis of TEL integration in higher education.

The project employed a parallel-convergent study design in two phases. Multi-phase designs allow early analyses to inform later stages of the research, as one phase informs the next, and produces synthesized data which provides insights greater than the sum of its parts. In a first phase, ethnographic observation, interviews, case studies, digital ethnography, document analysis, and textual analysis were employed to thoroughly explore four TEL innovation efforts and their institutional context. During this first phase, a survey instrument was also developed and deployed to a larger population of faculty on campus. This hypothesis-generating study allowed the researcher to selectively focus on descriptive statistics and effect size, especially direction and relative magnitude of coefficients as suggestive of various models. Results from this survey were used to inform the direction and focus of components of the remaining months of ethnographic observation.

Ethnographic research in this study entailed direct and indirect observation; continuous monitoring of meetings with instructional development teams, classroom activities, and collaborative work; collection of documents and observations from digital contexts of interaction across several digital platforms (including Google Docs, Piazza, email exchanges, Skype communications, Google Hangouts, software development environments, and others); collection and interpretation of physical and electronic documents and analysis of their contents; and unstructured face-to-face interviews with key participants. Teams ranged from seven to several dozen collaborators and observation continued for one year. Grounded theory, a systematic, iterative approach to theory-building, guided data collection and analysis. Insights were derived from an open and responsive approach to data collection which allows participants to drive discussion and an organic exploration of emerging topics (Glaser and Strauss 1967; Strauss and Corbin 1990). This research component had twin objectives of (1) understanding the meanings that people ascribed to their own behaviors and (2) representing the lived experiences of participants from their own perspective(s). Particular attention was paid to interactions between individuals in which mutual understandings were negotiated through collaborative action around shared goals (Mead 1967). Continuous coding of data resulted in identification of core themes which informed script construction for a series of semi-structured interviews. Dr. Herckis came to this research after many years teaching classes in various college and university settings, and after having spent several years in careful consideration of teaching, learning and educational technology in higher education while she served in the role of teaching center administrator in charge of future faculty development. Throughout this research, special consideration was made of the role and import of reflexivity for a higher education 'insider' conducting ethnographic research (Clegg and Stevenson 2013). There are no names associated with descriptions of individuals, units or quotations in this report, and details of individuals, including the identifying details present in some quotations, have been changed to protect the

anonymity and confidentiality of those who participated in this research. Descriptions of individuals are composites where anonymity would otherwise be compromised.

A survey instrument deployed in February and March 2016 included items related to demographic characteristics and values related to scholarly activities. A vignette approach was used to create a fractional factorial component of the survey. This specialized technique requires the researcher to present respondents with vignettes that describe hypothetical social situations and ask for their judgment about those situations. Each vignette contains some number of variables with many possible combinations. A factorial survey design combines the validity of randomized experiments with the reliability of survey research and allows the researcher to measure subtle differences in opinion. This survey was deployed to faculty at an urban, residential campus. Results of this quantitative research complement the ethnographic data and provide insight into the populations and variables which comprise the landscape of barriers and affordances to the successful and sustained adoption of TEL resources.

Semi-structured interviews with interactive prompts were conducted with 30 faculty (here defined as one who teaches full-semester courses to students enrolled at the institution), staff (here defined as other university employees), and administrators (here defined as faculty or staff in supervisory positions). Interview scripts were designed to collect specific ideas about "good teaching" and what it means to be a "good professor", as well as to identify the considerations, information, resources, and expertise which are involved in making instructional choices. Semi-structured interviews with interactive prompts allow the researcher to gather information directly from those engaged in relevant activities. They also offer flexibility in that they enable important factors to emerge from the analysis rather than requiring a-priori specification. The semi-structured format for these interviews was based on an interview protocol which contained a series of prompts to explore important topics in depth. The interviewer remained open and flexible, in order to pursue important ideas that arose in the interview process but which were not contained in the prompts. Three sampling frames were identified following analysis of ethnographic component of the research: teaching faculty, tenure stream faculty, and support personnel. An interview script with interactive prompts was piloted with four individuals before being extended to 19 instructional faculty with tenure-track and teaching-track appointments, as well as an additional eleven full-time university employees who held a range of appointments in support of faculty instructional efforts. Snowball sampling using a purposive sampling frame with multiple entry points was used to identify respondents. Participants were selected from populations across the institution to ensure thematic saturation complementary to results of the ethnographic component of this research. Interviews lasted between 25 and 72 minutes. Interviews were transcribed by a contractor and identifying details were anonymized before analysis. Using a structural coding approach (Charmaz 2006), two coders employed open coding to identify preliminary codes. Coders operated independently and for several rounds of coding, each of which was followed by a period of review and revision. Data synthesis entailed refining themes and identifying codes via axial coding (Saldaña 2015). Connections were made across coded categories using both inductive and deductive approaches resulting in a codebook containing all synthesized codes with key findings and themes organized categorically. Application of codes by members of a team facilitated inter-coder reliability and subsequent inductive analysis (Thomas 2006).

Qualitative analyses of semi-structured narrative data allowed us to describe and then compare factors which facilitate or impede the development, implementation, adoption, and sustained use of pedagogically sound TEL resources at this institution. The qualitative analytic process employed here entails a series of distinct tasks. The first task involves setting aside any bias toward the text with the goal of avoiding hasty conclusions and preconceptions that might

unduly cloud the analytic process. The discovery of units of a qualitative text which are meaningful to the central research topic is followed by sorting these units into categories or "codes" which are then gathered in a qualitative codebook and applied to the transcribed interviews. This first phase of axial coding, based in grounded theory, involves making connections across coded categories through inductive and deductive approaches. A subsequent phase of analysis entails organizing all codes and direct quotes identified during the first phase into a relational database for reorganization. Once so reorganized, a second round of coding further decomposes coded categories and results in the discovery of additional nuanced themes and key findings. This is followed by the "connecting phase" of analysis, wherein the researcher strives to understand how codes interrelate and gain insight into the study's research question. The final task is the formal composition of the analysis, of what has been described as "representing the account." At this point, quotations are chosen that best represent the meaning of the codes and final arrangements of those codes are presented.

