12-18-2020

Determining faculty capacity for transdisciplinary instruction

Nick Swayne

Determining faculty capacity for transdisciplinary instruction

Dominic Swayne

A dissertation submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

In

Partial Fulfillment of the Requirements

for the degree of

Doctorate of Philosophy

School of Strategic Leadership

December 2020

FACULTY COMMITTEE:

Committee Chair: Dr. Benjamin Selznick

Committee Members/Readers:

Dr. Karen Ford

Dr. Maria Papadakis

Dedication

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my wife Nicky, whose words of encouragement and push for tenacity (get it done already) rings in my ears. My colleagues and co-conspirators in the X-Labs have never left my side and are very special. I also dedicate this dissertation to my many friends and extended family who have supported me throughout the process. I will always appreciate all they have done, but especially my wife, for the many hours of proofreading and patiently waiting while I worked for so many weekends – she is always my best cheerleader.

Acknowledgments

This work would not have been possible without the outstanding support of the faculty of James Madison University's School of Strategic Leadership. I am especially indebted to Dr. Benjamin Selznick, Coordinator of the Postsecondary Education program and Chair of my Dissertation Committee. Dr. Selznick has been supportive of my research goals and taken a personal interest in the ongoing work of my innovation lab. He has provided me with sound mentorship, unfathomable patience, and great ideas to pursue further research. I am grateful to all of those with whom I have had the pleasure to work during this study, including the dedicated faculty and staff who were both understanding and supportive. Each of my Dissertation Committee members has provided me extensive personal and professional guidance and assisted in developing me within the context of this study and as a researcher.

Table of Contents

Dedication……ii

Acknowledgments……iii

List of Tables……v

List of Figures……vi

Abstract……vii

Introduction……1

Review of the Literature……16

Methodology……39

Results……51

Discussion, Implications, and Conclusions……95

List of Tables

Table 1 Demographic composition of qualitative participants……..46

Table 2 Emergent qualitative codes……...55

Table 3 Mixed Methods Mapping – Inclination……...….81

Table 4 Mixed Methods Mapping – Capacity……...……82

Table 5 Mixed Methods Mapping – Complex leadership…….……83

Table 6 Gender……...86

Table 7 Ethnicity……86

Table 8 Tenure Status……...…….87

Table 9 Faculty participants by academic college…….87

Table 10 Faculty Rank…….…….….87

Table 11 Factor loading and reliability……..89

List of Figures

Figure 1 Methodological diagram.....41

Figure 2 Unidimensional Scree Plot of FCII.....88

Figure 3 Histogram of FCII Composite Scores.....92

Abstract

The purpose of this study was to develop a reliable and valid survey instrument that would prove useful in identifying faculty with the capacity and inclination to succeed in team-taught, hands-on, transdisciplinary course programming. Using an exploratory, mixed-methods design, the qualitative component consisted of semi-structured interviews of nine experienced X-Labs faculty. The qualitative analysis process identified attributes that were vital to transdisciplinary teaching and demonstrated patterns that were consistent with complex leadership development. During the mixing process, these data were translated into a quantitative instrument. A panel of experts reviewed the prototype instrument and reduced the number of items included in the final instrument. This process formed the basis for the 56 item Faculty Capacity and Inclination Index (FCII). A valid and reliable personality index, the Ten Item Personality Index, was embedded in the instrument's final version, and results were correlated as a test for both duplication and reliability. An exploratory factor analysis was performed on the data collected from the 124 respondents. Communalities were all above .7, with the recommended minimum screening value being 0.3. Cronbach's alpha for the NCII was 0.931, reflecting a high degree of reliability.

The study presents implications for practice in expanding transdisciplinary pedagogy models in higher education and how that approach contributes to the development of faculty as future leaders in the complex institutions that define higher education.

Keywords: transdisciplinary, complex leadership, faculty recruiting, team-based, problem-based, learning partners

Chapter 1

Introduction

Study Background

The Eighteenth-Century age of Enlightenment began the transformation of higher learning and higher education from a unified body of knowledge into the highly-specialized, discipline-based system we have today (McKeon, 1994). The development of specialized disciplines accelerated the advancements of human knowledge that led to subsequent and ongoing revolutions in agriculture, manufacturing, transportation, and information that we enjoy today. While the post-enlightenment divergence into modern disciplines enabled these significant advances in knowledge and human understanding, by splintering off parts of the whole, they tend to limit today's University's capacity to address some of the most complex, emergent global problems. Many argue that preparing, challenging, and empowering students to solve today's wicked problems, where problem understanding and problem resolution are concomitant to each other (Rittel & Webber, 1973, p. 137), requires a convergence of disciplines – or an interdisciplinary approach to prepare them for the increasingly complex environment in which they find themselves upon graduation (Brooks, Fox, Okagbue-Reaves, & Lukomski, 2009; Newell, 2008).

Aside from being better prepared cognitively, students describe their transdisciplinary experiences as transformative. In researching experiences for his book *Creating Innovators*, Wagner (2012), noted that students describe the "opportunity to collaborate and build real products with others was the most exciting part of their education," (Wagner, 2012, p. 69). Examples in the literature provide insights into how

interdisciplinary, hands-on learning impacts students, and how the student transformation occurs. Campbell et al. (2001) noted that this type of learning, done in conjunction with a safe environment, helps surface learners transition to deep learning where they make meaning, order, and structure of the knowledge they acquire and are better able to synthesize information into new knowledge. In this context, "safe" would have a dual meaning; an environment where trying new things to the point of failure is encouraged, and where standards of practice regarding physical safety and injury prevention are maintained.

Modern approaches to interdisciplinary and transdisciplinary education re-emerged in the 1960s experimental colleges, cluster colleges, and integrative studies movements, but most large-scale examples did not survive beyond the transition of their founding leadership. While literature from that era identified many of the issues, challenges, definitions, and potential benefits of implementing these new models, no examples were advanced that would represent possibilities for broader adoption or implementation beyond a few sample classes and courses.

Renewed interest in interdisciplinary or integrative learning is again poised to challenge the undergraduate education roadmap. The concept's most recent re-appearance in the literature occurred in 1994, when Gibbons et al (2002) introduced the concept of new knowledge production where the focus of learning transcends traditional disciplines instead, shifting to the problem, context, or application of created knowledge (Gibbons et al., 2002, p 3). As Gibbons et al. (2002) note, the essence of Mode 1 knowledge was the complex ideas and scientific norms that emerged as a way to control the diffusion of the Newtonian model of science as it expanded to more fields of study

and became the foundation of sound scientific practice. In contrast to the traditional Newtonian scientific method, this new academic paradigm of learning by doing; creating multidisciplinary teams and focusing on problem solving were characterized as Mode 2 knowledge production (Gibbons et al., 2002, p. 167). Using and applying multiple aspects of discipline specific knowledge to synthesize and create new knowledge closely reflects the methodology that forms the focus of this research. Scholarship in the 21st Century involves innovations that transcend the traditional boundaries of education (Brooks et al., 2009, p. 820). Wraga's (2012) examination of classical discipline-dominant education led him to conclude that "these shortcomings of the discipline-centered curriculum as it is implemented commonly in our schools, it could serve more to hinder than to help the education of citizens who need to be capable of tackling complex public issues." (Wraga, 2012, p. 204-205). The value of having multiple faculty representing multiple academic disciplines, teaching together as a team, provides students with alternative perspectives and different approaches that translate to better problem-solving scaffolding for students (Davis, 1995). Yet despite the long-standing interest and anticipated benefits to students, with few exceptions, current examples of integrative liberal education are typically two-year experiences in general education programs (Newell, 2008).

In an optimally functioning market economy, demand would be expected to influence supply. Student, government, and industry demand for transdisciplinary courses as a product might be sufficient to create changes in the supply – adding more transdisciplinary-type courses and producing transdisciplinary-trained faculty. However, the demand-supply model has not provided sufficient pressure to induce a change in the

system of higher education. Student demand and interest in such transdisciplinary, problem-focused courses is a thread that runs throughout a recent longitudinal study (Wenger-Trayner & Wenger-Trayner, 2019). Employers, according to the Association of American Colleges and Universities (AAC&U, 2018) report on the future of work, are also increasing demand through their recruiting efforts by looking for students with transdisciplinary, problem-solving skills. Student demand, industry demand, and student outcomes converge on the benefits of transdisciplinary, problem-based education, but the higher education industry has yet to respond; either with a reformation in the doctoral preparation to produce faculty trained as transdisciplinary instructors, or to prepare existing faculty for transdisciplinary instructional roles. Disciplines continue towards greater degrees of specialization and isolation while the most interesting and challenging problems college graduates will need to work on grow more complex and multidisciplinary in nature.

Given that student, government, and employer demand are insufficient to change the way the academy prepares faculty, how might we start to change the system? Is there a process that could be adopted that would allow higher education institutions to offer transdisciplinary courses without first having faculty prepared as transdisciplinarians? If the desired outcome is to have strong, discipline-based faculty, the 50-year-old call for transdisciplinary, problem-based pedagogy might be solved without a revolutionary change to the doctoral preparation process. This study proposes as a solution, an efficient, valid, and reliable process of identifying faculty, in sufficient quantity, with both the capacity and inclination to adopt this pedagogical approach.

Definitions of Terms

The terms multidisciplinary, interdisciplinary, and transdisciplinary are frequently used interchangeably, without regard for their definition or distinction (Swayne, Selznick, McCarthy, & Fisher, 2019). While many of the benefits and challenges generalize across the conceptual model of bringing multiple disciplines together in a team-taught academic setting; it is important to define and distinguish the three concepts (Rives-East & Lima, 2013). Differentiation of these terms remains an ongoing work in the literature. It might yet be too early to have settled definitions, disagreement between the emerging definitions of each term appears minor (Dyer, 2003, p. 1-2; Choi & Pak, 2006, p. 353).

Multidisciplinary courses are team-based courses led by a primary, gatekeeper faculty member who determines the other discipline-specific team members. Independent team members provide additive, discipline-specific goals and achieve them independently, with little coordination. Klein, (1990) further distinguishes this method as "essentially additive, not integrative" (p. 56).

Interdisciplinary team-based instruction expands on the multidisciplinary approach through a process of collaborative communications, goals, and instructional planning. Unique disciplines are still represented and coordinated by a lead instructor. Significantly greater infrastructure is required to promote the interdependence, self-management, and responsibilities of the instructional team for student performance and outcomes. Again, Klein adds further distinction by noting that interdisciplinary courses tend to form hybrid fields such as biochemistry; borrowing concepts and traditions that are common to more than one discipline (Klein, 1990, p. 28).

Transdisciplinary team-based instruction values the knowledge, skills, and disciplines of the teaching and student teams, but team members intentionally cross

traditional disciplinary boundaries. Under this model instructors typically transform course titles from traditional discipline-based titles to a theme or problem-based titles. Instructional team members must be competent and secure enough in their disciplines to enjoy teaching and learning while giving up some roles and skills and acquiring new ones. Klein (1990), adds that overarching theories that transcend the disciplines are indicators of transdisciplinary work. Flexner and Hauser (in Kockelmans, 1979) provide a concise definition that encompasses much of the activity associated with higher education.

> Transdisciplinarity refers to research and discourse that attempts to solve a problem shared by two or more disciplines beyond the scope of any single discipline, and that does not attempt to integrate the disciplines involved into a new discipline (Kockelmans, 1979, p. 350).

The definition presented by Flexner and Houser provides specific clarity regarding the breadth and depth of the concept. Transdisciplinarity encompasses research and pedagogy; discovering and creating knowledge by bringing together teams of two or more disciplines that are focused on solving complex problems that are beyond the scope of any single disciplinary approach.

Wicked Problems as a concept, were introduced by Rittel and Webber (1973), to describe complex issues that, when taken in their entirety, defy definition and often don't have a single or final solution. Attempts to solve wicked problems typically result in the creation of further issues, dilemmas, or solutions where the answer is not good or bad, true or false, rather the best that could be accomplished at the time. Wicked is not a reference to morality (Brown, Harris, & Russell, 2010, p. 4).

Statement of the Problem

The higher education ecosystem is based on its ability to acquire and retain knowledge of the past. The basic approach to research is to develop a deep understanding of the current state of knowledge in a specific discipline and build upon that silo incrementally. The process has led to innumerable discoveries, and a strong conservative bias among university researchers and faculty. The conservative bias is acknowledged as a necessary form of cognitive and social organization that provides a stable basis for educational training and academic disciplinary identity (Gibbons et al., 2002, p. 139).

The bias towards keeping things as they are may also be rooted in concern over the splitting of resources where new classes formed between disciplines may threaten resources and support for established disciplines. Effective transdisciplinary instruction often means smaller class sizes, or at least lower faculty-student ratios which may, in the interest of instructor equity, increase instructional costs for both traditional and transdisciplinary courses (Mattson, 2005). Traditions of integrity and the autonomy of disciplines help define boundaries that members tend to defend – particularly against encroachment from administrators seeking to innovate or reorganize the academic structure (Kockelmans, 1979, p. 3-4). Academic disciplines and departments are a necessary part of the current model for higher education, but they simultaneously create formidable barriers to transdisciplinary work. These barriers may take the form of peer pressure, where those working outside the department are seen as not carrying their fair share of the departments load. Issues of workload equity can translate to tenure and promotion concerns when those same departmental faculty are empaneled to review and

recommend their peers for promotion and tenure. Working outside one's discipline may also reduce access to disciplinary-based research, research networks, and the scholarly productivity that departments consider for peer promotion (Niehaus & O'Meara, 2015). Scholarly articles written to bridge gaps in transdisciplinary teaching and research often struggle to find relevant and receptive journals for publication (Lattuca, 2001).

Prior research (Cai, 2017; Golde & Dore, 2001; Klein, 1990; Klein et al., 2001; Newell, 2008; Newell & Green, 1982; O'Meara, 2007; Selznick & Mayhew, 2018) has focused on a variety of topics ranging from the benefits to students, to the structural changes required within the institution that assign power and rewards, to disciplinary-based departments, to adapting the current methods of preparing faculty. While improvements in student learning outcomes and their capacity to innovate and solve problems have been well documented (Mayhew, Simonoff, Baumol, Selznick, & Vassallo, 2016; Selznick & Mayhew, 2018), the structure of undergraduate curricula has been slow to adapt.

Reflecting the social climate of the 1970s when many thought-leaders sought to expand these forms of education through a revolution in the development of future faculty (Apostel, Berger, Briggs, & Michaud, 1970; Lattuca, 2001). Others sought to modify the structural elements of the institution's organization – doing away with disciplines and departments and organizing the entire institution around problems and the shared interests of faculty (Apostel et al., 1970; Astin et al., 1974). Moving pragmatically beyond a restructuring of the institution of higher education or a revolutionary pathway to transform the Ph.D. system, tools do not exist to assist administrators in identifying or recruiting existing faculty with the capacity and

inclination for transdisciplinary work. Narrowly focused disciplines and singular approaches to education are no longer suited to meeting the complex, vexing problems and accelerating, dynamic nature of our global circumstances. In his discussion on personal and institutional problems of being interdisciplinary, Scott (in Kockelmans, 1979) pressed the urgency:

> The impossibility of mastering a significant body of knowledge that will not become obsolete nearly immediately, and the press of problems that threaten to engulf not only the foundation of what we have come to consider civilized culture but humankind itself. Thus, the problem-orientation and adaptability need to be stressed directly (p. 315).

While referring specifically to innovation studies research faculty, Steinmueller, (in Fagerberg, Martin, & Andersen, 2013) notes, "the means of reproducing, sustaining, and recruiting researchers to participate in the field [of innovation studies] are underdeveloped" applies equally to the reproduction, sustainment, and recruiting challenges in hiring faculty with the capacity and inclination to serve in transdisciplinary instructional roles. On the topic of transdisciplinary work, Apostel et al., (1970), effectively ties these two core academic activities, stating that teaching and research at all levels are complementary activities for both pedagogical and scientific reasons (p. 197).