RESULTS

This internal report presents a summary of some major findings and explicates the relevant methods and theory. Comprehensive results are at various stages of publication, and are available upon request. The primary aim of this project has been to identify and describe barriers and affordances. Experimental solutions to perceived challenges were identified in the process, and a number of subsequent studies and trials are underway to explore how some of the roadblocks identified might be better managed. Though the results of this work have clear implications for practice, the outcome of this research is not a prescriptive set of guidelines. This work focuses on the various experiences of faculty, staff, administrators, and students at a single elite institution, which cannot be described as typical of even its most-like peers. We sought to understand the culture of this institution on its own terms, with an aim to understand, assess, and constructively critique. There are implications embedded in this research for both this institution and for others, but the singular nature of ethnographic efforts is to caution against generalization of the particulars. Anthropology as a discipline has a well-known affinity for cultural relativism. A project conducted at a single institution can teach us how to read the lay of the land and how to understand relationships between different types of landmarks, figures, and structures. The import and intersections of these relationships can and should be meaningfully extrapolated to inform our exploration of other landscapes. The particular relationships identified through anthropological methods, however, are unique to the people, and places, and moments themselves.

Each project examined for the current study was conceived in response to a perceived need, with at least one collaborator of the firm belief that actualization of the innovation would improve the experience or outcomes of educational efforts at their institution. Throughout this research, by design and by the nature of the researchers, we assume that people act with the best of intentions and the best interests of others in mind. **Key findings focus on relationships: the relationship between faculty and their craft, the attempts of individuals to manage numerous tasks which require amongst them a tremendous breadth of expertise, the downstream effects of organizational and institutional structures on decision-making at multiple organizational levels, and some of the specific ways that institutional silos create unrecognized barriers to effective collaboration.**

Worthwhile Efforts: Projects, Process, and Policy

Over the course of a year, the administrators, faculty, and staff involved in each effort shifted, as did the goals of each of the projects. As projects moved from abstract ideas to actualized

deliverables, people and groups with different expertise and resources took on different tasks. These projects required different kinds of work—some tasks took place concurrently and some necessarily took place after one another. **The most significant roadblock for all projects was weathering these collaborative efforts.** All projects required sequential task management, with multiple collaborators engaged together on individual tasks and with others on subsequent tasks. Imperfect communication or misaligned efforts resulted in frustration at best. Such misalignment frequently derailed projects and remained unidentified. In cases where misalignment exists but is not noted, people believe that they understand shared goals but in fact have different understandings of their roles or of the "shared" goals. In these cases, outcomes are not as anticipated, and collaborators don't agree on (or don't discuss) where the effort went wrong. Sometimes, all collaborators remained content with the outcomes of interactions and resulting products of collaboration, but these interactions resulted in conflicting expectations or intentions. In one such case, two collaborators had different understandings of underlying goals for an online module. Mismatched pedagogies had implications for the structure, format, and language of the module; for the way the module was introduced by faculty and encountered by students; for the utility of data collected from student engagement; for student experience; and for metrics of success. Such miscommunications can be challenging to navigate, but **the most destructive miscommunications are in fact experienced by all participants as successful, comfortable communication: miscommunication is unnoticed and has persistent effects on the collaborative efforts**. Transactions such as those between agents of innovation and those responsible for instrumentation; between those responsible for instrumentation and the process of customization for specific use cases; between implementers and adopters; and between pioneering users and secondary adopters are particularly vulnerable. The effort is often either won or lost in these interstitial, high-stakes transitions from one stage of an effort to another. At the same time, players and conditions at each stage are often affected differently by policy and other contextual factors, and these factors can be difficult to measure: Stated priorities do not always map to allocated time. Some motivations are considered inappropriate to state publicly, and therefore go unreported. An adept champion who is motivated to move the project from one phase to the next can shepherd efforts successfully through these challenges. In these fraught transactions, a champion can mediate interactions and mitigate risks of coordination, communication, and collaboration. Efforts which do not have the benefit of individuals or tools to facilitate collaborative progress were more likely to stall as a result.

These projects each involved at least fifteen collaborators and varied in key characteristics too many to enumerate. A partial accounting includes characteristics of the concept or product (product here may refer to a process, protocol, tool, or other TEL intervention). These include different originators of each concept; its inspiration and originality; target pedagogical role and disciplinary context; mutability, reliability, and complexity of the product; measurability of product intended effect(s); presence, measurability, and relevance of secondary and unintended effects; incorporation of commercial elements; and perceived quality and value by faculty, administration, end user(s), and colleagues.

Characteristics of the collaborative efforts themselves were also significant: The disciplinary background, structure, and management style of project leadership; formality of collaboration; shared understanding of collaborator roles and contributions; funding source, if any; economic, social, and intrinsic reward for participation and/or completion of the effort; variability of collaborator investment and experience; administrative organization and context; spatial distance, technical expertise distance and variability of goals among collaborators; mode(s) and frequency of communication and coordination among collaborators; ownership, copyright, and patent considerations; and shared understanding of objectives. A single situation might be

interpreted differently by different participants, a challenging and sometimes painful reality which poses a threat to the sustained effectiveness of many collaborations.

Characteristics of key project personnel varied in meaningful ways as well: These include prior experience with cross-disciplinary collaboration, TEL resources, and teaching; professional age, appointment type, and technical expertise; self-confidence and formal training in pedagogy; preferred characteristics of collaborators, prior experience with collaborators, and personal goals for professional collaboration; value ascribed to various kinds of scholarship, including discovery of new disciplinary knowledge, scholarship of teaching and learning, application of disciplinary expertise, and integration of expert knowledge into practice.

The cohort of participants in each of these projects was fluid throughout the period of study. Those participating in a project at any given time described their roles in a wide variety of ways, from concretely inclusive "*my* project is…" or "*we* are planning…", to ambiguous "I think my role in this project *is supposed to be*…" "I don't know when *they* will call on me again…", and outsider "I don't know why I am not a part of that team…" "*They should have* called me in…" Each participant constantly (re)negotiated participation in a project and (re)negotiated his or her collaborative role. Sometimes this negotiation was formal and open, as when an individual had an explicit conversation with an administrator or project director in which preferred roles were discussed and decided. In other cases, this negotiation was internal and unexpressed, or even unacknowledged, as when an individual turned his attention to other matters and de facto disengaged from a project even as it continued without him. Many such decision points were effected by individual participants throughout the duration of each project. Thus the continuity of a project depended on continual, affirmative decisions to engage by key participants throughout a process. All participants had multiple tasks with which they could occupy their limited time, and so the decision to engage with a given project was fraught for the majority of participants. **Each participant was engaged in constant (re)assessment of the value of the project as a whole, and of their own participation in it. Exceptions were limited to individuals brought into a project by immediate supervisors to participate in clearly defined roles and/or on clearly defined tasks.**

Collaborators are often engaged with efforts in loosely defined ways. When roles, responsibilities, and goals are fluid, this **soft membership** confers flexibility which allows motivated individuals to make significant progress independently and promotes creativity and innovation. This flexibility also, however, leaves space for hesitance and exclusion. Some individuals may feel they have the right to take initiative when more senior collaborators have not explicitly granted such permission; others feel that they are not "real" collaborators, even when they are considered core personnel by others; still others may feel deliberately excluded when they have not been explicitly drawn into an aspect of the collaboration that they are suited for or interested in. When roles and responsibilities are made explicit, on the other hand, the deliberations required to create **hard membership** and define roles and responsibilities are often perceived as rooted in mistrust of collaborators, a desire for power, or a lack of respect for collaborator skills and autonomy.