Building the case for some level of adoption, there is strong general evidence that active, collaborative learning pedagogies help students understand, internalize, and synthesize knowledge in problem-solving applications (Committee for Economic Development, 2003; Lattuca, Voigt, & Fath, 2004). There are numerous case studies addressing specific added value examples for students (Balsiger, 2014), student outcomes

(Lepczyk, Wagner, & Cennamo, 2018), and the student transformation that takes place during transdisciplinary courses (Stauffacher, Walter, Lang, Wiek, & Scholz, 2006). Several discuss some loosely defined characteristics of those faculty, but none explore any aspect of how, in the effort to scale transdisciplinarity, additional faculty might be identified, developed, or transformed (Apostel et al., 1970; Larson, Landers, & Begg, 2011).

Klein (2004) was extremely positive about the transformative opportunities and bright future for transdisciplinary teaching as a means of addressing problems of society that are increasingly complex and interdependent (Klein, 2004, p. 517). In the years since that article was published, the term transdisciplinary is more broadly known and more frequently applied to a variety of courses, but exemplars of the method are still scarcely found. Many peer-reviewed examples citing transdisciplinary case studies within the literature exist, but most fail to rise to the level of disciplinary diversity necessary to create tension, friction, and innovation. Examples of case studies that may not reflect the possibilities and intentions of such work include those characterized as transdisciplinary courses, but only include engineering disciplines described by Snyder, Ozkan, Bairaktarova, Staley, & Biscotte, (2019). Similar questions arise about transdisciplinary bona fides when a transdisciplinary course does not meet the general expectations for being real, relevant, or a societal-level wicked problem as exemplified by a course based on a natural history and art exhibit (Poli & Stoneman, 2018). Conveying his disappointment with transdisciplinarity still not achieving mainstream acceptance, Lawrence (2014) noted,

> It is rarely recognized by professional institutions; it is still rarely taught in higher education programmes, and it is not often supported by funders of research. Indeed, transdisciplinarity is considered by many to be contradictory to the basic principles of conventional scientific knowledge production (Lawrence, 2014, p. 1).

This study addresses one of the persistent challenges of scaling transdisciplinary education; the gap that exists in how to identify existing faculty with the capacity and inclination for teaching in transdisciplinary undergraduate courses. By complementing the interest in student outcomes, and contrasting with the seemingly steadfast nature of the institution, this study will explore the primary role of faculty; specifically, how might we develop the tools needed to identify faculty with the capacity, inclination, and propensity to flourish in the emerging role of a transdisciplinary educator? Given that existing faculty are the product of traditional higher education development system, the most efficient and expeditious approach to increase the number of institutions offering transdisciplinary courses and the number of transdisciplinary courses offered within, might be to find those faculty that might be a good fit, possess the capacity to work collaboratively, and an inclination to rise to the challenges and do well in such unique circumstances.

Purpose of the Study

Larson et al (2011) noted, “Many academics assume that anyone can engage in interdisciplinary research, but it is clear that successful interdisciplinary efforts require mastery of specific competencies that can be learned and improved” (Larson, Landers, &

Begg, 2011, p. 38). The purpose of this exploratory, sequential, mixed-methods study is to identify patterns and factors among faculty with experience teaching in hands-on, transdisciplinary methodology that might serve as predictive indicators in identifying others with the capacity and inclination to engage successfully in transdisciplinary pedagogy. Through the qualitative exploratory component, identify those key factors that may translate to a quantitative instrument that reliably identifies faculty with the capacity and inclination to flourish as instructors in applied, transdisciplinary courses. The research methodologies will mix during the creation of the quantitative instrument and the items needed to differentiate faculty. A reliable and valid quantitative instrument that can aid in screening or identifying faculty that are capable and inclined to teach in a transdisciplinary pedagogical setting will help advance the innovation as a productive instructional methodology.

As a matter of process, the qualitative and quantitative portions of the study are weighted equally. However, with intentions for creating a quantitative instrument for future use, the overall importance of the study shifts to the quantitative component. Ultimately, the study will contribute to the literature regarding the identification of potential transdisciplinary faculty and provide useful tools in advancing transdisciplinary pedagogical practices in higher education by providing alternative methods for resolving the current gaps in higher education leadership and human resource development approaches for faculty.

Significance of the Study

Research has shown that problem-based, transdisciplinary courses improve student outcomes, retention rates, and innovation capacity. However, faculty tend to teach the way they were taught (Shymansky, Hedges, & Woodworth, 1990; O'Meara, 2007). The benefits to student learning outcomes, faculty productivity and retention, and an increasingly urgent need to solve societal and global problems might converge and coalesce on this approach.

Efforts to reform the doctoral candidate development process at the institutional level have yet to produce lasting results in producing new faculty, at scale, that are well versed and ready to teach in transdisciplinary settings. To achieve a modicum of success, a new approach to scaling this transformative method of teaching and learning must be found. Identifying, recruiting, and developing existing faculty within the academy that have the capacity and inclination to teach transdisciplinary courses is possibly a more logical and practical first step in creating the momentum for such transformation.

Transdisciplinary research and pedagogy are urgently needed to address increasingly complex problems in science and society. As Steinmueller (in Fagerberg et al., 2013) argues for innovation studies, the current state of affairs falls short of these objectives with regard to pedagogical tools, professional institutions, and communicative presence. Thus, unlike the body of knowledge, which I have argued is approaching, and in some cases, attaining the features of normal science, the means for reproducing, sustaining, and recruiting researchers to participate in this field are underdeveloped. Left without a practical means of scaling the needed transdisciplinary approach to solving complex or wicked problems, higher education institutions have continued to produce researchers and practitioners with traditional problem-solving skills and created a need

for managers capable of reaching across agencies, organizations, and to members of the public to help solve wicked problems (Weber & Khademian, 2008, p. 336).

This research contributes specifically to the literature on faculty recruitment and development in the field of innovation education and transdisciplinary pedagogy. The results of this research will provide higher education institutions with much-needed tools for identifying faculty with the capacity and inclination for teaching innovation using a transdisciplinary, problem-based, team-taught pedagogical model. An ability to identify faculty with this capacity and inclination creates opportunities for more targeted recruiting strategies, reduces barriers to implementation and eliminates the need for higher education to change the model for PhD candidate preparation before the implementation of transdisciplinary educational models. This research aims to make the following contributions:

(1) An understanding of the different factors required by faculty to excel in such pedagogical approaches.
(2) A reliable and valid quantitative instrument that might be used to identify faculty with the factors indicating their capacity and inclination to teach transdisciplinary courses.
(3) Demonstrate the potential impact of transdisciplinary pedagogy on the institutional ecosystem through faculty leadership development.

Research Questions

This study requires a mixed methods approach in order to develop an understanding of the factors and attributes of successful faculty and the application of that understanding in developing a quantitative instrument that can reliably aid in

identifying individuals with the capacity and inclination to teach using this pedagogical approach. Based on mixed methods research guidance from Creswell and Plank (2011), qualitative and quantitative research questions are included. Creswell (2015) notes that qualitative research questions often adapt and transform somewhat during the qualitative research phase, so these should be considered preliminary in nature.

Qualitative research question: *What attributes describe faculty persistence and involvement in team-taught, problem-based, transdisciplinary courses?*

Quantitative research question: *To what extent can these faculty attributes be reliably and validly measured?*

Organization of the Study

The dissertation is organized as follows. Chapter II presents an in-depth review of the relevant literature related to instructional models supporting innovation studies an understanding of the differences between and benefits of multidisciplinary, interdisciplinary, and transdisciplinary modes of instruction. An instrument to identify faculty with the capacity and inclination to teach transdisciplinary courses. A functional approach to building transdisciplinary, innovation-focused educational models.

Chapter 2

Literature Review

Introduction

This chapter presents the foundation for conducting research on the ability to identify faculty with the capacity and inclination to teach transdisciplinary, team-based, and problem-focused courses. Researchers focused on student outcomes have contributed significantly to our understanding of how college affects students and the benefits of transdisciplinary pedagogy on innovation, creating knowledge, and increasing student innovation capacities (Klein et al., 2001; Mayhew, Selznick, Zhang, Barnes, & Staples, 2018; Selznick & Mayhew, 2018). Significant research efforts on team teaching and research have developed an understanding of the virtues of that methodology (Gibbons et al., 2002; Klein, 1996) and in linking the two concepts, transdisciplinarity and team teaching, directly (Von Manen, 2001).

Transdisciplinary and interdisciplinary courses have been shown to improve student outcomes, retention rates, and innovation capacity. However, faculty tend to teach the way they were taught (O'Meara, 2007; Shymansky, Hedges, & Woodworth, 1990). While prior research has focused on the manner and magnitude of student and faculty benefits from participating in such pedagogical methods; Klein (1990, 1996) and Newell (1982, 1988, 1996. 2008, 2013) on interdisciplinarity; Magolda & King (2004) on student-faculty learning partnerships; Wagner (2012) on creating innovators, Davis (1995) on interdisciplinary team teaching, and Gibbons et al (2002) on creating new knowledge, little progress has been made towards scaling such innovative approaches to

higher education despite calls by the AACU, NSF and others that such changes are needed in order to prepare the next generation to solve the wicked problems emerging globally. This study will address the essential, underlying challenges that must be addressed – how do we find the faculty needed to start such programs and in sufficient numbers to bring transdisciplinarity to an institutional scale?

Chapter II, the literature review, is organized into six sections that represent the foundation of literature pertinent to the research study: (a) founding literature from the 1970s; (b) current approaches to transdisciplinarity; (c) faculty selection and self-selection; (d) pedagogy and practice; (e) characteristics of transdisciplinary, team-taught, problem-based pedagogy, (f) indicators of faculty capacity and inclination to implement this form of pedagogy, (f) contributions to developing faculty as leaders, (g) theoretical framework.

Founding Literature from the 1970s

The movement towards combining disciplines, approaches, and problem-solving arose in the 1970s from the awakening social movements, general global discontent, and dissension of the 1960s. Several eminent thought leaders expressed dissatisfaction with the intransigent system of higher education, its inability to adapt to the changing needs of society, and a bias towards conservation of traditions of knowledge creation rather than developing solutions to deal with increasingly complex pan-society, technology, and historical matters that were brought to light during the tumultuous era of the 1960s (Apostel et al., 1970; Astin et al., 1974; Kockelmans, 1979). As J. R. Gass noted, “the guiding principle is not the need to demolish the disciplines, but to teach them in the context of their dynamic relationships with other disciplines and with the problems of

society" (in Apostel et al., 1970, p. 10). The early thought leaders represented in this literature produced incredible insights into the potential for inter and transdisciplinary pedagogy, but possibly more importantly, they identified many of the pitfalls, challenges, and obstacles that would certainly be encountered by such an effort to transform the academy. These insightful articles bring to light the breadth and depth of scholarly understanding regarding the entrenched, conservative system of higher education and correctly identified many of the obstacles. Now, nearly 50 years after the first international conference to consider problems of interdisciplinary teaching and researching in higher education, nearly all those same issues resonate as ongoing challenges (Holley, 2009).

These early works serve as the foundational literature that defines interdisciplinary and transdisciplinary teaching and research. Aside from changes in modern dialects, reading this literature out of context, one might assume they were current, contemporary publications. The promise and challenges posed by inter and transdisciplinary teaching and research remain as vivid today as they were when this literature was first presented. Subsequent research developed lines of literature around more specific positive ideals, issues, and challenges. However, the profound contribution of this early literature in a current study demonstrates their prescience. Combined with the lack of significant transformation given 50 years of effort serves to reveal just what a challenging endeavor it is to transform traditions of the academy.

Current Approaches to Transdisciplinarity

Transitioning the emphasis of learning from a discipline-centered approach to a problem-centered approach is at the heart of the transdisciplinary movement. Complex

problems, those involving matters of public policy, government, society, the environment and many other areas of concern, have been characterized as wicked problems, because they are so complex that they are never really solved (Rittel & Webber, 1973). Complex, wicked problems are unstructured; involve multiple, overlapping, interconnected subsets of problems that cut across multiple domains; they are relentless – and often interrelated such that progress on one aspect may create new problem consequences in other areas (Brown et al., 2010; Weber, Lach, & Steel, 2017). Complex problems are common in many aspects of the modern world that address culture, science, technology, and society (Klein et al., 2001).

Transdisciplinary practices are directed towards solving these complex, wicked policy issues and address scientific knowledge production (Maasen & Lieven, 2006, p. 400). Transdisciplinary courses are designed and scaffolded to introduce students and faculty to a variety of innovation processes used in real-world problem-solving needed to address modern, complex systems and wicked problems (McCarthy et al., 2018). Individual authors in the collection of works edited by Brown, Harris, & Russell (2010), entitled *Tackling Wicked Problems,* addresses many benefits and concerns that encompass transdisciplinarity. Lawrence (in Brown et al., 2010) addresses the power of the transdisciplinary approach in changing the manner and scope of defining the problems. Rather than deconstructing a complex problem and isolating a small component, the transdisciplinary approach is to take on the complexity through a multidisciplinary team, include local context and ambiguity, and emphasize internal and external communications as part of the process. Smithson (in Brown et al., 2010) expands on the challenges of problem curation in his contribution addressing the manner

in which inherent bias, ignorance, and uncertainty influence narrowly-focused disciplines and the public. A well-managed team comprised of diverse disciplines and laypeople tends to overcome many of these issues and develop a common language and more prevalent sense of trust in the problem-solving process and any solutions. Foreshadowing a pedagogical practice, Hocking (in Brown et al., 2010), addresses how the design thinking approach contributes to the recursive nature of complex and wicked problems where the problem is embedded in the process. She argues that the design process is an inherently human characteristic that should be used more broadly in the pursuit of solutions in complex problems. The collection of articles provides comprehensive insights into the challenges and power of transdisciplinary research, establishing a community of practice, and the results of open, holistic inquiry. While their emphasis tends toward a comparison with classical research, it is clear that as they describe the shift from traditional, discipline-bounded research that the methodology also provides a solid foundation for implementing transdisciplinary work as an instructional model. Addressing the topic of human ecology and the value of international exchanges and diversity in transdisciplinary work, Dyball concludes that "bringing together different values, worldviews and traditions of understanding into conflict can help to surface assumptions and open them up for questioning and critique, including self-reflexivity (in Brown et al., 2010, p. 278).

Translating pedagogy to action, there are several approaches to implementing transdisciplinary teaching. This research study will focus on two prominent methodologies: design thinking and lean startup, combined as a pedagogical process. Lean startup as a methodology was developed by Eric Ries (2011). With assistance from

Steve Blank, the customer-development focused methodology was transformed into Stanford University's Lean LaunchPad curriculum and subsequently formed the basis of the National Science Foundation I-Corps program (National Science Foundation [NSF], 2019, p. 7). The program starts with an idea or a product concept and focuses on customer discovery techniques, stakeholder interviews, rapid low-cost prototyping, and adapting the innovation to meet the critical needs of potential customers. As an instructional model, it challenges students to talk to potential customers, overcome the fear of failure, make small hypothesis, and test them quickly (Blank & Dorf, 2012).

A similar, customer-discovery focused methodology, design thinking follows a parallel discovery path but starts with a problem. The design thinking methodology evolved as a process from Stanford University d.School and IDEO's Tom and David Kelley (Mueller & Thoring, 2012). Design thinking uses qualitative research methodologies and ethnography techniques with a recursive process that develops ideas, solutions, or products as part of the process. The two methodologies, design thinking, and lean launchpad are artfully integrated in a graphic reference developed by Osterwalder, Pigneur, Bernarda, & Smith, (2014).

Faculty Searches and Self-Selection

Based on five-years of intentional though informal observations of this instructional model, the ambiguous, unstructured nature of design thinking and lean launchpad are problematic for many faculty. As previously noted, current faculty are trained and developed using Gibbons et al. (2002) Mode 1 methodology. Beyond training and development, the entire faculty system is firmly siloed in a Mode 1 methodology that includes recruiting, leadership development, and the hiring process.

The literature on faculty selection, recruiting, and self-selection is relatively thin and underdeveloped. Among the few studies available, few broke new ground, add significant insight, or appeared to be seminal works. The general, unifying theme of this body of work concluded that the doctoral preparation programs have a significant impact on searches, recruiting, and hiring practices offering that research-intensive institutions tend to produce Ph.D. faculty that are prepared nearly exclusively as research assistants rather than teachers (McFadden & Perlman, 1989; Thomas, 1997). Thomas (1997) reviewed the traditional steps of the faculty hiring process and explained the importance of each. While it is difficult to argue that any step in the hiring process is not essential, Thomas' does little to break new ground or provide insight into this study.

The second line of literature considered indicators of faculty quality and how to discern those in the hiring process. Moore's (1987) approach was to survey education college deans to ascertain their views on what constitutes faculty quality. While he also noted the need to align teaching faculty expectations with their preparation, he added to the literature by noting that only four of the top ten indicators of quality cited by the deans surveyed (special preparation, journal publications, teaching experience, degree-granting institution) were likely to appear in common forms of vitae or common application data. The other six indicators proved difficult to document and offered few, and unreliable indicators during the hiring process, including integrity, supervisor reports, emotional stability, energy and motivation level, and compatibility with colleagues (Moore, 1987, p. 46).

A final strand of literature identifies strong evidence of hierarchy and traditions of hiring practices that tend towards systemic inequality based on institutional preferences.

Clauset, Arbesman, & Larremore, (2015) identify strong evidence of a hierarchical network of hiring that tends to favor applicants from prestigious institutions, as lower-ranking institutions attempt to copy the practices of their more prestigious institutions in hiring. Presenting evidence that 25 percent of institutions produce 71 to 86 percent of tenure-track faculty, their contention that prestige may play a greater role than merit, goes beyond the scope of this study, but is a clear indication of the need to find better predictors of faculty capacity and inclination to teach than currently exist in practice (Clauset et al., 2015, p. 2).

Pedagogy and Practice

Given that the pedagogical model of transdisciplinary teaching focuses on bringing multiple disciplines and multiple disciplinary approaches to bear on problems, it is not surprising that the pedagogical approaches and methods manifest differently in each application. However, there are several underlying principles and foundational approaches that transcend each instance.

Within the context of a flexible approach to complex problems, Paul Gibbs' (2015) edited volume provides a comprehensive overview of transdisciplinary application; specifically, in professional development and education. While providing significant depth to transdisciplinary literature, the overarching theme of the edited volume concludes that disciplinarity and transdisciplinarity are complementary aspects of a single, more complex whole: routine scholarly work (Gibbs, 2015, p. 1). Gibbs captures the essence of the intention, describing how, "transdisciplinarity crosses disciplinary boundaries in an attempt to resolve complex, value-laden issues. These issues are at once too complex and too important to be constrained by any single

discipline. The important pedagogical aspect is a recursive construct in that the knowledge needed to solve the problem is also the goal of the solution" (Gibbs, 2015, p. 2).

Julie Thompson Klein championed significant research and many scholarly works, broadly addressing aspects of interdisciplinary and transdisciplinary work. One early conference, the International Transdisciplinary Conference held in Zurich Switzerland in February 2000, resulted in another seminal compendium of literature on the topic of joint problem-solving. The conference proceedings were published in book form in 2001 (Klein et al., 2001). Through this collection of articles, the editors address the need for a new kind of knowledge that can respond to the overlapping and competing forces of a market economy, science, and democracy. In traditional Mode-1 science, scientists made an effort to inform the public of their discoveries and accomplishments – providing the context of the application. In Mode-2, researchers need to create opportunities to contextualize knowledge production – bringing people into the process. Understanding the forces of economics and democracy, researchers must also include the context of the application and, more importantly, bi-directional sharing of the implications. Within that work, Gibbons and Nowotny (2001) note the potential of transdisciplinary research and pedagogy to advance Mode-2 knowledge creation, bring together multiple stakeholders with essential skills and expertise, and combine with a healthy disrespect for disciplinary and institutional boundaries to solve real-world, complex problems. Gibbons and Nowotny (2001) describe several new aspects of Mode-2 knowledge that may have a role in the context of identifying capacity and inclination to teach in such settings. First, is an openness to bi-directional and multi-modal

communications. Second, they conclude with the idea that bringing together more stakeholders creates a more socially robust solution. How might that inform the question of capacity and inclination of the faculty needed to teach in these pedagogical models?

Characteristics of Transdisciplinary, Team-Taught, Problem-Based Pedagogy

Maasen and Lieven (2006) provide a formative article entitled *Transdisciplinarity: A New Mode of Governing Science,* on the potential of transdisciplinary research and the relative importance of transdisciplinary work that bridges the scientific community to industry, citizens, and political stakeholders. They characterize this trust-building process as a symmetry of enlightenment where scientists have a responsibility to apprise their stakeholders and stakeholders enlighten the scientists on their reality and contribute by expressing what they think should be done (Maasen & Lieven, 2006, p. 404). A necessary component of transdisciplinary research and pedagogy is this dynamic dialogue between scientists and stakeholders that builds trust and improves communications. In addressing the tensions that arise from multiple stakeholder involvement, Maasen & Lieven (2006) identified the transdisciplinarity as a means of processing and resolving conflict rather than solving it. They conclude that transdisciplinary teams must develop systems to process multiple values and goals, uncertainty and fragmented knowledge, and multiple stakeholder input. Several of their conclusions contribute to establishing identifying characteristics of faculty with the capacity and inclination to undertake transdisciplinary pedagogy. These include: the willingness and competence to assume responsibility for the research and its application; the ability to process uncertainty [ambiguity] and fragmented knowledge; receptiveness to stakeholder input and bi-directional communications; translate and transform disparate

knowledge. Transdisciplinary work changes attitudes about expertise, creates a hybrid situation between science and politics and tends to develop solutions that are a compromise, the approach tends to reduce factual, temporal, and social complexity (Maasen & Lieven, 2006).

Maasen & Lieven (2006) build on the seminal work of Gibbons et al., (2002), *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies* where they describe the role of interdisciplinary and transdisciplinary pedagogy in transforming research and knowledge creation through a socially distributed, application-oriented, transdisciplinary process they characterize as Mode 2. While potentially threatening to the most established disciplines and research institutions, Mode 2 knowledge production provided a conceptual framework for politicians, administrators, professional disciplines, and newer institutions to connect science with innovation and research (Nowotny, Scott, & Gibbons, 2003). In this and subsequent works by Nowotny and Gibbons, they describe Mode 2 recursively as both a conceptual framework and a project; both being necessary responses to a changing research environment where research priorities are being steered by social, economic, and political interests, increasing interest in intellectual property and commercializing research, and the general trend towards holding science accountable for the effectiveness and quality of their research. In Mode 2, transdisciplinary research, the creative activity is as much the mobilization and management of multiple perspectives as it is in the development of new theories or research methodologies. Another unique characteristic of Mode 2 and transdisciplinary knowledge production is the loss of boundaries through technology and the reduction of border constraints previously formed by geographic, institution, and

organizational that created collaboration barriers with non-traditional academic-based knowledge organizations like think-tanks and activist groups (Nowotny et al., 2003).

Interdisciplinarity, while distinct in its application from transdisciplinarity, at the macro scale offers many applicable insights in the literature. A seminal work by Lattuca, (2001) on the topic of interdisciplinary research and teaching represents a significant mixed methods study. Among her findings and contributions during the qualitative phase, she identified four typologies of interdisciplinary teaching and research: informed disciplinarity; synthetic interdisciplinarity; transdisciplinarity; conceptual interdisciplinarity (Lattuca, 2001, p. 79). Of particular importance for this study, she discovered a complete absence of evidence of transdisciplinary courses, concluding that they must be a rarer form of interdisciplinarity and suggested the lack of evidence may suggest even greater departmental challenges in creating and sustaining them (Lattuca, 2001, p. 93). Citing Jantsch (1972) and Piaget (1972), she notes that they conceived of transdisciplinary pedagogy as the ultimate coordination among disciplines; providing an excellent summary of several historical references mentioned previously (Lattuca, 2001, p. 116). Lattuca's work also noted several challenges that appear elsewhere as institutional obstacles. Faculty teaching loads in a given department may increase when member of the department chooses to teach outside the department. When responding to senior administration initiatives, junior faculty are often serendipitously selected, almost by accident, as the ones required to teach outside their discipline (Lattuca, 2001, p. 183).

Associations such as the American Association of Colleges and Universities (AACU) and the Association for the Study of Higher Education (ASHE) have commissioned a variety of studies and special reports on the topics of interdisciplinary

and transdisciplinary pedagogy and research. One prominent example is Holley's (2009) special report commissioned by ASHE, which addresses both the challenges and opportunities of interdisciplinary work. Concluding that faculty are not traditionally prepared for interdisciplinary practice, she quoted from Hansen, Biros, Delaney, and Schug (1999) that "Individuals who work in interdisciplinary fields experience a necessary acculturation to language, behaviors, symbols and norms prevalent in other fields of study. The success of this process requires the interaction of disciplinary scholars, who communicate both formal and tacit knowledge among members of the interdisciplinary research group (in Holley, 2009, p. 65-66). While identified as challenges of practice, these may also serve as signposts to further distinguish indicators of faculty capacity and inclination.

Indicators of Faculty Capacity and Inclination

Given that the significant purpose of this study is to contribute to the tools needed to identify existing faculty with the capacity and inclination to teach transdisciplinary courses, the theoretical linchpin is the ability to identify factors, evidence, and artifacts within the academy that might serve as indicators. In their comprehensive study of how higher education affects students, the authors conclude that active learning had a profound effect on helping students achieve desired outcomes (Mayhew et al., 2016, p. 593). Educators engaged in leading co-curricular experiences were also seen as providing significant contributions to student success through innovations, engagement opportunities, logistical support, leadership, and the ability to create formal and ad hoc communities of learners (Mayhew et al., 2016, p. 598-599).

While making major contributions to the definition and classification of interdisciplinary and transdisciplinary teaching and research, the foundational nature of the 1970 conference on interdisciplinary problems of teaching and researching at universities identified the need for a change in attitude; describing interdisciplinarity as a state of mind that must be adopted by practitioners. Noting significant challenges, they also offer some insights into those qualities that might contribute to finding those with the necessary capacities; citing humility, open-mindedness, curiosity, willingness to engage in dialogue, capacity for assimilation and synthesis, accept teamwork from other disciplines, and seek a common language (Apostel et al., 1970, p. 192). These qualities and characteristics may serve as significant contributions to the framework needed.

Rossini, Jurkovich, Porter, & Paelinck, (1984) contribute to a practical understanding of the value of diversity in interdisciplinary research that might contribute to the defining characteristics of instructional faculty capacity. Their hypothesis was that the greater the diversity between disciplines, the more difficult it would be for faculty to collaborate on research projects. Their findings demonstrated that just the opposite was true. Faculty were more productive when there was greater diversity between their academic disciplines. Extending conclusions about seeking a common language, the desire, ability, and empathy necessary to communicate between disciplines is likely to have a role in transdisciplinary team success as well.

In Kockelmans (1979) anthology, Scott (1979) adds significant, if somewhat unflattering characteristics of faculty that might consider such an approach. First, he concludes that most faculty will be convinced that interdisciplinary courses already exist, and nothing needs to be done differently. A much smaller subset of the faculty will be

open to joint research and educational innovation as this approach appeals and is valued by those who see themselves as the creative minority. Scott (1979) concludes these are the misfits (p. 309). While Kockelmans (1979) work has direct implications for the characteristics that might define and identify such faculty, the chapters contained in the anthology broadly address other issues associated with institutional, structural, and cultural challenges that must be addressed and overcome by any participants in higher education innovation.

One study, emerging from the medical literature on preparing interdisciplinary research teams, offers significant tangential insight with significant potential to aid in identifying transdisciplinary instructional faculty. Rather than working to identify faculty with the capacity and inclination to do interdisciplinary research, Larson, Landers, & Begg (2011), identified the competencies required to conduct interdisciplinary, collaborative research. Their objective was to create a course to teach those competencies to medical professionals with an interest in participating in interdisciplinary, collaborative research. Larson, Landers, & Begg (2011) identified 17 different competencies that formed the basis for their interdisciplinary research collaboration course. While clearly beyond the scope of their work, these competencies may also assist in forming the qualitative line of inquiry for this study.

Contributions to Developing Faculty as Leaders

How might a shift towards transdisciplinary pedagogy inform leadership in higher education or prepare new leaders for a complex future? While Fullan (2001), sees few distinctions and much overlap between leadership and management, he notes one important difference in that “leadership is needed for problems that don’t have easy

answers" (Fullan, 2001, p. 2). Speaking specifically about the need for interdisciplinary problem solving, he noted that it was not important to bring people together to address problems already conquered, rather "leadership is utilizing people to confront problems that have never yet been successfully addressed" (Fullan, 2001, p. 3). His significant contribution to the literature develops from his model of components, competencies, and characteristics of leaders. Fullan (2001) identifies moral purpose, an understanding of the change process, the ability to build relationships, the ability to create knowledge and share it, and the ability to find or make coherence as key leadership competencies. Personal characteristics include a level of energy commensurate with the role, enthusiasm, and hopefulness. Translating ideation to action, Fullan's model also includes commitment, both internal to the team and external to other leaders, rules, and the regulatory environment.

Bryman (2007) noted the dearth of empirical research on the topic of effective leadership styles or behaviors in higher education. At the same time, while Amey (2006) highlights a simultaneous exodus of university leaders due to retirement and an increase in the complexity faced by prospective leaders. In their study of faculty collaborations, Amey and Brown (2004), identified cognitive changes among faculty and administrative leaders who participated in collaborative, interdisciplinary problem-solving teams for an extended period of 18 months. As the researchers observed the process using an ethnographic approach, they identified four key dimensions (discipline orientation; knowledge engagement; work orientation; leadership orientation) and three distinct stages of organizational development (traditional, transitional, transformative). They conclude that "interdisciplinary collaboration as a form of faculty work is really a process

of learning, and that leadership in such a context is really about facilitating faculty learning" (Amey & Brown, 2004, p. 96). The cognitive changes gained from working on a collaborative, interdisciplinary, problem-focused team emerge from being "continually confronted with newness—new problems, ideas, techniques, concepts; new gestalts; new possibilities and new limits; new awareness and understanding of oneself. Learning also means reinterpreting things already understood, letting go of former understandings and techniques, even if at the level of brain physiology, one never literally 'unlearns'" (Vaill in Amey & Brown, 2004, p. 125).

Combining these perspectives in a coherent model of leadership focused on teaching and learning, Quinlan (2014) presents a model of holistic learning development and the educational leadership necessary to achieve the holistic, learner-centered model. Leaders must know and be involved in learning principals, curricular and learning strategies; demonstrate leadership in creating the organizational characteristics that support student learning by aligning the institutional culture, curriculum, and co-curricular environments; model leadership of purpose, meaning and integrity for the students and faculty (Quinlan, 2014, p. 35). Expanding these concepts further, Britos Cavagnaro & Fasihuddin (2016), challenge institutions—and institutional leaders by proxy, to engage students as change agents. Students are not bound by the same political, disciplinary, or cultural norms as faculty and administrators. Britos Cavagnaro & Fasihuddin (2016) challenge current and future institutional leadership to learn how to activate them in a positive manner; compounding their impact as change agents through experimentation and low-cost pilot projects.

Perhaps the most appropriate framework for studying the phenomenon of leadership in the context of transdisciplinary pedagogy is the emergent Complexity Leadership Theory covered in the seminal work on the topic by Uhl-Bien, Marion, & McKelvey, (2007), in examining the shortcomings of transformational leadership in the context of a learning, adaptive, complex organization – characteristics that should apply to all institutions of higher education. The authors describe the challenge of knowledge industries as no longer concerned with matters of maximizing production or optimizing physical products, rather the enabling knowledge assets and distributed intelligence rather than a concentration of hierarchical leaders at the top of the organization. Providing a unifying framework of complexity leadership theory in transdisciplinary science, Makinen (2018), conducted a three-year ethnographic study of research team leaders combined with leader interviews, to compile a longitudinal case study of the work leaders do in transdisciplinary research programs. Balancing administrative, enabling, and adaptive leadership becomes a key role of leaders in complexity leadership theory. Building vision, implementing strategy, and assigning responsibilities are traditional administrative leader tasks even in the complexity model. However, the intent under of complexity leadership is to create a situation of managed chaos. The second requirement of complexity leaders is to create the conditions for problems-solving and new learning, a place where diversity is valued in the interaction and collaboration. Finally, complex leaders use adaptive leadership to create new knowledge from collisions between existing and seemingly incompatible ideas, knowledge, and technologies (Uhl-Bien & Marion (2009) in Makinen, 2018, p. 136-137). Makinen (2018) found that transdisciplinary research challenged leaders—simply modeling the behavior themselves was insufficient

to spark collaborative interactions. Such collaborations required a significant level of intentionality through at least the first six months of the project, echoing the transitioning phase identified by Amey & Brown (2004). Reflecting the challenges of igniting transdisciplinary work, leaders were required to frequently re-catalyze the collaboration until that transition phase occurred. Further, Makinen concluded that the different forms of leadership should be intentionally entangled and lose their distinction—forming adaptive dynamics within the complex system (Makinen, 2018, p. 149).