Some collaborations require hard membership, with clearly defined roles and responsibilities, at one level and soft membership at another. Hard collaborators may include core collaborators and a hierarchy of management, while soft collaborators are drawn in for consultation or for specific tasks on a case-by-case basis. Institutional hierarchies may lend a collaboration the formality of hard membership, even when prescriptive participation isn't intended. Hegemonic approaches to team-building promote innovation and invite motivated participation, but require soft membership: mandated collaboration is often the enemy of motivated innovation.

Maintenance of institutional hierarchies and the performance of collegiality in collaborations often takes place through veiled comments which embed assessments of collaborators' professionalism, competence, priorities, and goals.

Good Professors: What Is Good Teaching?

Faculty consider postsecondary education central to their personal identity, though this means different things to different people. We can characterize six distinct kinds of mental models of the kind of professor that faculty strive to be. Since these mental models are central to personal identity, faculty frequently reject approaches to teaching which are not in harmony with their mental model of good teaching even if these approaches come highly recommended. These mental models can be categorized along two axes: an **innate/learned axis and an experiential axis**.

On the innate/learned axis, there are two poles. First, those for whom teaching is something that must come from a private wellspring, "from the heart" and learned "by intuition." These innate mindset individuals may believe that teaching skills can be honed, but do not believe that they can be taught. Such professors describe themselves as "a do-it-yourself guy" and "born to teach." Many are aware of empirical research on effective teaching, but generally approach these findings with skepticism. A second group of faculty believe that instructional skills can be learned and taught. These learned mindset faculty often seek out new methods and approaches, advice, research, and mentorship.

On the experiential axis, faculty associate "good teaching" with different kinds of learning experiences. These fall into **four categories of experience: relational, content-focused, measurable, and practical**. Faculty often described "good teaching" or what it means to be a "good professor" by referencing personal formative experiences, such as relationships with parents or their own inspirational teachers.

Relational models of good teaching place a primary focus on interpersonal emotional bonds. When asked what makes someone a good professor, faculty with relational mental models of good teaching respond with stories about personal relationships in which they felt like they grew: often, these are relationships with parents, mentors, and beloved professors. These faculty tend to stress a feeling of emotional connection as the central characteristic of good teaching.

Content-focused models of good teaching place a primary focus on the organization and delivery of disciplinary content. When asked what makes someone a good professor, faculty with content-focused mental models of good teaching describe passionate lecturers, organized presentation of problems, clear language, or the centrality of specific content. Learners are described as recipients of instructors' wisdom. These professors tend to describe an "ah-ha!" moment in which important ideas, usually concepts central to their discipline, become clear.

Measurable models of good teaching place a primary focus on quantitative data, especially student performance on tests, faculty scores on student evaluations of teaching, and assessments related to mastery of learning outcomes. These faculty trust the numbers to tell them what is working in the classroom, and what is not. Many tell stories in which their own ideas about how learning is accomplished were subverted or revealed to be incorrect. These faculty place their faith in external measures.

Practical models of good teaching place a primary focus on experiences in which the student learns through active engagement in an experience which makes an impression. Faculty with

practical mental models of good teaching describe formative learning experiences in which they were trying new things, engaged in unfamiliar tasks, guided by those with more expertise, practicing skills, or otherwise actively grappling with their own lack of mastery before improving and experiencing a sense of accomplishment.

These models are not mutually exclusive, though faculty generally represent one of these combinations as their primary orientation. A mental model held by a particular faculty member will impact his or her priorities and proclivities when it comes to teaching. For example, a faculty member who espouses an innate, practical mindset may view her role as selecting the best challenges for her students to face, and then requiring her students to face and grapple with those challenges. In this mindset, she has spent her career curating appropriate challenges, and the suggestion that she might improve her teaching by working with someone who is not as uniquely equipped to identify the correct challenges—due to a lack of disciplinary expertise, theoretical orientation, or teaching experience—is likely to be viewed as a waste of time. A faculty member with a learned mindset who focuses on measurable outcomes might actively seek novel approaches to teaching, but reject suggestions which do not have a readily or rapidly measurable impact. It would be more palatable to try a flipped classroom for one unit of a course, for example, than to commit to a flipped classroom for the entirety of a semester. After one trial unit, if outcomes are (measurably!) worse, the remainder of the semester can revert to tried-and-true methods with predictable outcomes. A more extended commitment comes with a perceived risk of learning after the fact that the course as a whole had returned disappointing results.

Faculty strive to perform "good teaching", and feel good about themselves when they do. Different mental models of good teaching lead faculty to focus on different aspects of instruction. **When advice about how to teach contradicts personal feelings about good teaching, faculty often reject evidence-based methods.** For faculty with an innate mindset, a new teaching practice, however minor the adjustment, must be compatible with the ideas central to their identity as a teacher if it is to be seriously entertained. If a professor thinks that exuberant enthusiasm is the most important characteristic of a good professor, a mode of teaching which makes it impossible to emote (text-based distance education, for example) is incompatible: that faculty member is likely to say that text-based distance education is missing a necessary ingredient of good teaching.

Faculty with a learned mindset are by definition more open to innovative ways of teaching. Because these professors tend to have a very specific idea of how students learn, however, they are most receptive to new ideas about teaching practice that do not compromise the characteristics central to their mental models of good teaching. For example, a faculty member who feels her role as a professor is to provide students with opportunities to try something new, fumble, improve, and recognize their own growing mastery may spend a great deal of time designing and directing a service learning project. She is less likely to spend time quantifying or analyzing learning outcomes. If someone told her that her students would benefit more from her time spent quantifying learning gains than her time spent developing a service learning project, she would probably disagree. If she were told by an administrator that she must spend time quantifying learning gains instead of developing a community action project, she would likely ask the administrator to reconsider.

Faculty are more likely to adopt new ways of teaching which are compatible with the specific tenets at the core of their instructional identities. These core tenets might include modes of instruction, philosophies of teaching, centrality of relationship-building, and willingness to explore alternative approaches to engaging with students. The importance of

being a “good professor” contributes to risk-averse teaching strategies and creates tension around the already-fraught subject of evaluation. As a result, faculty are much less likely to innovate in ways which risk student dissatisfaction and/or fail to align with personal philosophies of teaching. In a majority of the cases described above, faculty (sometimes unconsciously) strive to replicate the teaching and learning experiences that they found inspirational or impactful as students. However, our students are not ourselves: university faculty overwhelmingly teach college students who are not likely to become university faculty or researchers. The educational experiences which inspired these faculty will not necessarily be received the same way by their students.

Good Professors: What Role Does Teaching Play?

A decision to incorporate new TEL is a decision to take a risk. When faculty adopt a new educational practice or technology, they are entering into new territory. Even if the TEL in question has been tested in laboratory and in natural classroom conditions, even if a trusted friend and colleague has used it and vouches for it, even if the TEL has been used in the context of the same course of instruction with students from the same institution, the incorporation of new-to-the-instructor technology entails a learning curve and adaptations of the TEL for a novel classroom context, which will require some unknown (and, to some extent, unknowable) amount of time to realize, with some unknown (and, to some extent, unknowable) degree of uncertainty of the effect of incorporation. The implementation of new TEL implies immediate risks (eg, it fails to work as anticipated) as well as risks of downstream effects. Even a one-time-use intervention can have cascading effects on other aspects of a course: differences in mastery of skills which rest on earlier mastery of knowledge or skills introduced or practiced with TEL earlier in the semester; student frustration with one class meeting or module translating into student disengagement later in the course; etc. These risks include many disasters faculty imagine ("You’re going to have to know how to use this system well enough that you’re not an embarrassment to yourself, in front of your students") and the understanding that some challenges can’t be anticipated in advance: “it” never works perfectly the first time (“To just get the technological tools, the computer programs running smoothly and without bugs, this is not trivial… You can't do this in one fell swoop.”)

Mental models of “good teaching” vary, but faculty commitment to good teaching is often entangled with ideas about self-worth, effective personhood, professional goals, and personal fulfillment. Student evaluations of teaching play a role in review, promotion, and tenure decisions despite concerns about validity and reliability (eg, Aleamoni 1999; Anderson, Cain, & Bird 2005; Balam & Shannon 2010; Chen & Hoshower 2003; Clayson 2009). Faculty desire to receive good evaluations of teaching may in part be motivated by promotion and review, and evaluations are also perceived as opportunities to learn how well they are meeting their personal and professional goals related to teaching and mentorship. For many faculty, the best indicator of whether they are good professors is student response to their teaching. In formal and informal contexts, did students express (or appear to experience) satisfaction, inspiration, or other desired outcomes as a result of my instruction or mentorship? When students are favorably impressed by their educational experience, faculty they thank often feel as though they have done well personally and professionally. This is both gratifying and affirming. When faculty believe that students are disappointed or have unfavorable views of them as individuals or as professors, this is often deeply troubling and disheartening. Many faculty described dread and dismay at reading negative comments in student evaluations of teaching. Student evaluations of teaching may play a role in promotion and tenure, but they also play a role in the emotional wellbeing and self-efficacy of faculty. If one risk of innovation is student dissatisfaction,

administrators may promote innovation by taking the resulting student evaluation data out of consideration in review and promotion decisions. However, if faculty are primarily interested in satisfied, inspired, educated students, obviating student evaluation data has little effect on faculty aversion to disappointing, boring, and failing to effectively educate those same students.

How often do faculty undertake the risks inherent in innovation? More than half (N=113, or 55%) of respondents to a survey of faculty who had taught the same course more than once reported incorporating a new TEL intervention in the previous three years. Most of these (105 out of 111 respondents or 95%) reported that the intervention represented an improvement. A third of respondents who taught the same course more than once in the previous three years (N=69, or 34%) indicated that they had innovated a technology, component, program, or module of their own design for use in the course. More than a fifth (N=47, or 23%) indicated that they had used a technology, component, program, or module of someone else's design, adapted for their own purposes. Nearly as many (N=43, or 21%) reported using a technology, component, program, or module of someone else's design, off the shelf. Of faculty who incorporated an original TEL intervention (N=67), nearly half (N=33, or 49%) designed the new technology, component, program, or module with collaborators. Faculty with greater professional age were less likely to experiment with changes to format or goals of assignments or to adopt TEL of someone else's design. With every year since degree, the odds of changing the format or goals of an assignment or assignments decrease by 4% and the odds of adopting TEL of someone else's design, without modification, decrease by 49%.

Mental models of good teaching predispose faculty to more readily accept even evidence-based tools, practices, and materials when these novel interventions are compatible with expectations and personal experience. Resistance to the incorporation of novel tools and approaches which are less compatible with mental models is often subtle or even unconscious. If faculty believe that well-constructed, engaging content delivery is the defining feature of good teaching, they are less likely to accept a loss of control over content delivery (as through mandated textbook use, prerecorded lectures, etc.) even if they maintain full control over practice opportunities, assessment and any other aspect of instruction. This same faculty member may readily incorporate homework assignments, exams, or other components of instruction which do not play a central role in his or her model of good teaching. Evidence from pedagogy research does not impact faculty predisposition to accept some kinds of interventions over others, when the change conflicts with strongly held mental models of good teaching.

Faculty understanding of the role(s) of teaching in their personal and professional lives and identities are complex and varied. Faculty models of teaching and teaching practice, and decisions about acting in accordance with these personal views and values, are embedded in larger considerations of research, service, reputation, and other professional obligations, as well as personal, lifestyle, and work-life balance considerations. Faculty guard their time fiercely but haphazardly: Time is seen as a precious resource, and many professors have structured approaches to deciding how to allocate time to different tasks. Decision-making about the allocation of specific increments of time to specific tasks is often influenced by myriad factors, however, leading to inconsistent allocation of time on a day-to-day and semester-to-semester basis. Teaching accounts for a theoretically fixed percentage of faculty effort, but in practice this percentage is inconsistently associated with actual time dedicated to teaching-related tasks (Ziker 2014; Ziker et al, 2017). Ideas about the best use of this teaching-allocated time varies with the prior experience of the faculty (eg, novices devote more time to tasks which they later learn to perform more efficiently or are later able to delegate, and a course offered by the same person more than once benefits from lessons learned and materials developed in earlier iterations of the same course), with the nature of the course (especially, the degree to which

grading and feedback require focused attention from faculty, and whether a course is delivered electronically, face-to-face, or in hybrid format), with the appointment type and career stage of the faculty (eg, tenure stream, teaching track, and contingent faculty; pre-tenure, recently reviewed, and so forth), and with the ways and degree to which boundaries are drawn around teaching and other aspects of professional and personal lives. Some faculty describe teaching-related tasks as competing for time exclusively with other professional responsibilities, such as writing and research-related tasks. Others describe the challenge of deciding how to allocate time to professional and personal tasks, as in the case of a faculty member who said,

"I would be willing to spend some time on it, but not a lot. Pretty little, you know? What I can do in the 40 minutes every couple of days between when I put my three-year old to bed and my wife puts the four-year old to bed, when it's her turn to do the four-year old and my turn to put the three-year old to bed. Things that I can do off and on like that, I would be willing to spend a little bit of time. But if it went beyond 20 minutes here and there, ramping up to 22 minutes here and there, then I wouldn't want to commit to that."