Theoretical Framework

Transdisciplinary approaches to pedagogy in higher education represent a relatively new evolution in the academy. Transdisciplinarity is not a return to the early days of pre-disciplinary study, nor is it an attempt at replacing or merging current disciplines. Rather, it is an effort to use the existing expertise from within the academy, both students and faculty, as well as external stakeholders, to bring the unique perspectives of many disciplines together to address wicked problems. This approach promises to develop highly effective students with empathy and team working skills and the necessary disciplinary expertise to add real value to industry and society. Such an approach requires faculty that are prepared to engage in such a pedagogical approach, acceptance, and support from the disciplines and departments, and the institutional support and recognition necessary to foster the transformation.

This approach represents a complex system involving the individual faculty, their existing discipline-based department, the institutional traditions and perspectives towards non-traditional instructional models – all operating with the existing higher education ecosystem. While complex, the approach reflects the modern necessities of problems-

solving and research. Applicable to both research and problem-solving, Maasen and Lieven (2006) observe that "the demand for outcomes that are not only scientifically reliable but also profitable, ethical, sustainable and safe provokes all kinds of negotiations (Maasen & Lieven, 2006, p. 404). Identifying faculty willing to work across disciplinary boundaries and prepare students with these skills is a necessary precondition to implementation.

A model that facilitates the analysis of such a complex system in higher education was developed by Berger & Milem (2000). That model was recently adapted as a recursive model with integrated faculty components (Selznick, McCarthy, Ludwig, Swayne, & Lewis, 2019, figure 1). The new, recursive model provides a framework that addresses the complexity of the problem and complements the Mode 2 knowledge production methodology.

Because of the recursive and complex nature of transdisciplinary work, Gibbons et al., (2002) the Mode 2 knowledge production model appropriately frames this study with the process of discovering the factors contributing to faculty capacity and inclination to teach in transdisciplinary pedagogical settings recursively embedded in the study. Drawing on factors identified by Apostel et al., (1970), Kockelmans, (1979) and the lens of Klein's transdisciplinary joint problem solving (Klein et al., 2001).

Complexity Leadership Theory provides the most appropriate framework for analyzing the recursive and complex nature of leadership within the context of transdisciplinary pedagogy. While transformational leadership holds many similar constructs, it is frustratingly limited due to its ties to a specific transformative leader (Malloch, 2014, p. 62). Still something of an emerging theory of leadership, evidence

presented by Uhl-Bien, Marion, & McKelvey, (2007) indicates that the Complexity Leadership Theory (CLT) framework lends itself perfectly in this situation as it frames leadership as a dynamic, complex system and process, that enables the learning, creative, and adaptive capacity of complex adaptive systems in knowledge-producing organizations, rather than a specific individual transformative leader (Lichtenstein et al., 2006). Beyond the scope of transdisciplinary pedagogy, the CLT model fits exceptionally well with the current environment of higher education, providing a layered benefit that prepares faculty to teach in the complex, transdisciplinary pedagogical environment and simultaneously preparing a future generation of institutional leaders.

Gallant & Getz (2009) describe the current state of higher education an organizations faced with unprecedented and often conflicting challenges with increasingly diverse student bodies and faculty, creating environments where diverse groups can thrive while meeting ever more demanding federal accountability measures, increase efficiencies through technology while improving the powerful impact of interpersonal relationships, maintaining excellence in teaching and learning while simultaneously meeting the pressures of increasing research, and admitting more students without additional physical infrastructure. Managing these tensions, meeting the needs and demands of multiple stakeholders, while maintaining institutional cultures and traditions creates situations that demand continuous renewal and improvement. Leading large, diverse organizations with multiple sources of intra-organizational conflict and extra-organizational conflict is a fitting, operational definition of a complex leadership challenge. The Complexity Leadership Theory was designed for the purpose of

developing the capacity and experience needed to lead effectively in such an environment; the modern ecosystem of higher education (Gallant & Getz, 2009, p. 93).

Summary

The broad issues of interdisciplinary and transdisciplinary pedagogy have experienced significant episodes of punctuated equilibrium since the first international conference on the topic convened in Paris in 1970 (Apostel et al., 1970). While the movement continues with periodic episodes of subsequent equilibrium punctuations, the relatively small scale, localized efforts of pedagogical innovation have not led to substantive transformations in higher education teaching, faculty preparation, or hiring practices. This study proposes a new approach. Rather than starting with a transformation of the academy's doctoral preparation as proposed by Apostel et al. (1970), developing a reliable measure of faculty attributes that describe capacity, and inclination in transdisciplinary pedagogy, it should be possible to develop faculty leaders and transform the academy using existing human capital. In order to realize this opportunity, a valid and reliable instrument to assess applicable factors and predict a level of success are increasingly important.

The theoretical framework and preceding review of literature establish the foundation for those attributes that are likely to describe faculty involvement, persistence, capacity, and inclination to teach in these unfamiliar circumstances. A well-grounded understanding of the characteristics of transdisciplinary pedagogy, how it differs and often creates tension among traditionally prepared faculty contributes to an understanding of the unique attributes required for capable instructors. Understanding traditional processes used in faculty selection, self-selection, and hiring practices contribute to our

ability to create a process intervention that might accelerate such a transformation to transdisciplinary pedagogy. Finally, team-taught, problem-based courses require significantly more faculty effort outside of class in order to address the logistics, planning, coordination, vision, and management requirements are inherent to the method. In a microcosm of a single class, these challenges replicate the complexities of the larger, higher education organization and contribute significantly to leader development among participating faculty.

Chapter 3

Methods

Introduction

The primary goal of this study is to develop an instrument that can reliably and validly measure faculty attributes that predict persistence, involvement, capacity, and inclination to teach team-taught, problem-based, transdisciplinary courses. Despite an abundance of research on the topic of multidisciplinary, and problem-based learning focused on student outcomes, the lack of a coherent model for identifying faculty with capacity and inclination to serve as instructors of transdisciplinary courses hampers broader adoption of the pedagogical model for innovation in higher education. In order to resolve this shortcoming, this study seeks to identify attributes that accurately describe faculty capacity and inclination to teach in transdisciplinary, problem-based pedagogical settings, and develop a quantitative instrument that can reliably identify those attributes in a larger audience.

In this chapter I am introducing the methodology used to explore the factors that contribute to capacity and inclination, and they are subsequently used to develop the instrument to test those research questions. The chapter is organized into five sections: (a) study design and analysis, (b) an explanation of the qualitative strand, (c) selection of participants, (d) data collection for the qualitative strand, (e) data collection for the quantitative strand. Merriam & Tisdell (2016) also recommend addressing researcher bias and assumptions that might influence the qualitative portion of the study, hence researcher bias and assumptions are included.

Study Design and Analysis

An exploratory, sequential, mixed-methods design begins with a qualitative, exploratory phase. That strand concludes with the mixing of data which informs the development of a quantitative instrument, the Faculty Capacity and Inclination Index (FCII). The quantitative phase consists of testing the instrument with a larger sample size (Creswell, 2015). The exporatory, mixed-methods approach is appropriate for this study as little is known about the specific attributes that contribute to faculty capacity and inclination to teach using the transdisciplinary pedagogical model. The qualitative data are required to explore and define the parameters in order to create a quantitative instrument to gather data from a larger sample (Merriam & Tisdell, 2016, p. 47).

During the quantitative strand of this study, I am seeking to validate an instrument (the Faculty Capacity and Inclination Index [FCII]) that measures factors that indicate faculty capacity and inclination to teach transdisciplinary, problem-based pedagogical model courses. The answers to the first research question inform the process of selecting specific items for inclusion that reliably operationalize faculty capacity and inclination attributes. The qualitative phase included an analysis of pedagogy from the faculty perspective. This analysis served the purpose of understanding the specific themes, methods, and impressions that differentiate transdisciplinary classes from other college courses the faculty teach. It framed the assessment of faculty perceptions based on the theoretical framework of higher education established by Berger and Milem (2000), and expanded to include faculty by (Selznick, McCarthy, Lewis, Ludwig, & Swayne, n.d., p. 20). Within that context, specific attributes associated with interdisciplinary and transdisciplinary pedagogy were coupled with the attributes of the Complexity Leadership Theory. This helped determine whether there are differences between the

emergent faculty groups that were identified, and it also helped to isolate differences that might distinguish members of each group. If the faculty articulate themes that sufficiently differentiate attributes that define them as participants, a generalizable and reliable quantitative instrument can be developed to differentiate and identify future faculty. The research diagram for this study would be characterized by the mixed methods notation of qual → QUAN. A complete methodological diagram is provided in Figure 1.

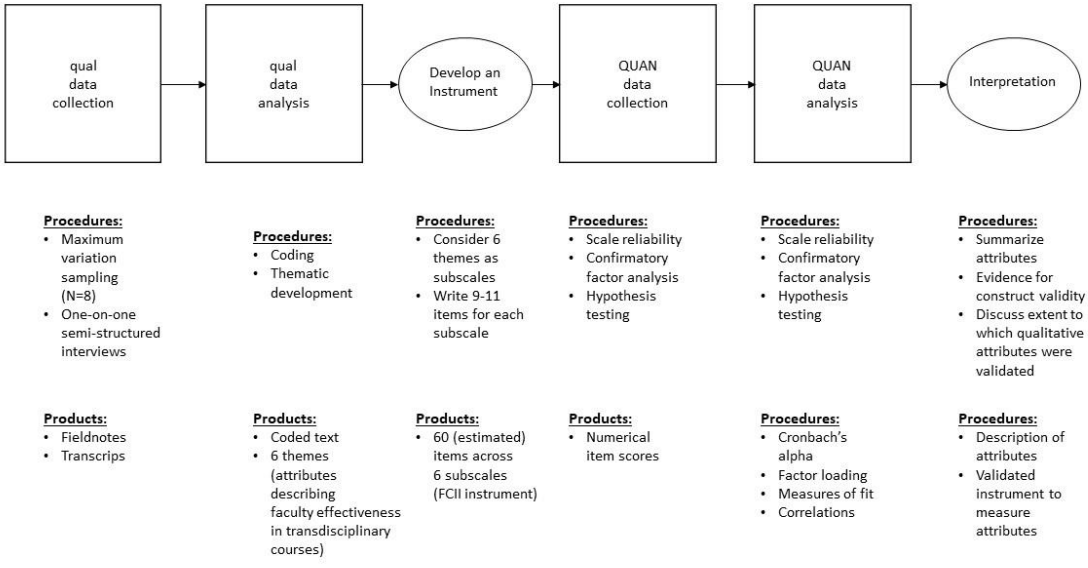

Figure 1. Methodological diagram of this exploratory, sequential, mixed-methods study. FCII reflects the proposed Faculty Capacity and Inclination Index. The diagram is based on an example in Creswell & Plano Clark (2011, p. 124).

Through the qualitative strand, this study addressed the following qualitative research question:

What attributes describe faculty persistence and involvement in team-taught, problem-based, transdisciplinary courses?

Qualitative Strand

Protocols developed for the qualitative phase are framed around the extant literature. A thorough review by a panel of experts included a pilot test of an initial version of the FCII. While working to close a significant gap in the literature by identifying specific, research-based factors, some hints do exist that serve as a starting point in developing the qualitative protocols. Without the benefit of shared research evidence, the expert founders of the modern transdisciplinary movement identified what they expected might be required: a state of mind requiring each person to balance humility and open-mindedness, curiosity, willingness to engage in dialogue, capacity for assimilation and synthesis, accept teamwork from other disciplines, and seek a common language that factors first postulated in Apostel et al. (1970, p. 192). These transdisciplinary attributes appear congruent with the attributes of the Complexity [and chaos] Leadership Theory characterized as collaboration, breaking down hierarchy, local decision making and organic processes (Kezar, Carducci, & Contreras-McGavin, 2006, p. 40). The conjunction of these theoretical attributes served as the starting point for qualitative protocols.

Selection of Participants. The purpose of this study is to identify factors that can be used to develop a measurement instrument to reliably identify the faculty most likely to flourish as instructors in transdisciplinary, problem-based courses, hence a purposeful sampling strategy was employed. The number of faculty with experience teaching transdisciplinary courses at the target institution is small – currently 51 – and the faculty have distinct experiential differences that are based on the variety and number of course iterations with which they have instructed. Based on their careers, prior professional

experiences, and specific experiences with teaching transdisciplinary courses, there is an expectation that they would perceive a low threat and have a rich framework from which to reflect and respond as part of their learning process (Kolb & Kolb, 2005). The sampling plan calls for interviews with eight faculty members. However, a ninth is added to ensure saturation (Creswell, 2015, p. 77).

This study proceeds with semi-structured interviews of faculty that have experience in teaching transdisciplinary, problem-based courses at a specific innovation instructional laboratory, at one regional comprehensive university located in the mid-Atlantic region of the United States. While the number of participants continues to grow, at the time of the study there are at least 51 faculty that have undertaken such experiences since the lab's opening in the fall semester of 2015, and they are considered for participation in the qualitative phase. Based on researcher familiarity and experience, these faculty are further identified into four emergent groups defined by specific, observed behavior characteristics.

The Core Faculty. The core faculty are those who assumed the greatest risk; taking on significant initiative, organizing the first classes, participating in developing subsequent classes, participating as an instructor nearly every semester, contributing to ongoing research on student outcomes, and working to formalize the pedagogical model. These are characterized as the core faculty group.

The Regulars. The second group regularly participates, at least once each academic year, but does not contribute significantly to other aspects of course development or research. These are characterized as the regulars.

***The Curious*.** The third group is the largest numerically. The members of this group of faculty have taught one to two courses and expressed some level of interest in further participation. Some have expressed concerns about the impact of teaching outside their disciplines, unfair burden placed on departmental colleagues, time commitment, tenure considerations, and departmental research and publication expectations, among other considerations for not participating further. This group is characterized as the curious.

The Traditionalists. The final group is the smallest among those identified. This group, identified as traditionalists, expressed an interest in teaching in the lab using the pedagogical model, attempted to do so, but self-selected out at some point either during the semester or upon completion of the course.

Data collection - qualitative strand. An Institutional Review Board, or IRB, approval was obtained prior to any interviews or surveys being disseminated. A two-part IRB approval was followed with separate and distinct protocols provided to address the unique differences between the qualitative and quantitative phases of the study. As the qualitative phase includes semi-structured interviews, the identity of the participants is known to me, and their reflection responses are known and attributed to each individual interviewed. However, their responses are safeguarded. Pseudonyms are used throughout the study. Any identifying characteristics such as specific discipline, references to specific classes, and academic major are edited from the documentation.

Interview protocol. Questions are designed to help the interviewees reflect on their experiences and what they consider to be the factors that influence their capacity and inclination to teach in transdisciplinary, problem-based pedagogical models. The

data serve as qualitative snapshots that elucidate formative or emerging trends, patterns, and characteristics that differentiate members of each group and capture those responses when they were current. The most discerning attribute descriptives from the literature are those identified by Asa Briggs and Guy Michaud in the proceedings of the first international conference on the topic, and include humility and open-mindedness, curiosity, willingness to engage in dialogue, capacity for assimilation and synthesis, accepting of teamwork, and a search for common language (Apostel et al., 1970, p. 192). Again, the qualitative protocols (see Appendix A) are designed to help interviewees expound those factors through their insights and experiences as participating faculty.