Good Professors: What Role Do Faculty Play?

There is a common myth that faculty (at research institutions in general) view teaching as a distraction or a nuisance. Faculty are rewarded with course releases and bemoan the time that teaching-related tasks take from research: in these and other ways, the subordination of teaching to research is reinforced. **This time allocation and reward structure institutionalizes teaching as relatively less valuable than research activities.** Our research revealed that faculty members, as individuals, are deeply committed to excellent teaching. It is important at this juncture to distinguish the practice of teaching from the scholarship of teaching. Faculty place a high priority on the practice of teaching, take pride in their role as teachers, and strive to teach well. This was a pervasive and powerful theme that ran throughout all phases of research: **faculty identify as professors, and faculty identities feature teaching as a strong and sometimes primary component.**

Prioritizing the practice of teaching does not mean that faculty place a premium on measurable teaching excellence or on scholarship on the subject of teaching. As discussed earlier, faculty conceptualize teaching a number of different ways; only some of these models feature measurable assessment of teaching excellence or teaching as a site of scholarship. Many faculty explicitly distinguish good teaching from each of these, stating that no measure of teaching excellence can capture the ineffable qualities which make good teaching good, or that they are not experts in teaching (or pedagogy, or scholarship of teaching and learning) and therefore cannot make definitive statements regarding the nature or assessment of good teaching in general. Some faculty are primarily interested in the development of doctoral students and disdain undergraduate instruction, while others feel most engaged in the delivery of large introductory lectures. The perception of institutional prioritization of teaching was a significant source of conflict for some faculty, especially those whose concept of "good teaching" requires significant investment of time or scholarly productivity less compatible (or incompatible) with the institutional reward structure.

Survey questions included 25 values-related items drawn from the Faculty Professional Performance Survey (1999, 2000, 2002), which shed light on the priorities and perceptions of faculty. These include measures, at the individual and institutional level, for scholarship of discovery and scholarship of teaching. The value that individuals place on scholarship of discovery is based on participant responses to the statement, "I value research that leads to new disciplinary knowledge", are scored from 1 ("Strongly Disagree") to 4 ("Strongly Agree"). The

value that individuals place on scholarship of teaching a composite variable, based on responses to questions including, "I value scholarship that contributes to the improvement of college teaching." The corresponding institution score reflects faculty perception of institutional values; it derives from questions such as, "At my institution, scholarship that contributes to the improvement of college teaching is valued."

	Research	Teaching
Institution	3.59	2.68
Individual	3.71	3.21

Mean scores are scaled from 1 (Strongly Disagree) to 4 (Strongly Agree). Differences in all means above are statistically significant. Faculty value the discovery of new disciplinary knowledge more highly than they do scholarship of teaching. But faculty do value the scholarship of teaching, and perceive a lack of similar institutional prioritization of scholarship of teaching. However, the esteem in which faculty hold the practice of teaching does not predict the esteem in which they hold scholarship of teaching: for many faculty, the scholarship of teaching and the practice of teaching are decoupled, such that one faculty member expressed a deep commitment to teaching and to teaching well, and less than a minute later stated that research on teaching is outside of his expertise and interest. Interestingly, perception of the institutional value of teaching did matter in allocation of faculty time: the greater the difference between institutional and individual value of scholarship of teaching—that is, **the more a faculty member perceives scholarship of teaching as a personal interest unshared by the institution as a whole, the more time that individual allocates to course improvement efforts.** Identifying causal relations in this correlation will require further research.

In consideration for hire, tenure, and promotion, scholarship of teaching is perceived as less valued, and therefore less valuable, than discovery of new disciplinary knowledge. This relationship obtains across appointment types, meaning that teaching faculty and tenure-track faculty alike share this perspective. As employees and professionals, faculty have key skillsets which can be detailed by hiring committees, human resource professionals, and others at the institution. The criteria on which faculty are evaluated for hire, review, promotion, and tenure vary from one role or department to another, and often include aspects of research, service, and teaching. The importance of demonstrating and exercising each of these skillsets, or component skills, varies with role: one faculty member may find mentorship and community engagement deeply rewarding, while understanding that his or her department, school, or institution prioritizes other tasks such as writing grant proposals, publishing results of research, or teaching large introductory classes over these preferred tasks. When personal goals, departmental priorities, and institutional mandates on teaching are not perfectly aligned, faculty often express regret or wistful resignation to the fact that they don't have as much time to dedicate to those tasks as they would like.

The centrality of postsecondary instruction in faculty personal identity means that faculty talk about being part of a university with pride, and center the development of students in their fields as a significant part of their lives. Many faculty are living their avocations and performing their passions. When institutional policy changes the ways that faculty engage with students or other instructional tasks, this touches a personal nerve. When institutional policy interferes with faculty performing these aspects of their identities in even minor ways, policies are often met with significant overt or covert resistance. The centrality of teaching to personal identity paired with the perception that scholarly tasks related to teaching are less valued than scholarly tasks

within one's discipline of specialization reinforce the primacy of personal experience in faculty understanding of what students need and how they learn. In particular, faculty frequently express skepticism about attempts to generalize principles of teaching and learning across disciplines.

Faculty who construct their models of good teaching based on their own experiences as students often explicitly or implicitly seek to recreate these personal experiences in their role as faculty. This implies a motivation to recreate formative relationships and/or formative moments which they themselves recognize as powerful learning experiences. Faculty can often recount an "ah-ha!" moment in their own scholarly development which they seek to foster in their students. This preference for certain kinds of relationships and prioritization of certain kinds of learning experiences leaves students vulnerable to selection bias. In some cases, faculty may support the narrowly defined group of students who exhibit familiar characteristics or with whom rapport is reminiscent of the faculty member's own relationships with instructors and mentors. Student learning is most readily recognized when it most reminds faculty of their own experiences of academic engagement as a student. In these cases, faculty may not recognize student dedication, skill, or talent if it does not trigger the "right" associations for faculty.

A structural disconnect exists between the roles faculty envision for themselves, validated through performance of "good teaching", and the roles shaped by institutional policy. This disjuncture reinforces an individual need for personal satisfaction and positive experiences of "good teaching" as distinct from, and sometimes at odds with, the requisite activities and metrics which play a central role in professional success.

Membership in a scholarly community, and the perception of faculty by others in their professional cohort—disciplinary colleagues, departmental colleagues, institutional colleagues, collaborators across multiple sectors—is additionally important to faculty self-perception and validation. Many faculty members believe that the discovery of new disciplinary knowledge is the highest professional achievement they may attain in the eyes of their colleagues. This is related to two phenomena. First, **faculty effort expended on improvement of teaching may be perceived as inappropriate allocation of time**. Second, scholarship related to college teaching is by definition scholarship which diverges from the disciplinary specialties and research foci of the vast majority of faculty. Therefore, **scholarship related to teaching excellence represents someone else's area, and many faculty are quick to recognize their own lack of expertise.** Faculty discussing research outside of their disciplinary specialty frequently express concern that others might perceive them as naïve interlopers, treading clumsily in others' domains of expertise, and lacking academic etiquette.

<u>Integration of Diverse Complex Systems</u>

Paces of Change

Universities are complex systems, composed of many units which often operate independently from one another. Often, this parallel autonomy provides flexibility of operation; it also increases competition between units for resources and recognition, and enhances "siloing", the isolation of these units from one another. Development of a teaching practice or resource happens in the context of one set of conditions. These conditions are determined by the current state of institutional facilities (eg, classrooms with movable desks or support for specific technologies), faculty involved, instructional goals (the way curricular goals align with course organization and preferred student outcomes), state of the discipline for which the resource is

developed (disciplines change over time in terms of relative import of subject matter, experiential learning, etc.), state of disciplinary knowledge in teaching and learning, state of the art of faculty development, availability of faculty or technological support (units like Centers for Teaching Excellence provide services and support which are ever-evolving), etc. When an evidence-based tool or practice is developed, it may produce better student outcomes. However, **some or all of these contextual factors will necessarily change** in time, and this state change may result in a poor fit for any given intervention, regardless of how effective the intervention in its development and test phases. With the passage of time, greater state changes result is more potential obstacles to fit. Tools and practices will require considered, constant updating or maintenance in order to maintain goodness of fit. After some period of time has passed, states will sometimes have changed so significantly that a practice or technology effectively maintained will have no resemblance to its original form.

This misalignment can have profound effects. Faculty uncertainty about the potential for future state changes results in reasoned reluctance to adopt methods which may lack necessary institutional support in the future. On the risks of adopting novel TEL, one professor said, "I used to use something called Flash, but Flash is outdated. Now there is Vimeo and other video websites that make it easy, but those are proprietary. Does the university own them? Often, if you use the free services, they're housed at their website. What happens if you leave?" On the risks of maintaining use of TEL which is established and supported, another professor said, "There was a decision by fiat. They did not talk to any of the faculty who consistently used video tape. They just said, "It's too old." They pulled all the VCRs. Individual departments who had instructors who frequently used video tapes, they just collected some machines. They still get used on a reasonably regular basis. But as far as the university is concerned, it was old technology and gone." When the context is complex and lacks temporal stability, informed choices about effective change can be bewilderingly difficult to navigate. **Adoption of any instructional technology leaves faculty vulnerable to the sudden loss of that technology for any number of predictable and unpredictable reasons.**

Time, Resources, Rights and Responsibilities

When it comes to balancing teaching, research, and other responsibilities, many faculty feel that they are constantly juggling, negotiating, and restructuring time and priorities. Each challenge is a new challenge, and so each faculty member is constantly looking for creative solutions to novel problems. **New teaching challenges require ingenuity, innovation, and efficiency, and many faculty feel that they can and should be able to find solutions both quickly and independently.** The university has a number of resources available to faculty who are faced with an instructional challenge. How do I put this course online? Would a graphical depiction of this relationship help students understand the principle better? How can I make my lectures more interactive? Would it be possible to show students an animated version of this thing I'm describing? Is there software which can help students with group work? Faculty who are faced with a novel challenge—a challenge they have not faced before—nearly all reach out to friends and colleagues with whom they have worked closely, or to faculty who have taught the course before. There are a multitude of resources available to faculty, including experts who can advise on technology, pedagogy, student needs, scholarship of teaching and learning, and more; resources for creating, improving, and sharing media; and more. Despite the availability of these resources, most faculty we spoke to considered these resources useful *when other recourse was not available*. Official campus resources were sometimes described as a failsafe: when nothing is working, perhaps an outside perspective will spark the needed creativity or suggest the kernel of a solution. In some cases, faculty described utilizing these resources as an indicator of incompetence: "if you have to call for help, you are clearly out of your depth." With

so much to do, so little time, and a reluctance to leverage support, **faculty are hindered by their own relatively limited expertise and training in instruction.** This barrier is exacerbated by two factors: First, the concern that seeking support reflects poorly on faculty is related to a tendency to leave the value of such support out of conversations with other faculty, which perpetuates a perception of teaching as a solo effort. Second, many faculty members are unaware of these resources, or aware of units but not aware of the kinds of support which can be accessed through them. Such siloing means that a faculty member casting about for someone to ask may not know that there are experts are at their disposal.

Faculty reach out through personal networks more readily than through professional networks for support, and look to commercial rather than institutional resources. In interviews, faculty described receiving (free) suggestions, advice, labor, and resources from friends, family, and colleagues. Capable and favored students—graduate and undergraduate—as well as junior collaborators were frequent sources of support. One faculty member described asking a "teenage daughter [who] was an aspiring filmmaker" to create digital lecture content to provide for students. Faculty are aware that services may exist on campus, but many are confident that an outside service provider would provide higher quality services. One faculty member said, "[In terms of] production value, I would want to talk to somebody who has experience doing this sort of production. So I don't know about media services here, I've not dealt with them, but I will talk with them about what they could or would be willing to do. If I had access to a private company I would probably go with them."