Interview procedures. Participants are interviewed for 60 minutes, individually at campus locations of their choosing, and face-to-face interviews are preferred. Participation is voluntary. The participants were informed that participation is voluntary and that they could refuse to answer any questions or terminate the interview at any time without prejudice. Interviewees were further informed that the purpose of the research is to develop a scale for determining factors or attributes that define faculty capacity and inclination to teach transdisciplinary, problem-based courses. Participants were assured that the recorded interviews would not be shared with administrators or others outside the process of recording and transcribing the recordings. All interviewees were assigned a pseudonym prior to the start of the interview. Pseudonyms have been used in citations throughout the study.

Participants are asked to reflect on their experiences and how they responded to participation in courses where they served as instructors. They are asked to share experiences they believe characterize the factors or attributes that influence their capacity

and inclination to teach in transdisciplinary, problem-based courses, as well as how their experience might have influenced their perceptions of leadership, helped them understand leadership in a complex context, or helped develop them as leaders. Follow-up questions were asked in order to probe for additional details that helped identify specific factors or attributes. Table 1 reflects the demographic composition of faculty participating in the qualitative strand.

Table 1

Demographic composition of qualitative participants

Identifier	Gender	Tenure Status	Population Group	Discipline
Mabel	F	RTA	Core	STEM
Dania	F	Tenured	Core	Health
Esme	F	Tenured	Traditional	Liberal Arts
Lee	F	Tenured	Curious	Business
Atticus	M	Tenured	Regular	STEM
Zakariah	M	Non-Tenured	Curious	Liberal Arts
Brendan	M	Tenured	Core	Liberal Arts
Michelle	F	NT	Curious	Liberal Arts
Vivaan	F	Tenured	Curious	Health

Qualitative Analysis. Initial open coding and analysis of the qualitative data begin during the collection phase and continue deliberately throughout the interviewing process by developing categories and themes from the data. Axial coding is used simultaneously as the open coding took place (Merriam & Tisdell, 2016, p. 206). Using

the constant comparative method, or continued axial coding, categories are developed from the data and further sorted and refined throughout the process. Validity is enhanced through the use of the recommended member check-in review of individual interview transcriptions (Creswell & Plano Clark, 2011, p. 212).

Instrument Development. Characteristic of an exploratory, sequential, mixed-methods study, the data were mixed during the transition to the quantitative phase of the research (Creswell, 2015, p. 83). Saturation required nine interviews to accomplish the goal of the study.

The qualitative mixing phase concludes with the development of instrument items that constitute a quantitative assessment prototype. The prototype instrument operationalizes the differences between faculty with experience teaching transdisciplinary, team-taught, problem-based courses. Based on themes that emerge from the qualitative data analysis and an extensive review of the literature, specific items are developed that help isolate attributes identified from the qualitative findings from phase one (Creswell, 2014, p. 235).

Quantitative Strand

Quantitative Data Collection. Quantitative sampling involves a convenience sampling of the entire population of faculty at the institution. Based on institutional research information, there are 950 full-time faculty employed at the institution. Creswell (2014, p. 158), recommends a random sampling, if possible, for this phase of the research. However, with a population of 950 faculty, it is possible to achieve sufficient responses for a factor analysis of the instrument from a convenience sampling

(Creswell, 2015, p. 76) of this population using an online methodology and normal response rates. Faculty from phase one are not excluded from quantitative sampling.

The quantitative instrument developed is based on the categories, themes, and factors that emerge from the phase one qualitative analysis. A panel of experts reviewed the prototype items that formed the prototype FCII. Subsequently, those experts also participated in a pre-test of the prototype FCII instrument to improve its validity and reliability. The target audience for the FCII was currently-serving university faculty. Descriptive statistics were collected to aid in developing a comprehensive model by demographic condition (gender, tenure, years of service, discipline).

Quantitative Analysis. Based on the design of this mixed-methods study, an exploratory factor analysis (EFA) was used to establish the reliability and uncover any possible underlying structures or relationships between the measured variables. The EFA further served to provide the analytical processes necessary to establish a basis for reliability and validity. In addition to the EFA quantitative analysis, the study concluded with meta-inferences drawn from the two methods that provided a broader focused interpretation of the conclusion and findings (Creswell & Plano Clark, 2011, p. 234).

The developed instrument's effectiveness was evaluated on the basis of its validity and reliability. Does the instrument demonstrate reliability and validity measures that indicate the potential to differentiate based on the attributes identified? The goal of the instrument is to ultimately establish sufficient predictive validity that it proves helpful in identifying faculty with the capacity and inclination to teach transdisciplinary classes, although that level of psychometric analysis goes beyond the scope of this study. Reliability of the instrument was assessed using Chronbach's alpha. Given that the full

instrument consisted of 56 content-specific items, a consistency coefficient was calculated for each of the developed subscale constructs.

Summative Analysis. The transdisciplinary pedagogical model developed in the X-Labs was not designed to develop faculty leadership. However, that aspect of the program emerged as a very successful by-product with results that may be as significant as the student-focused pedagogical model. Throughout the initial five years of programming, faculty participants ranged from senior, full professors to new assistant professors serving in their first faculty position. Despite traditional disciplinary norms that presuppose a high level of risk associated with such extra-disciplinary endeavors, to date, all eligible participating faculty have gone on to achieve tenure, promotion, and leadership positions within the institution. While a causal relationship may not be concluded, anecdotal evidence suggests that administrators recognize some level of professional leadership capacity or development among faculty participants. Given the complexity of the courses, the circumstances present a compelling by-product. Do these classes play a role in developing or identifying faculty with the potential and capacity to lead complex organizations?

In a mixed-methods study, the summative analysis was intended to interpret the quantitative results through the lens of the qualitative findings. The results of the quantitative phase established statistically significant markers for the attributes identified in the qualitative phase.

Researcher Positionality

Positioning Statement: It is important to note that as a researcher, I am also directly involved in JMU X-Labs as an administrator and program coordinator, so I have

an intrinsic bias towards these courses and programs. However, I have no formal or informal supervisory responsibility or authority with any of the faculty involved and no influence on their professional careers. I approach my research with a pragmatic lens and a constructivist epistemology. The validity and reliability of this study are enhanced by a variety of comprehensive, mixed-methods techniques. That process started with the selection of the nine participants. The basis for the selection was theoretically sound and served to enhance the findings of the study. The sample size increased through each phase of the study. Divergent findings of significance did not emerge, so a re-analysis of the data or procedures used in the study was not required (Creswell & Plano Clark, 2011, p. 240).

Summary

This chapter restated the study's purpose and presented the qualitative and quantitative research questions in context with the methodology used. Participants in the qualitative phase were chosen from a limited sample of faculty with the requisite experience and expertise. Participants in the quantitative phase were selected using a convenience population of full-time faculty. Data collection procedures and the methodology used to evaluate the reliability and validity of the developed instrument was discussed. Finally, the methods of analysis for each of the research questions were presented. The results of the data analysis are presented and discussed in the following chapter.

Chapter 4

Results

Introduction

The purpose of the study was achieved by developing and analyzing the data required to construct the Faculty Capacity and Inclination Index (FCII) instrument. This chapter presents the results of the data analysis and instrument development pertaining to the qualitative and quantitative research questions.

With five years of informal course observations, now more than sixty faculty participants, over one thousand student participants, and twenty-five unique courses offered in the JMU X-Labs since its 2015 opening, the number of artifacts contributing insights, experience, failures, and successes are innumerable. The formal qualitative research work for this study was approved under Federal Wide Assurance 00007339 by the Internal Review Board at James Madison University and assigned protocol number 20-1744. That protocol was amended and extended to permit telephonic interviews in response to the COVID-19 restrictions. Subsequently, the quantitative survey instrument developed for the quantitative portion of the study was granted an exception under 45 CFR 46.104 Categories 2 and 3 by the IRB and assigned protocol number 21-1925.

This study identified patterns and factors among faculty with experience teaching in hands-on, transdisciplinary methodology that might serve as predictive indicators in identifying other faculty with the capacity and inclination to engage and persist in transdisciplinary pedagogy with the ultimate goal being to develop a reliable and valid quantitative instrument that might aid in identifying faculty with the capacity and inclination to expand the transdisciplinary education model. The literature provided a

sound basis from which to develop the semi-structured interview questions and a foundation for developing initial qualitative codes.

Theoretical frameworks from the literature and development of the qualitative questions for the semi-structured interviews were addressed in previous chapters. This chapter focuses on the analysis and processing of the data. Beginning with a presentation of evidence and support extracted from the qualitative phase, I present evidence of qualitative codes and their integration into survey item development. The items were clustered around hypothesized constructs and shared with a panel of experts for review and feedback. These finalized items formed the basis of the Faculty Capacity and Inclination Instrument. Demographic questions were added to position the results within the academy, and an existing reliable and valid, open-source, ten-item personality instrument (TIPI) was incorporated so that the FCII could be tested as a unique measurement instrument. Responses to the FCII were subjected to a series of exploratory factor analysis processes. Each construct was evaluated for loading factors and tested using Cronbach's alpha. Scores were computed for each construct, and regression analysis performed to test the openness construct of the FCII against that of the TIPI. Finally, a composite score was computed from all FCII constructs and used to develop a histogram demonstrating variance among respondents from the population, indicating potential value as a means of identifying faculty with the capacity and inclination to teach transdisciplinary courses.

As the literature suggests, transdisciplinary experiences may double as a professional development system for faculty as complex leaders under the complexity leadership theory. Items included on the FCII were developed to help identify those

factors among the respondents and determine if they contribute to the value of the instrument.

Qualitative Results

Qualitative interview participants were drawn from the population of faculty with prior experience teaching in the X-Labs using problem-based, transdisciplinary course pedagogy. A total of nine semi-structured interviews were necessary to reach saturation. Seven interviews were conducted in person, but the ensuing conditions imposed by the COVID-19 outbreak during the study required a transition to telephonic interviews for the final two.

Qualitative Research Question and Coding. ***Part one of this chapter presents the results of data analysis for the qualitative research questions posed previously: What attributes describe faculty persistence and involvement in team-taught, problem-based, transdisciplinary courses?***

The qualitative research question was successfully addressed through the qualitative and mixing phase of the study, attaining saturation and identifying concepts and descriptors of the desired attributes. The semi-structured interview questions used for the qualitative portion of the study are included in Appendix A. The interview questions reflect the literature, observations, and multiple informal discussions with faculty, students, and administrators. Despite the interviewees representing a wide range of experiences teaching in the transdisciplinary setting of JMU X-Labs, constructs identified in the literature were consistently described and supported by the participants. These consistent responses helped locate the importance of those points and clarify particular factors, attributes, aspects of leadership, and an individual's ability to lead and

thrive in complex environments. Reflective of the complexity leadership theory, several factors presented complex intersections and sentiments that echo the changing relationship patterns between faculty and colleagues, faculty and students, faculty and disciplines, and faculty as leaders.

All participants agreed to have the conversations recorded, and recordings were done in accordance with the approved IRB protocol. Each interview was fully transcribed using automated transcription software. Transcripts were then shared with each individual interviewee as a member check-in review for accuracy and intentionality considerations. Each respondent confirmed the accuracy of their interview transcript. The transcription files for each interviewee were loaded into Nvivo (version 12 for Windows) and coded in accordance with the methodology discussed in chapter three. Data analysis ensued in parallel with the transcription of the interviews and a concurrent process of both open and axial coding using NVivo qualitative analysis software.

Throughout the exploratory process, visual tools in the NVivo software, such as word clouds and heat maps proved valuable in identifying, detecting, and clustering codes. As suggested by Creswell and Plano Clark (2011), open coding progressed in parallel with the ongoing interview process. Periodic and summary axial coding was used to combine the emerging concepts and codes extracted from the text through open coding and combine them into the presumptive constructs.

The six emergent qualitative codes developed from the literature and semi-structured interview data are listed in Table 2.

Table 2

Emergent qualitative codes

Code	Description
Openness to New Experiences	Evidence presented demonstrates intentional curiosity
Intrinsic Motivation	Willingness to work on passion projects with no expectation of external recognition
Learning Partnerships	Willing to work with diverse students and colleagues as equals
Empathy	The ability, willingness, and demonstrated ability to contrasting perspectives
Continuous Learning	A degree of fearlessness as an expert in one field to broaden one's understanding beyond that field
Complex Leadership	The ability to work at a systems level accomplishing shared, team progress with often competing requirements, conflicting goals, and ambiguous objectives

Openness to new experiences. On the topic of transdisciplinary pedagogy, the literature addresses openness to new experiences from multiple perspectives. Manifestations of this attribute appeared to align well with that leadership attribute of the Five-Factor Model where Hogan, Curphy, & Hogan (1994) noted that people with higher levels of openness tended to think more strategically about problem-solving. Faculty presented evidence in their prior experiences and frequently noted it as a defining characteristic of their teaching experiences in the lab. All of the respondents provided rich examples of programs, projects, and explorations beyond their doctoral field of study. The qualitative data reflect many of these perspectives as well as several points of intersection. For example, openness to new experiences was manifest in faculty willingness to learn a new pedagogical approach and teach new content simultaneously, research and publish outside of one's discipline, lead study abroad programs, collaborate on research programs that combine disciplines in new ways.

> I guess you probably wouldn't technically consider [course name] to be outside of my disciplinary area. But that said, I knew nothing about [course name] when we started teaching a class and actually used the class, you know, as an opportunity to deepen our understanding. Because we saw it. We read enough to think this is probably gonna be significant. So it was a stretch. I was pushing my own personal boundaries in terms of what I knew and understood to be able to teach a class like that. *Atticus*

While her discipline has no obvious academic ties to the topic of human trafficking, Lee shared her openness to create bridges of research and scholarship that extend beyond traditional disciplinary bounds. This willingness to have an open mind about new topics and how they should be incorporated into one's discipline was shared consistently by the interviewees. As Lee noted,

> Currently, I'm in a research project dealing with human trafficking. I took what we're currently doing in X-Labs and was able to create a research project based on looking at curriculum and pedagogy and integrated it into [discipline named] programs across the USA. *Lee*

Several respondents shared experiences involving their active openness role as going beyond being open to change and actively seeking and creating the changes themselves. Vivaan offered her experience with bringing new technology to her discipline.

> Supervising students with technology. It wasn't present before, but I brought it into our field. The same thing with simulations and tele-supervision and those kind of things. These are things that other people have been using effectively, and

> so I've seen my role in applying those concepts in my world and my profession. *Vivaan*

Esme reflected on the opportunities she created to further an interest in learning through external cultural experiences. Her openness was demonstrated by developing new content, instructional approaches, and partnerships with faculty from other countries.

> Just recently in August of 2018, I took a group of [students] to [country named], formerly known as [country named]. And there we brought 4 [faculty], including myself and my husband went there, and we taught students from an orphanage, students in high school, students in college, as well as established [content area named]. In 10 days we had an opportunity to touch the lives of hundreds of people through our envoy of [discipline named]. They called it an [discipline named] envoy to [country named]. *Esme*

The openness required by faculty to engage in collaborations to construct new knowledge that crosses traditional disciplinary boundaries is a hallmark of the transdisciplinary pedagogy. Mabel reflected on her experience working with two math faculty.

> I've written a case study with two mathematicians on teaching bio-math classes. So it's, I guess, tangential to my discipline, but not rooted squarely in it. That was an interesting experience because I taught with both of the mathematicians. We taught the classes two different ways, and we were comparing them in a case study. *Mabel*

Having multiple instructors from different disciplines working together in class at the same time can be a bit intimidating and rewarding at the same time. Mabel noted that,

when working together, faculty often observe subtle differences in student teams and can greatly expand the toolkit available to help them progress.

> First of all, the courses are taught with multiple instructors in the room simultaneously. In my disciplinary classes, if they are taught by multiple instructors, we're not in the room at the same time. It's sequential by maybe weeks or something like that. *Mabel*

In addition to requiring faculty to learn new pedagogical approaches and work in teams, teaching in the X-Labs requires that faculty leave their familiar classrooms. Homerooms tend to be comfortable places where faculty have significant experience. They offer the opportunity to practice and lend some sense of control over the instructional equipment and classroom layout. The X-Labs is not a traditional classroom, providing technology that is designed for collaboration locally with students in the space, and remotely with students, faculty, and guest instructors joining virtually. It is also well equipped with basic prototyping equipment, milling machines, laser cutters, a variety of hand tools, and mobile furnishings. It does not fit the mold of a conventional classroom for most disciplines. Technical support and scaffolding are available for both faculty and students, but the environment itself exposes faculty to student questions on topics where faculty are unlikely to be experts. Captured as an aspect of openness, the prospect of working in an unfamiliar classroom seemed to present as both an interesting and intriguing opportunity and something of a barrier. Teaching in the lab required faculty to learn the technology and adapt to an unfamiliar setting. Doing so often created a level anxiety about the arrangement of furnishings and performance in a new environment.