When faculty *do* reach out, they often do so after assessing the broad context of the challenge and identifying a specific problem and accompanying solution. Often, these focused problems represent minor hurdles which, once cleared, allow the faculty member to continue executing the solution they have envisioned. For example, a faculty member who has decided to create a more active classroom, and who has heard of clickers from colleagues (or from targeted marketing) may decide to try clickers this semester for the first time. A quick online search may point to an apparently well-respected brand, leading the faculty member to begin designing classroom implementation around their understanding (and assumptions) of this tool. When they struggle, the faculty member may identify a challenge such as "can I present results of polls to the class using Prezi instead of PowerPoint?", and a likely source of useful information as the company which makes the clickers. Calling customer support will allow him or her to determine whether, and how, to make this brand of clickers work with Prezi. This approach allows faculty to go it alone, but does not necessarily lead them to the efficient and effective solutions they seek. Learning engineering, a holistic approach that might instead lead faculty to infrastructure already in place (a particular brand of clickers already owned by students; a campus resource which obviates the need for integration of presentation software with clickers; a university-wide effort to leverage student-owned devices in lieu of additional technologies) or approaches which serve the same pedagogical end but obviate the need for such time-consuming problem-solving, such as the incorporation of think-pair-share exercises.

Faculty who make choices independently about course transformations have special insight into the particulars of the course at hand, but lack expert knowledge in other relevant areas: pedagogy, educational technology, and learning engineering among them. Faculty who are (or who feel) short on time look for rapid solutions to recognized challenges, and turn first and foremost to known and accessible resources: personal relationships and familiar tools. This reliance on the personal and familiar creates a situation in which faculty often make use of subordinate relationships that they don't recognize as hierarchical in order to offset labor. Community members who expect technology to offer inherently better solutions are pervasive at

an institution with a reputation built on collaborative innovation and entrepreneurship. The incorporation of specific innovations into quotidian use by faculty, staff, and administrators poses often unexpected challenges, which conflict with expectations of technological ease and effectiveness. Many technologies are leveraged in the promise that they will offer faculty a relief from an overwhelming workload. Generally speaking, these moves shift the workload to others while merely transforming faculty workload (eg, from grading to implementing automated grading software). Use of technologies, especially technologies created by unfamiliar others—individual colleagues who are not friends or widely recognized colleagues, commercial entities without accessible documentation, etcs.—are unknown quantities. Many faculty members express concerns about these unknowns, especially about access and continuity. What data is being collected and stored, and who will have access to it? Who might need to pay fees, and is it okay for me to pass those on to students? Is free support available in case I need it? Will the current level of quality, support, or affordability change in the future? If I leave the institution to take another job, will the materials or implementations I've developed here need to be left behind? Will all of the work I've put into developing my courses be lost? These concerns intersect in complex ways as faculty consider their own efficient use of resources, their hesitancy to rely on stable technology, support, and structures from year to year, and their responsibilities to students. Engaging with TEL of someone else's design requires a willingness to take risks. One faculty member relying heavily on a free educational tool said, "I'm sure the company is going to do something to make money in the not-too-distant future. And then one has to either come up with a replacement or put up with whatever nefarious scheme."

Mitigating Risk

Faculty learn to teach through experience, through mentorship, and through training. Often, faculty have their first experiences teaching postsecondary students when they themselves are graduate students. These formative teaching experiences vary widely, from highly structured programs of teacher training to informal apprenticeships. Several faculty recount the experience of teaching a classroom full of undergraduate students for the first time, having received no guidance or training beforehand: a trial-by-fire introduction to university teaching.

Regardless of the specifics of faculty mental models of, or introduction to, university teaching, faculty hone their classroom techniques over years of experience. This research also indicates that the trajectory of this development of a practice is also wildly variable among faculty. Some faculty recall receiving explicit mentorship on the topic of teaching; others recount attending a class, seminar, or workshop on university teaching. The development of faculty as instructors continues throughout the career, whether through formal or informal professional development experiences. All of this is to say, faculty begin their instructional careers with different skillsets and ideas about teaching, and **faculty learn from their experiences and hone their teaching practice**, as well. Faculty support personnel would be well-advised to consider faculty competencies and expectations when designing supportive services, and to eschew one-size-fits-all models of faculty support.

Each time they anticipate teaching a specific class, faculty start from a set of assumptions and understandings about teaching. These include:

1. The role of teaching in **personal identity**: specifically, the fact that engaging with students, as a professor, validates career choices and reinforces a sense of self-worth for many faculty.
2. A **mental model** of teaching which may embed expectations surrounding the faculty-student relationship. This might involve achieving measurable improvement in student

performance on assessments; building relationships of mutual respect and admiration; instilling in students a sense of appreciation for disciplinary knowledge or skills; etc.

3. Expectations surrounding **content and format**, often derived from a class the faculty member has taught or taken in the past and intimately tied to expert disciplinary knowledge.
4. Requirements for teaching which are tied to **professional obligations**: expected course load in context with service, research, and other requirements; minimum number of students in a class; curricular relationship to other courses (for majors and/or non-majors); role of student evaluations of teaching in review and promotion; consideration of areas of disciplinary expertise and faithful execution of professional obligations; etc.

When faculty approach a course, they do not begin with a blank slate. Instead, faculty begin with a set of conditions from which they might deviate: conditions shaped by their conception of teaching and the role it plays in their lives; the courses they've taken and taught in the past and ideas about how this class fits into larger instructional, disciplinary, and cultural paradigms; and the role of this course in their professional lives. For example, a chemistry professor might feel that one of the great privileges of her life is introducing first year aspiring chemistry majors the fundamentals of the field. Perhaps it is important to her that these formative experiences for the newly initiated are inspiring, instilling an awe and appreciation for the deep mysteries of the discipline, while also challenging these students to attain a level of rigor necessary for success in subsequent required classes. These factors influence syllabus development and other aspects of course development and delivery as she anticipates teaching an introductory chemistry course for majors. Different priorities and assumptions may be in play as she contemplates teaching an introductory chemistry course for non-majors.