> At least at the beginning, just being in a different kind of classroom is another significant difference. I would say, just because, you know, I have taught in the exact same classroom - all my classes every semester for almost 14 years now. With very few exceptions, I'm in the same room. It's a standard technology classroom with a computer. I'm involved in setting up what software is on it, so I'm intimately familiar with the capabilities of what's available in that room. And then when you come down here, there's just so many more things to take advantage of. And just little things, like knowing where the light switches are and how to control the telepresence monitors and all those things. There's just a learning curve that I'd say that that's different. *Atticus*

Intrinsic Motivation. Solving complex real-world problems often requires more than a deep understanding of one specific disciplinary content area. While some faculty were confident of their motives, others shared that they thought their motivation was to develop a deeper understanding of a particular topic. However, their stories reflected that while other incentives may serve as the impetus for starting a project, at some point, there was a coalescence around wanting to create impact and or initiate direct action.

> So justice is the primary motivation behind pretty much everything that I do. I am most motivated to have an impact on people's lives in ways that make our society more just, more fair, more exciting, more motivating. Focusing on impact and real-world results as the motivation for research. *Atticus*

Brendan and Dania share similar sentiments asking, “If the objective is not to do something, to be useful, to impart change, why are we doing it?”

> I want the research that I'm involved in now to be either sector change or bust. So I suppose number three. I consider my research to be most almost exclusively here at this stage, even though I have to map it onto my home discipline. Still, the research that we do here has the potential if it's not already a sector change proposition of value for higher education. And so it's either that or why are we doing it? *Brendan*

> Yeah, the viable, workable, and impact. Things that are useful are a motivator to me. They don't necessarily have to be useful to me directly, although it's nice when that happens. I'm motivated if it's ultimately useful to science, or my profession, or the greater good. *Dania*

Michelle provides an interesting perspective that demonstrates a level of internal ambiguity and a process that arrives at an intentional impact. Aspiring to use her research efforts to improve understanding and predictive power, ultimately, she returns to the objective of getting things done, or intrinsic motivation and a bias towards action and impact in her research.

> I think there's a combination between, helping people to develop to, understand, or developing tools that help people understand, but not in ways that are constraining in ways that help them to see more than they could see before. My hope is that not everybody sees the exact same thing when they read my research, but that they see the things they've seen before in a new and different way, and that new and different way opens up new possibilities for the way they can be in the world and for the way they can organize other people in this world and essentially get things done. So that eventually ends up [as impact]. *Michelle*

Transdisciplinary pedagogy recursively creates new knowledge as it creates new processes of discovery. Faculty reflected on the challenges and successes that result from participating in new methods that extend beyond the bounds of their traditional disciplines. Considering the work and commitment required to undertake research and publish, Brendan's experiences demonstrate the power of intrinsic motivation when activated and supported.

> I'm now publishing more outside of my discipline than inside my discipline as a result of working in the X-Labs. I would say that right now, 70% of my publications are coming out of working the X-Labs, which is only tangentially related to my own discipline. *Brendan*

Dania shared her lifelong experiences that demonstrate the common thread of intrinsic motivation among the interviewees. Many shared their joys and frustrations in learning both musical instruments and foreign languages. These two activities require significant effort but rarely result in remuneration or academic rewards outside of those disciplines. Despite her son's criticism, she exemplifies intrinsic motivation in her passion for learning.

> When I was a child through when I was a teen, I played the violin. I really was quite good at that. I haven't touched it since. I am trying to learn Spanish, but according to my son, doing a terrible job. He quizzes me with cards, and I fail. *Dania*

The willingness to exert extra effort to push against an established system, intrinsic motivation in the form of persistence, was apparent in the data. While most interviewees mentioned the initiative and their willingness to undertake the work because they saw

inherent value in the outcomes, Atticus was quite blunt in his observation of transdisciplinary work and seemed to characterize what others were expressing more subtly.

> It's not gonna happen on its own. It's gonna require people who see that possibility and are rooting for it, to work their asses off to make it happen. *Atticus*

Learning partnerships. Transdisciplinary literature is replete with examples of the benefits resulting from diverse teams working on complex or wicked problems. However, combining non-adjacent disciplines in upper-division, undergraduate courses, and focusing those courses on problems rather than disciplinary knowledge was a new approach for most faculty. What emerged in the data was an apparent awakening of faculty to possibilities arising from working with diverse instructional teams. Faculty noted functional differences that develop from the diversity of the approach. As instructors, they became aware of the range of disciplines present in their classes, often significant demographic shifts, different levels of student motivation, expectation, and focus that ultimately led to greater levels of thought diversity in solving complex problems.

> The non-adjacent part of the disciplines is also different in that I might be teaching with somebody from math, and maybe we are in the room at the same time cause it's a bio-math class, but we're pretty close in our disciplines. In X-Labs, those participating disciplines are very far apart on the color wheel of disciplines. *Mabel*

> Whereas in X-Labs classes, there's a lot more focus on collaboration, complex problem solving and working with clients. Even though I also work with clients in some of my other classes, it's in a different kind of way. The biggest difference being, I suppose, the problem focus, and also the team teaching is obviously a huge thing. I mean, I never team teach in my own classes. I'm always the solo professor, and that changes things absolutely radically because it changes your relationship to the methods that you're teaching and also to the way that you interact with students. *Brendan*

Several faculty noted that their experiences at the institution frequently involved student teams and often teams of faculty instructors. What they noted as different in these courses was how the faculty members contributed concurrently to the class model. Faculty worked with the student teams and frequently developed a just-in-time delivery of instruction that blended the current state of the problem-solving process with specific content knowledge that helped students overcome roadblocks. Conceptually, team teaching is not new, and several interviewees expressed experience and preference towards the approach while noting a uniqueness to their X-Labs experience.

> I have been in favor of this kind of approach. So it was not foreign to me to be in a classroom with four other professors working on a project. In fact, one of the best courses I've ever led was a course in [course named]. Esme

Atticus noted that gender representations changed dramatically, but more profound was that the different composition of disciplines removed his ability to generalize or make

assumptions about class knowledge, skills, or behaviors which required more intentional consideration to his instructional planning.

> My classes tend to be about 90-95% male. When you're working with students where you have a much deeper sort of sense of what their background of preparation has been, as opposed to, you know, a group of students that are just way more diverse and a lot different than all the ones you normally teach. You can assume that they have certain skills or habits. Here, you can't assume that they have any particular background or set of interests. *Atticus*

Atticus also noted that, for a variety of reasons, students in his X-Labs classes showed up with more focus and motivation. Students often had to work through particular registration issues to find the class; others decided to take X-Labs classes that were non-standard, particularly challenging, and often did not count directly towards completing their degrees. He voiced a sense of satisfaction he felt in rising to meet the learning demands of students. Interviewees noted an increase in student motivation that helped change the faculty-student relationship to a more rewarding partnership.

> I think one of the things that's fairly safe to say is the level of interest of students who take the X-Labs classes is going to start out being higher. The level of interest, a little motivation, sort of initiative, or entrepreneurial spirit that they're gonna have. You know, the classes they take down here may or may not count towards their major. The marketing for any particular class may or may not have been great. And so you know, on average, the students you tend to see in a class are more plugged in. They care more about their education. They are looking for opportunities to expand and branch out. *Atticus*

Forming specialized instructional teams around problem sets seemed to generate a sense of trust and improved comfort-levels that demonstrated the value of experts from different disciplines, working together, and sharing their expertise. Otherwise characterized as a distributed human operating system, this also factored into later discussions of diversity complex leadership theory.

> It's a different point of view entirely. It requires different methods. And I'm really excited about that because everything we do here is collaborative. So I feel that now I'm doing the kind of research that I would never dream of touching on my own. So the methods that we're using, I have confidence in being able to do that, because I'm doing that collaboratively. I feel like I have a sort of a power base of methodological tools at my disposal. But they happened to be in other people, and I don't know that we often think about methods that way. And that to me, changes everything. Because you can do anything if you have assembled people around you. *Brendan*

Voicing the value of diverse learning partnerships, Atticus noted the necessity of combining the strengths of everyone wanting to help solve complex problems.

> Given everything, if you look holistically in the world right now way can't afford to miss out on anybody's strength or capacities to solve the sorts of problems we have to solve. *Atticus*

Students rarely have an opportunity to observe faculty debating methods, content, or disciplinary approaches. Particularly as students reach upper-level undergraduate courses, they tend to get a more homogeneous perception of their discipline and increasingly isolated from other perspectives. Transdisciplinary courses taught by a team

of widely variant disciplinary faculty provide those faculty the opportunity to discuss problems from multiple perspectives and participating students gain the opportunity to observe those rich interactions. Zakariah reflected on how that played out in the course he taught with three other faculty.

> The interdisciplinary nature for faculty is really important. And not just for the students, but I think for the faculty too. I think I learned a lot being a faculty member in a class with people from another discipline. Because I learned about how they think about the world and how they approach the world. Someone would pitch something that seemed really persuasive and especially suited for presenting for their projects that seemed great. And then one of the other instructors would be like, "that doesn't make any sense to me." And you know...watching faculty debate about what to do I think was really enlightening. *Zakariah*

Empathy. Empathy, often expressed through the use of human-centered design, exists as one of the core methodologies of the innovation ecosystem that has influenced nearly every aspect of X-Labs courses. Centering course design around problem-solving for humans has helped create a culture where experimentation and hypothesis testing, and even failures are the norms. Based on reflections from faculty, for many, the ecosystem seems to have matured into a more robust culture that supports the pedagogical and research endeavors of participating faculty. With a modern emphasis on learner-centered pedagogy, many faculty expressed a new appreciation for empathy that they acquire through the human-centered design process. Getting beyond fundamental classroom interactions, faculty noted things like a) the need to have or develop a culture, b) the

ability to get students to intentionally think about others as part of the problem-solving process, c) the ability to employ the problem-solving techniques outside of the X-Labs, where they are part of a problem-solving process, d) the difference between feelings of empathy and using empathy as a tool in the problem-solving process.

> I didn't know that [problem-solving] was a function of having the culture. And that is an empathy question. That sounds to me like an empathy question. *Mabel*

The human-centered design is useful in helping students understand that the objective of their problem-solving endeavor lies in the interviewee and contributes to the organic nature of the ecosystem development.

> Empathy map and understanding it's not your empathy; it's the empathy of the interviewee. I think helping the students to make that connection was really key. *Lee*

The difference between empathy and sympathy is rarely amplified more than in the intentional innovation or problem-solving process. As Dania notes, some disciplines have unintentionally conflated the two concepts. While sympathy is a passive emotion, empathy can serve as a trigger for action, particularly within a problem-solving process.

> The interviewing for empathy thing is interestingly different because in [discipline named] we definitely do interviews. We definitely have empathy, but there are two different constructs in the X-Labs classes versus the discipline-based classes. To me, empathy tends to skew towards sympathy in our disciplinary courses where here it is a more effective tool for problem-solving. *Dania*

Faculty frequently commented about the direct, honest, and open form of communication used in the X-Labs, not just in classes, but as part of the subculture. Clear communications. Learning to give and take direct feedback is something many faculty and students note about the culture of X-Labs and a distinctive form and function of empathy. Empathy, vulnerability, and clear communications were frequently noted practices that faculty reportedly take back to their departments and disciplinary courses.

> There has to be a way for radical candor to happen. That's not ruinously empathetic; you know that position between brute honesty and ruinous empathy because we're not taught to be vulnerable with each other in a meaningful way. The teams that work best are actually vulnerable with each other. We, as humans, don't know how to do that all that well. It's very easy for us to not do that in every other setting. It's got a kind of a procedurality where you don't have to deal with it. But I think that's a really important part of a good faculty team here [in X-Labs]. It allows that vulnerability to express itself and be nurtured in a way that you don't really get anywhere else, because the faculty are in relation to the project in a different way than they are anywhere else because they have to be there with their peers in the room as well as with students. *Brendan*

Continuous learning. For faculty, engaging in transdisciplinary instruction often necessitates a different pedagogical approach. Sometimes the differences are unique to a particular discipline, although a focus on solving problems with multiple disciplines reportedly rarely occurs in traditional pedagogical models. Faculty identified differences between their discipline-based courses and the transdisciplinary courses taught in the X-Labs as a) being team-taught and problem-focused, b) non-homogenous with a product

focus, c) an emphasis of process over content, d) setting the conditions for learning rather than instructing.

Dania noted that in her disciplinary courses, teams are assumed to have a certain level of homogeneity and understanding that may not have been present in X-Labs classes where there are no safe discipline-based assumptions. All instruction, from how to work together in teams to prototyping solutions, must be explicitly addressed in some manner.

> In my core discipline, we may have teamwork tensions or differences in a team [discipline named], but we haven't necessarily assumed that those differences were there, and we haven't necessarily done the coaching to help overcome that. Versus when we walk into an X-Labs class, the differences overt because of the mix of disciplines, and so we go ahead and do that coaching. That's a pretty major difference. The expectation for hands-on, showing something you know, whether it's showing a process or a product is also very different. *Dania*

Several faculty shared opinions that their work in the transdisciplinary pedagogical model helped satisfy their quest for continuous learning. Dania noted her observation that many of the faculty she had worked with shared a common “learner” strength, identified on the strengthfinders survey instrument. Esme’s observed her experiences learning with and from the students.

> I do think one thing is the learner strength. A lot of the strength of X-Labs faculty, in my experience, having worked with this scope of faculty is that they have the learner strength, and I think that serves people well as they try to develop the

> other skills necessary. So that's something thing I've noticed that people have that we didn't quite touch on. *Dania*

As a teen, Brendan faced several international moves with his family that forced him to learn different languages and cultures. Despite being a talented young musician, he ultimately rejected the field of music because he came to disdain the mandated, formal instructional model.

> And that's actually a primary reason why I think I gravitate towards teaching here. There's something about the X-Labs which is not just about creating a better learning experience for our students, but also trying to get to the heart of what learning means. Because it's been very important to me from a very young age, and I've had variable experiences with learning. *Brendan*

The quest for a continuous learning model was not just an individual competency; faculty tended to enjoy the interaction and opportunity to learn with and from their students. Esme captured the sentiment in her reflected experience.

> Every time I sent them home to do an exercise, they'd come back with information that I may have known, but I may not have known either. So they were teaching me. And when they understand that we're all students together, then the learning becomes really a wonderful experience. *Esme*

Most faculty were quick to note the shift from acquiring discipline-specific content knowledge to the process of problem-solving as a prominent feature of transdisciplinary courses over their traditional discipline-based courses.

> The biggest thing is that they are process-based as opposed to content-based, or the content becomes whatever the problem is. Typically, within our discipline,

> we are charged in each class with certain learning objectives that have to do with the mastery of certain skills or concepts or ideas. But when you are doing the X-Labs classes, they tend to be about outcomes and developing process skills. When you walk into the X-Labs, I think the biggest difference is that you're teaching students how to figure things out, and to master that particular process, as opposed to the content, analogy, or a specific skill set. *Michelle*

Changing the faculty mindset to consider new approaches to their own disciplinary curriculum has been observed as a byproduct of the X-Labs experience. Here, Brendan reflects on the opportunity to lead a curriculum design project that would allow him to bring lessons learned in the X-Lab back to his department as a component of the new curriculum as well as a process for developing it.

> There's a possibility that I might be tasked with redesigning the undergraduate curriculum for our program. My experience here will completely inform the way that I could do it over there in a way that I would have done it completely differently. It would have just been a committee assignment, whereas if I decide to do it, it will be as a wicked problem. Kind of like, let's work through this. Let's think about who we're actually designing for. And it will be a lot more human-centered design than it would be in a committee formulation. *Brendan*

Another unique characteristic of transdisciplinary-based pedagogy is that it involves and empowers the non-expert. Involving non-experts in the process is frequently addressed as a critical aspect of attempting to solve complex and wicked problems. The problems are inherently difficult, it’s unlikely that a solitary expert exists, so creating an intentional

process of exploring, expanding, understanding, and converging on the problem and possible solutions was seen as an empowering feature of X-Labs classes.

> Everybody's there working on something that nobody knows how to solve. So vulnerability has to be allowed to be [exist] otherwise, I don't think it works. *Brendan*

Evidence of some theoretical, pedagogical transformation emerged. Some faculty experiences were the direct result of their teaching practice, as noted by Vivaan. Others reflected on how an earlier experience, often as a student, moved them to participate in a different model through the X-Labs.

> I thought beforehand as being an educator and someone who's interested in the pedagogy, instructional design that I got it. But I didn't. What I understand now, as far as this generation of students, as we need to, I believe my role is to create the learning environment and then get out of their way. *Vivaan*

Complex leadership. This code captures aspects of leadership that seem to arise from transdisciplinary teaching that is grounded in the literature and five years of pre-study observations. Experiences faculty gained from working on teams from non-adjacent disciplines and focusing on problem-solving rather than disciplinary content delivery, faculty were directly affected in two areas of leadership. The first was that they developed a greater understanding of the multifaceted and complex nature of higher education leadership – what do leaders do? The second being direct leadership development experience arising from their involvement collaborating and coordinating complex courses with personnel, timing, logistical, and budget considerations that go beyond the expectations of usual course preparation. Given the ambiguous nature of the

X-Labs and higher education in general, the essence might be described as learning the ability to influence without authority, which rings particularly true in academic leadership roles. Finally, a thread that permeates the interviews was the revelation that real-world problems, many being addressed in X-Labs courses, are so complex that understanding them and developing solutions requires an approach that is more inclusive of the standpoint of multiple disciplines. Throughout the interview process, I recorded several perspectives on how faculty view leadership, leadership development, and what leaders do routinely. Several faculty made direct connections between a) the actions required to coordinate complex courses and leader development, b) the frequent roadblocks that may be native to one discipline and completely absent in another – with faculty myopically considering their circumstance representative of the entire institution, c) the ambiguity of X-Labs transdisciplinary courses and leadership roles, d) leadership roles, like transdisciplinary problem solving, often require leaders develop their vision and to take action without experience or plan even when the outcome is unpredictable, e) an understanding that leadership is a privilege and a doctorate is not necessarily a qualification, f) becoming a leader and the opportunity to practice those skills.

> I think there's something interesting about faculty working together in dynamic ways. That's not a committee. Because that's a very structured way of doing things and ends up in very predictable ways. But there's something really, really interesting about having a faculty team teaching a student team because that can actually be a training ground for leadership among faculty in a way that I have not seen before. *Brendan*

Developing an understanding that academic departments often operate in a very closed system, and the possible consequences of such a siloed system provide an exceptional window into the complex operating system of higher education. Atticus shares how he observed different levels of bureaucracy between his department and that of a colleague with whom he co-taught a course. He realized that some of the administrative barriers appearing to be universal are sometimes self-imposed at the college or department level. These differences are infrequently noticed when one's domain exists within one department, but are readily apparent when working with transdisciplinary teams in the X-Labs classes. These insights will prove useful for faculty in future committee or administrative work above the department level.

> So one of things that sort of opened my eyes about that experience was not that we're from different disciplines per se, but the hoops he had to jump through to convince the faculty in his department that teaching down here was worth his time. You know, he had to, like, put together this whole detail proposal and go in front of the committee and make his case, and they had to review it. I think it was a multistage process before he got the thumbs up and the green light to come down here and teach a class. In contrast, I sent an email to the scheduling guys.
>
> *Atticus*

Helping faculty develop a comfort with ambiguity is another aspect the X-Labs class experience that contributes to attaining complex leadership

> The comfort with ambiguity has served me really well in my leadership roles in my faculty. So, that's something that I wouldn't have felt was a strength before. You know, the ability to be comfortable without knowing the outcome in a

> difficult situation. That's something that I've needed to cultivate to work in this space and that I have taken back and used in my faculty council chair role in my department and in other difficult conversations with faculty. *Dania*

Gaining experience in leadership roles requires an opportunity. Possibly unique to the nature of X-Labs transdisciplinary, team-based courses are the opportunities they provide faculty to take leadership development steps with relatively low risk. Several faculty noted the benefits of these opportunities from slightly different perspectives.

> I think a lot of faculty are very comfortable with leading in the classroom, and then become pretty uncomfortable when they get outside of that setting - with some of the same leadership skills that they've even implemented there in the classroom. I think I always saw my role as a coach when it came to student teams. However, I have had a lot more experience with it now. So, whereas I may have felt like I was muddling through it before, the X-Labs has given me frequent opportunities to hone those skills of helping a team to become productive. So, I'm more confident in those skills, and I have gained knowledge and confidence in those coaching skills. *Dania*

> I don't think I would have had the courage or the skillset or knowledge set to do that work. I would not have had the skillset to have a difficult conversation. I think intuitively I did. But not, with any sort of framework or repeatability. *Mabel*

> We tend to think in terms of course and content rather than who we're training and what they're going to do. It's a fundamental problem, and I would not have seen

> that with such clarity until I came in here. There's a way that the density of the bureaucracy in the university blinds people to the actual job that they're doing. *Brendan*

Faculty acknowledged that developing leaders is an important and sometimes neglected aspect of higher education. They focused on the often high-cost of promoting leaders without developing them. Esme and Lee reflected on some of their experiences when that process does not go well.

> I think there are faculty members that have a great potential to be leaders. However, I also know that there are people who should never grace the classroom. *Esme*

> It's not just by being given a title because they're academic unit head or they're curriculum committee chair. I think some faculty members are leaders because they have the backing and the respect of the other faculty in order for us to allow them to lead us. *Lee*

Sharing the sentiment of many regarding the learning leadership opportunities, Brendon reflected that his experiences teaching in X-Labs classes, developing comfort with ambiguity, and working with multidisciplinary teams has helped him develop as a more confident leader.

> I never really stood up for leadership roles. Partly because I'm disorganized, but it's just partly my personality. I have since become more organized, but I've come to realize that it's not about a particular protocol or even a specific personality type. It's about inhabiting a role. What I mean by inhabiting is that it's like pulling

> on resources that you have, but that you didn't necessarily know were resources until you were put into the role. *Brendan*

Leading in complex, ambiguous situations requires a level of confidence in one's abilities and problem-solving skills. Some faculty expressed a distinct unease with teaching in the lab because the space did not conform to their traditional instructional facilities, and the perceived experiences were so far outside their disciplinary norm. Working with peer teams and overcoming their anxiety and apprehension increased their confidence and resiliency.

> I will share something that was really important for me is a more experienced colleague compared to [named instructor] and [named instructor]. Um, it was uneasy for me. And I was very nervous about moving into that setting with them. Because quite frankly, I didn't even know where to stand in the X-Labs. And I'm short. And I was like, where do I stand? How are people gonna see me? So all those things... and I was really nervous about how this was gonna work because I have success in my didactic teaching methods to date. And so I was really nervous about that. *Vivaan*

Faculty frequently conveyed a systems approach and the acquired ability to shift the granularity of their focus from close-up to big-picture. The ability to transition quickly between fine, detailed work, and strategy was well reflected in Mabel's comment.

> I think I see systems. So I can see a whole picture, and one of the skills that I do have is being able to see whole picture while simultaneously seeing what you

> have to do at the microscale to get to the whole picture. I can bounce back and forth between that really big broad course-view and that really fine-view. *Mabel*

The transdisciplinary instructional model provides an experiential foundation that encourages exploratory learning, researching new approaches, identifying potential solutions, prototyping, and frequent failures that serve as learning opportunities for faculty as well as students. Faculty reflected that allowing them those same opportunities to try different approaches, do things differently, and sometimes admit that they didn't know the answer or weren't the expert contributed to their professional development.

Learning to thrive in an ambiguous environment is a foundational component of complexity leadership theory. Several faculty noted that they felt the transdisciplinary teaching experience provided an independent source of empowerment and the opportunity to find new pathways forward in their academic careers. They developed the ability to leverage the strengths of a team to achieve synergy and learned an empowering approach to effective communication.

An interesting aspect that emerged from this line of questioning and others was that despite never working as part of a cohesive, collaborative instructional team, they found the experience of doing so to be its own source of empowerment and support.

> There's a way that this is a kind of a nurturing ground in interesting ways because particularly faculty teams are working with each other, they find out different strengths against each other, as well as against the students. *Brendan*

> I don't know if I would say that my perspective has changed because of being in X-Labs, but it's certainly not an accident that I would end up being in a place like

> X-Labs, given my general outlook on the world and education, teamwork, and all of this stuff. *Atticus*

Sharing this sentiment from a slightly different perspective, Mabel discovered what might be described as self-confidence to have her voice and even lead colleagues and students without being the recognized content expert.

> I see it more as empowering. I feel empowered to ask better questions. To stay true to vision and values, while constantly questioning those vision and values. I personally question them all the time to make sure that they are making sense and things like that. But I feel empowered to execute my vision and my values. In my own abilities, I think I have the confidence of voice to say it's okay not to have the answers because that's not the point anymore. *Mabel*

The team and problem-focused nature of the transdisciplinary experience lend opportunities for faculty to explore rewarding career advancement opportunities that exist outside the traditional disciplinary bounds. Still, they may be difficult to discover within a strictly discipline-based environment.

> You're dealing with a bunch of people who chose to train in a highly specialized way that had very clear and defined, but very few pathways to onward progression. And now every single one of the people that we work with probably has quite different ideas about what that forward progression might be. And I think that could be an interesting part of the way that we message the lab. So it's not just professional development like you get better at what you do, but it opens up possibilities for what you might do, right? *Brendan*

Exemplifying an intersection between empowerment and complex leadership theory is the ability to work on specialized teams where each member brings a unique skill or talent, something that differentiates a homogeneous group from a highly effective team. Practicing and living through the shared experience as a team makes it a practical and accessible skill for faculty.

> When you're working with people and you have a level of trust and there's a level of communication, then methods actually become something very different. In a regular methods class, you're reading Cresswell and you're like, oh, I've got to do this, that and the other. It feels like a very solitary thing and I don't follow steps very well. So the fact that I get to do that in conversation makes it a really interesting proposition, because now if I feel like I have a sort of a power base of methodological tools at my disposal. *Brendan*

Developing the Items for the Instrument

The purpose of the qualitative research phase was to address the qualitative research question: *What attributes describe faculty persistence and involvement in team-taught, problem-based, transdisciplinary courses?* Nine individual hour-long interviews produced a tremendous amount of qualitative data. Interviewees shared life experiences that were intertwined with experiences from academia and their transdisciplinary teaching experiences from the X-Labs. The data reflected strong sentiments that multiple perspectives should be considered. The process of mixing the qualitative and quantitative methods are depicted in tables 3 – 5.

Table 3

Mixed Methods Mapping – Inclination

Theory and literature	Overarching domain	Qualitative questions	Emerging codes	Evidence/example qualitative quotes	Items
Openness to new ideas, approaches, interactions	Inclination	Describe how X-Labs classes differ.	Intentional curiosity	I knew nothing about the topic when we started and used the course to deepen my knowledge.	I am comfortable seeking help outside my discipline.
		Experience studying or teaching abroad?		I recently took students abroad for the first time. I included other faculty as well. We touched hundreds of lives.	I have no problems asking for help.
					I am comfortable seeking collaborators.
Intrinsic Motivation		Describe any research work outside your discipline.	Willingness to work on passion projects with no expectation of external recognition	I want the research I'm involved in to be sector change or bust. It's either that, or why are we doing it?	It's important to demonstrate the impact of unconventional approaches.
		What best describes your research motives?		I'm publishing more outside my discipline than inside it.	I enjoy taking an unconventional approach.
				I'm focused on impact. Things that are useful motivate me.	I think there is overlap between teaching and research.
Teamwork & Learning partnerships		How would you seek help outside your discipline?	Willing to work with diverse students and colleagues as peers or equals	The non-adjacent part is a big difference. In X-Labs, participants are pretty far apart.	My students would say I'm comfortable learning along with them.
		Have teaching methods in X-Labs changed your departmental interactions?		The problem focus and team teaching are huge. That changes things radically.	My students would say I deliver more than content.
				Here, you can't assume students have any particular background. Students seem more focused on learning.	My students would say I'm comfortable working with them on projects with uncertain outcomes.
		Describe any experiences you may have as a voluntary participant on a team that required significant effort.		I learn a lot being in a class with other faculty from different disciplines.	

Table 4

Mixed Methods Mapping – Capacity

Theory and literature	Overarching domain	Qualitative questions	Emerging codes	Evidence/example qualitative quotes	Items
Empathy and the role of passion and persistence in creativity	Capacity	Describe any experiences you may have in learning to play an instrument or speak a foreign language. What is your greatest contribution to an academic team?	Empathy Continuous learning Partnerships Complex leadership	I didn't know that problem solving was a function of having culture. Empathy mapping; realizing it's not your empathy. After X-Labs, I discovered my discipline interviews for sympathy, not empathy. Empathy allows for radical candor which contributes to good vulnerability and strong team development.	I am willing to be vulnerable working with colleagues I trust. I am willing to take risks when working with colleagues I trust.
Pedagogy and common learning		Has your role or perspective changed since your first experience teaching in X-Labs courses? How would you describe your mental model or process for making meaning from new concepts?	Continuous learning	From my work in X-Labs, I learned there are tensions in my discipline-based teams that haven't been addressed. I learned coaching. I gravitate to X-Labs because it's not just about creating good experiences. We're getting to the heart of what learning means. In every homework assignment, students find and connect things I never considered. I'm always learning from them. In X-Labs classes, I'm teaching students how to figure things out as opposed to learning specific content.	I learn by challenging myself in new roles. My colleagues would say I'm a lifelong learner. My students would say I'm interested in helping them apply lessons out of class.

Table 5

Mixed Methods Mapping – Complex leadership

Theory and literature	Overarching domain	Qualitative questions	Emerging codes	Evidence/example qualitative quotes	Items
Think in complex & integrated ways; transformational and complexity theory in higher education	Complex leadership	Describe your perceptions of faculty as leaders. Has your role or perspective changed since your first experience teaching in X-Labs courses?	Complex leadership	I've been amazed at how different departments behave so differently. Some have a lot of hoops to jump through, and I thought we were all using the same rules. I gained the confidence and framework to lead difficult conversations.	I am good at balancing the needs of others when working on complex problems. My colleagues would say I challenge them to think differently.
Competencies for effective leadership in higher education		Have the methods used to interact with students in X-Labs classes influenced how you interact with faculty in your department? Have you ever led a semester abroad program?	Partnerships Complex leadership Openness	There's something interesting about having a faculty team-teaching a student team that can actually be a training ground for faculty leadership. I've not seen this before. Lots of faculty are comfortable in front of the classroom but not outside that setting. I've learned to be a coach and that helps me be more productive in my department. We tend to think in terms of content, not who we're teaching or the purpose. I would not have seen that with such clarity. The density of the bureaucracy blinds people of their purpose.	My students would say I am comfortable giving them direct, meaningful feedback. I am open to taking on leadership opportunities outside my department. My colleagues would say I enjoy working on complex problems.
Leadership competencies for transdisciplinary research		How would you describe your mental model or process for making meaning from new concepts?	Continuous learning Complex leadership	Comfort with ambiguity has served me well. X-Labs has helped me understand and cultivate that and bring it back to my department.	I understand how to give direct, meaningful feedback.
		If you were leading a research team, what would you do if one member was toxically disruptive?	Complex leadership	Everyone has a different perspective on the path forward. In X-Labs, we don't just get better at what we do, it opens up possibilities for what we might do.	I am good at understanding group dynamics.

The purpose of developing the quantitative instrument was to test that research question: *To what extent can these faculty attributes be reliably and validly measured?* Capturing the rich context of the qualitative data from these multiple perspectives resulted in 111 items in the initial draft of the instrument (Appendix B). While similar, these were designed to elicit potentially different responses. Items designed to probe an individual's perspective were prefaced with "I think" or "I feel." Similar items were designed to reflect how respondents think their colleagues or students might respond were prefaced with phrases such as "My colleagues would say," or "My students would say." While these added significantly to the item count, the qualitative data suggested these different perspectives might contribute to the reliability and validity of an FCII.