At the same time, it might be important to our imaginary faculty member that she covers specific principles in chemistry which have served her well in those courses for majors. Perhaps she didn't encounter these principles until later in her career (because they were *not* considered key by her own instructors)—at which point her understanding of the discipline shifted in a fundamental way. Wouldn't it have been easier, she thinks to herself, if I'd learned this approach earlier in my education? So she feels that incorporating these apparently fundamental concepts is deemed necessary for majors. It is also necessary to cover many other core concepts—concepts she *did* encounter in her early introduction to the field. Beyond her own strong feelings about appropriate structure and content of an introductory course for majors, there are curricular requirements that our imaginary professor is aware of. She will teach many of these same students in their junior and senior years, and after a few cycles of teaching these courses she has seen students struggle in advanced classes because they have not mastered key skills—skills she feels are best introduced now. Beyond our chemistry professor's ideas about appropriate course content, delivery, and goals, there are likely departmental expectations as well as parameters imposed by needs specific to the institution, agents of accreditation, etc. This faculty member may also be working on the development or delivery of other courses at the same time; mentoring undergraduate and graduate students, meeting service obligations, applying for research funding, collecting data towards current research goals, meeting submission deadlines for writing projects, and juggling other professional obligations. These many considerations compete for faculty attention, however, and our intrepid instructor may not be able to dedicate more than a few reflective minutes to these issues before other pressing concerns supersede them.

Compromise in any of the categories above carries significant risk to personal satisfaction, self-efficacy, and/or professional achievement. Faculty express concern that they are not meeting or may not meet personal expectations of themselves, shaped by the

role of teaching in their lives and personal ideals related to course content and format. They aim to satisfy mental models of good teaching and professional obligations. Failure to meet these expectations is often framed as a disservice to themselves, their students, or their discipline, and faculty contemplating such compromises express dissatisfaction and/or fear that they will lose professional standing. Different faculty have different experiential strengths. Each navigates his own professional trajectory, through experiences as a student, formative experiences as an instructor, priorities and preferences, available support and necessary inventions. As faculty strive to meet or exceed minimum expectations in each of the categories described above, the introduction of a novel approach, content area, instructional aid, educational technology, or other element which is *unknown to* or *untried by* that faculty member entails risk.

What Professors Are For

Universities have many policies in place regarding the hiring of new faculty and the training of future faculty. The faculty I interviewed in the context of this effort overwhelmingly reflected on their lack of training and preparedness for teaching responsibilities. Often, this was presented as an abundance of *opportunities* for professional development and training in instruction paired with a deprioritization of such training or preparation. A significant population of faculty describe teaching as something that requires no training nor support, and the use of support, therefore, as evidence of personal or professional inadequacy. This reflects a culture and attitude which extends beyond the institution in question: the overwhelming majority of faculty received their training and first instructional experiences outside of the institution. There is thus significant friction between our faculty production system and our faculty intake system, and our expectations for the role of professors. Faculty who are hired have little training in instruction; they understand that they are expected to be able to teach without training in instruction. This cycle reinforces the expectation that teaching is not something which one can learn about. **In order to a create a professoriate which recognizes teaching as a skillset that can be learned about, studied, practiced, and improved, a complex culture shift will entail revaluing future faculty training, mentorship for graduate students and junior faculty, and a shift in the tenure system.** This is no simple undertaking.

MOVING FORWARD

Changes in one part of a system can create changes in other, often unexpected, parts of the system, and these changes can cascade and ripple through an institution having secondary and tertiary effects. A process-oriented approach to ongoing investigation of key (and sometimes local) factors in such relationships, complemented by tools for facilitating transfer of key information at critical points in the chain of practice, are necessary to improve the likelihood of successfully shepherding innovative teaching tools and practices from the conceptual phase to sustained use. A key preliminary result confirms that a the mixed-method, process-oriented, anthropological approach such as that used in this research has the potential to return valuable data for institutions to understand and manage the complex dynamics that collectively determine the success or failure of instructional innovations. Specifically, our data shows that at each stage in the selection, implementation, customization, deployment, use, and refinement of instructional innovations, a distinct suite of considerations shapes practice and experience. An examination of any of these stages—for example, surveys of faculty experience, measures of student learning outcomes, student satisfaction surveys, or analyses of product characteristics—*in isolation or in comparison*, fails to capture important relationships between the characteristics of one stage and those of another. Experiences of and relationships between

vendors, products, instructors, institutions, students, and support staff, are complex and multivalent.

To this end, we recommend the translation of principles, method, and theory from implementation science to the question of facilitating transfer of research to practice in postsecondary education. There is an immediate and compelling need for a robust, evidence-based approach to bridging the gap between research on, and practice of, teaching in higher education. The implementation science model developed for biomedicine can be fruitfully applied in postsecondary contexts to bridge the gap between research and science-based educational practice. An implementation science for postsecondary education represents an evidence-based approach to understanding and refining the implementation of science-based, technology-enhanced instruction in higher education. To scale adoption of science-based teaching practices and proven educational technologies, we need a better understanding of what happens between the introduction of individual new tools and practices and the successful (or unsuccessful) integration of these tools and practices into postsecondary education.

Some excellent steps have been taken to understand characteristics of both educational technologies and the contexts in which they will be implemented (Gannon-Cook, Crawford, and Warner 2009; Parthasarathy and Smith 2009; Thille and Smith 2004), and isolated efforts have been made to explore pathways to bridging the gap between research and practice (eg. Twigg 2012). Yet this lacuna stands in contrast to the increasingly robust bridges which are being incrementally built between research and practice in a growing number of fields with comparably complex administrative, cultural, technological, disciplinary, and social landscapes.

Implementation science has been bridging the gap between research and practice in biomedicine for the past two decades. Implementation science comprises a diverse suite of research protocols and theoretical frameworks which take an empirical approach to evaluating effective interventions, designing research protocols, identifying strategies which can produce the greatest impact, tracking outcomes, and defining barriers to uptake of evidence-based interventions across diverse real world contexts. This empirical approach to streamlining the translation of new scientific advances to effective applications in real-world settings is rapidly being adapted for use in community health, early childhood education, organizational behavior, epidemiology, social work, and a rapidly growing number of other disciplines (Bero et. al. 1998; Bostrom & Wise 1994; Geddes & Harrison 1997; Rubin 2014). Studies in this arena take an evidence-based approach to the effective dissemination, adoption, implementation, and sustained effective use of research results in practice. (Brownson, Colditz & Proctor 2012; Palinkas & Soydan 2012). In the case of biomedicine, much implementation science research focuses on the practice settings of barriers and affordances that play a role in the successful implementation of evidence-based practices. The identification, development, and evaluation of evidence-based strategies for overcoming barriers and leveraging enablers has made a significant impact on improving the quality of health care (Palinkas and Aarons 2009; Hovmand and Gillespie 2008), and rely on a coordinated, focused, collaborative, transdisciplinary effort to address specific challenges in implementation in a systematic way. This approach has not been widely adopted in education, and has yet to be applied in the context of higher education. There is every reason to believe that the development of parallel processes and strategies, with the goal of translating evidence-based educational technologies into classroom use, will similarly improve our ability to deliver more effective education at scale.

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