The draft instrument was subjected to a thorough review by a panel of experts (Groves et al., 2011). The panel reviewed the items both as a text document and in instrument form. Clear feedback from the expert panel indicated that those items created to capture the different perspectives were seen as redundant, excessive, and likely annoying to future respondents. One example of multi-perspective sequences included these three statements: "I enjoy working on complex problems," "My colleagues would say I enjoy working on complex problems," and finally, "My students would say I enjoy working on complex problems." Members of the expert panel provided nearly universal feedback that, in their view, the differences between these items were too nuanced for a survey. The subtle differences between the items went unnoticed by most panelists in their first reading and reported thinking the items had been repeated in error. An analysis of the quantitative data generated from the panelist responses was useful in further reducing the initial item count. Most noteworthy were items associated with diversity of

thought, academically diverse teams of colleagues and students. Panelists scored all of these items as extremely positive. With no variance in their responses, these items were clearly important, but they did not contribute statistical significance in differentiating individuals.

The panel made one additional substantive suggestion that was incorporated into the final version of the FCII. Four items that were intended to contribute to complex leadership were identified as more appropriately considered as institutional-level demographic data. These items focused on the sense of support an individual has from their department to explore new research agendas or curriculum. The panel felt that these were important demographically but should not be included as part of the individual's FCII score. A tabulated listing of all initial items, how they mapped to revised items, and any eliminations are included with justifications as Appendix C.

Eight items were added to situate basic demographic information and position the respondent within the institutional framework. Finally, the ten-item personality measure (TIPI) was embedded in the instrument going to the larger population of faculty. That addition enabled the ability to contrast the findings of the developed FCII constructs against an establish, valid personality instrument. The final FCII released to faculty included 56 FCII items, the TIPI, four institutional demographic items, and eight individual demographic items.

Implementation of the Quantitative Instrument. A link to the revised FCII instrument was disseminated to 1,068 full-time and 404 part-time faculty via the institutional bulk e-mail system, or 1,472 total individuals. 140 individuals responded, for a response rate of 9.5 percent. While the sample size is relatively small, the purpose

of the study is to determine if the attributes could be measured rather than infer conclusions on the population and the literature provides little guidance on the matter (Osborne, 2014). After initial data screening to remove incomplete responses, 124 respondents comprised the total sample, a completion rate of 88.57 percent. Responses were eliminated in cases where the submission contained no recorded answers or when the total elapse time spent by the respondent on the instrument was less than four minutes.

Demographic data, reflected in tables 6 – 10, indicate the sample generally reflects the population of the institutions full-time instructional and professional faculty.

Table 6

Gender

Gender	Frequency	Percent
Female	68	54.8
Male	44	35.5
No Response	12	9.7

Table 7

Ethnicity

Declared	Frequency	Percent
Asian	1	0.8
Black	2	1.6
Hispanic	3	2.4
Middle Eastern	1	0.8
Native American & Hispanic	1	0.8
no answer	14	11.3
other	1	0.8
White	100	80.6
White & other	1	0.8

Table 8

Tenure Status

Tenure status	Frequency	Percent
No Answer	6	4.8
Non-Tenure	31	25.0
Pre-Tenure	15	12.1
Tenured	72	58.1

Table 9

Faculty participants by academic college

College	Frequency	Percent
Arts and Letters	18	14.5
Health and Behavior Studies	31	25
Integrated Science and Technology	15	12.1
Business	7	5.6
Education	17	13.7
Science and Mathematics	15	12.1
Visual and Performing Arts	6	4.8
Honors	2	1.6
The Graduate School	2	1.6
No response	11	8.9

Table 10

Faculty Rank

Rank	Frequency	Percent
Adjunct	2	1.6
Administrator	11	8.9
Assistant Professor	21	16.9
Associate Professor	27	21.8
Full Professor	41	33.1
Lecturer	8	6.5
No Response	7	5.6
Other	7	5.6

An exploratory factor analysis was performed on the data collected from the 124 respondents. Communalities were all above .7, with the recommended minimum

screening value being 0.3. The Kaiser-Meyer-Olkin Measure (KMO) verified sampling adequacy for the analysis of the FCII, KMO = 0.748 which is above Kaiser's recommended threshold of 0.6 (Kaiser, 1974). Bartlett's test of sphericity returned an approximate Chi-Square of 4015.594 (1540), p = .000, indicated that correlations between items were sufficiently large for EFA. With 56 items under analysis, Cronbach's alpha for the NCII was 0.931, reflecting a high degree of reliability. Computed communalities and the first component of the structure matrix are included at Appendix E. The complete structure matrix is included at Appendix H.

The overall measure demonstrated robust unidimensionality as indicated by the scree plot, Figure 2, as well as the potential for further examination of the constructs. The first construct accounted for 24.12 percent of the variance, with a total sixteen components resulting in Eigenvalues greater than 1. This suggested the possibility for all items or their factored constructs to be aggregated into a single score.

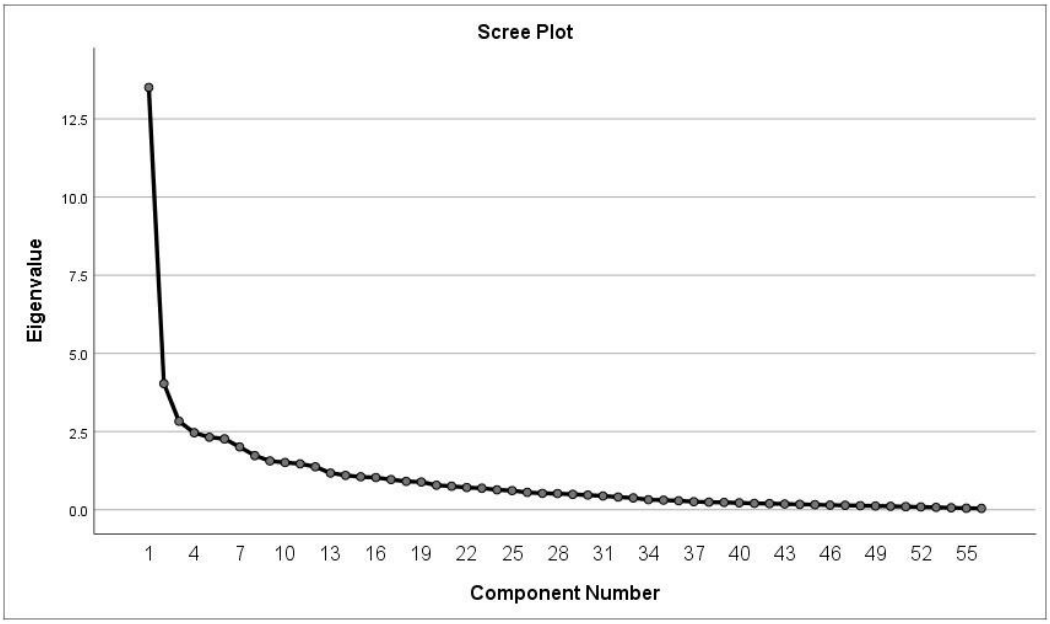

Figure 2. Unidimensional Scree Plot of FCII

Given the theoretically derived nature of each construct and the developmental purpose of this study, each construct was then separately analyzed using principal component analysis. Initial Eigenvalues indicated significant variance explained. The Oblimin rotation process was used to compute the factor loading in order to account for the correlated nature of potential factors. Cronbach alpha factor reliabilities ranged from 0.792 on the high end to 0.49 on the low end. While this indicates moderately low internal reliability, it is generally accepted for exploratory factor analysis studies of this type when the constructs and items are grounded in theory. Table 11 reflects the items with corresponding values for Cronbach's alpha included for each theoretically-based construct with a complete version of the released instrument included at Appendix D.

Table 11

Factor loading and reliability

Scale and individual item measure	Loading	Alpha
Openness to New Experiences		0.767
I am comfortable seeking help from among my close colleagues outside my discipline.	0.844	
I am comfortable seeking project collaborators through my extended network.	0.793	
I have no problem asking others for help.	0.790	
I am comfortable seeking help from among my close colleagues within my discipline.	0.780	
My colleagues would say that I enjoy trying new pedagogical approaches.	0.281	
My colleagues would say that I often come up with creative solutions.	0.222	
My colleagues would say that I enjoy using multiple modalities.	0.173	
My colleagues would say that I am comfortable teaching topics where I have knowledge but am not an expert.	0.098	
Intrinsic Motivation		0.782
I think it's important to demonstrate the impact of an unconventional approach to research or pedagogy.	0.897	
I enjoy taking an unconventional approach to teaching.	0.855	
I think there is significant overlap between research and teaching.	0.727	
I enjoy the challenge of inspiring students to find their potential.	0.511	

My main focus in research is to create impact.	0.367	
Demonstrated experiences in creative problem solving should make graduates in my discipline more valued members of future teams in academia or industry.	0.328	
Demonstrated experiences in processes of innovation should make graduates in my discipline more valued members of future teams in academia or industry.	0.310	
My students would say that I challenge them to reflect on their future careers.	0.306	
My students would say that I push them to try things they don't know.	0.288	
My main focus in research is to improve predictive power.	0.206	
I see professional value in working on multidisciplinary teaching teams.	0.175	
My colleagues would say that I enjoy developing new curriculum.	0.171	
My colleagues would often describe me as a change agent in our department.	0.168	
My students would say I put nearly as much effort into developing them as in delivering content.	0.126	
My main focus in research is to increase understanding.	0.078	
Learning Partnerships		0.792
My students would say I am comfortable learning along with them.	0.875	
My students would say that I am comfortable learning something from them.	0.852	
My students would say that I deliver more than content through my teaching style.	0.771	
My students would say I am comfortable working with them on projects with uncertain outcomes.	0.690	
My colleagues would say that I am good at working on complex problems.	0.541	
My students would say that I allow them to fail safely their projects.	0.413	
I am confident seeking non-academic sources when working on a problem.	0.345	
I am confident about collaborating in a network of experts to work on challenging problems.	0.268	
My colleagues would say that I enjoy expanding my network outside of my discipline.	0.253	
I am comfortable calling on my network to help me work through challenging matters.	0.252	
Focusing on applying content knowledge towards solving real, relevant problems might differentiate education from training.	0.152	
Empathy		0.668
I am willing to be vulnerable when working with colleagues I trust.	0.953	
I am willing to take risks when working with colleagues I trust.	0.950	
I am good at understanding problems from the perspective of my students.	0.286	
I am a good listener.	0.147	

Continuous Learning		0.490
I learn by challenging myself in new roles.	0.891	
My colleagues would say I am a lifelong learner.	0.772	
My students would say I am interested in supporting them in applying in-class learning to problems outside of class.	0.387	
I see pedagogical value in working on multidisciplinary teaching teams.	0.162	
My colleagues would say that if I had the opportunity to completely redesign the general education curriculum, it would look a lot like it does now. (reverse coded)	0.076	
Complex Leadership		0.788
I understand how to give direct, meaningful feedback.	0.860	
My students would say I am comfortable giving them direct, meaningful feedback.	0.830	
I am good at balancing the needs of others when working on complex problems.	0.621	
I am good at understanding group dynamics.	0.423	
My colleagues would say I challenge them to think differently.	0.370	
I am open to taking on leadership opportunities outside my department.	0.321	
My colleagues would say that I enjoy working on complex problems.	0.304	
When serving on committees, I tend to focus on results over procedures.	0.202	
Faculty leaders also tend to be strong teachers.	0.176	
Getting things done is important.	0.140	
I am open to taking on leadership opportunities outside the classroom.	0.130	
I consider helping students learn how to work in multidisciplinary teams to be an important responsibility in their higher education experience.	0.065	
My colleagues would say that I enjoy working on teams when the outcome is unknown or uncertain.	-0.004	

Note. Items are based on a seven-point scale.

Factor scores were computed for each construct using the scores function in the SPSS factor analysis module. Using the regression method, which accounts for the loading of each item onto its hypothesized factor, a standardized (i.e., z-score) was generated for each construct independently. This process created six new standardized variables: openness to new experiences, intrinsic motivation, learning partnerships, empathy, continuous learning, and complex leadership. Given the demonstrated unidimensionality of the items (see Figure 2), these six constructs were next added to

create a sum total factor score. This total FCII score was then utilized in two ways: to evaluate its distribution and as a dependent variable in subsequent regression analysis (DiStefano, Zhu, & Mindrila, 2009, p. 4). Given the appropriate use of EFA in this study and the application of the calculated regression scores here, their use meets the threshold expressed by DiStefano, Zhu, & Mindrila (2009).

The calculated composite FCII scores were plotted on a simple histogram, Figure 3, which reflects a generalized, normal distribution of scores.

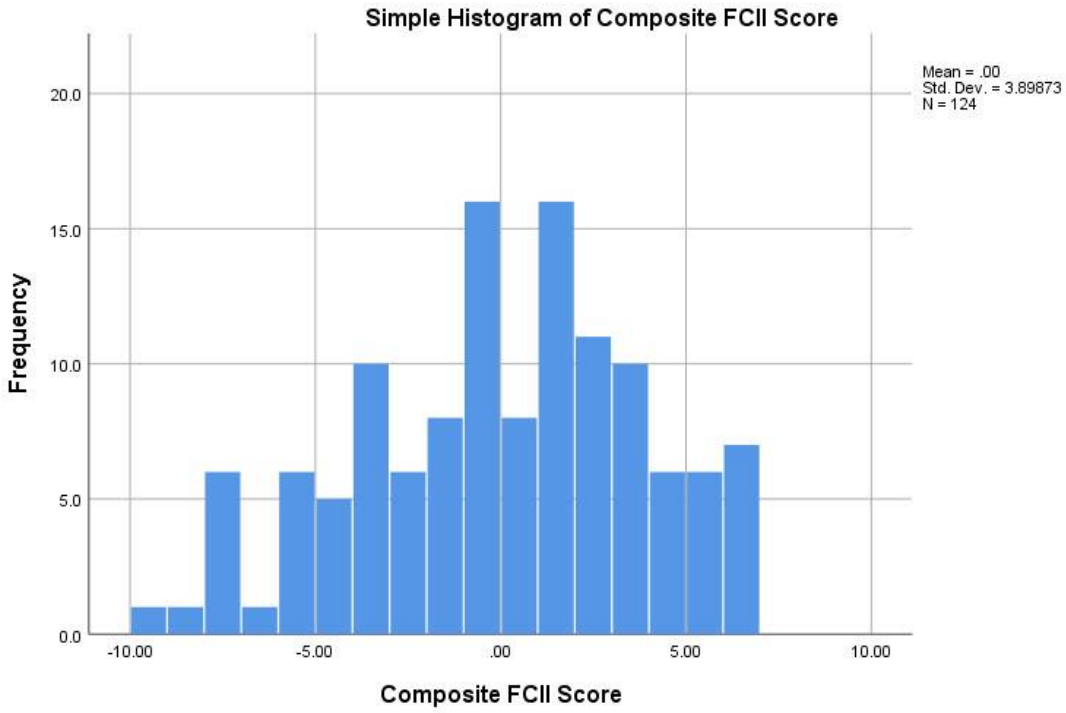

Figure 3. Histogram of FCII Composite Scores

The distribution of the calculated standardized regression scores reflected in Figure 3, indicate that the instrument is able to stratify the target audience and differentiate individual faculty along the scale. With internal reliability established through the EFA, the normal distribution of respondent's FCII scores demonstrates a

strong indication of progress towards answering the quantitative research question, *"To what extent can these faculty attributes be reliably and validly measured?"*

The study's method of establishing a validity check was to compare one construct from an established, valid instrument to a similar construct developed for the FCII. Openness is well established in the transdisciplinary literature as a hypothesized construct that is also a well-established construct in related leadership and personality literature. By embedding the Ten Item Personality Index (TIPI) in the final, released version of the FCII it was possible to compare the resultant scores. Given that the two constructs should be measuring somewhat different aspects of the openness characteristics, the correlation should be strong and significant but not equivalent.

To test this, a regression analysis was conducted on the openness constructs from the TIPI against the calculated scores from the FCII. The analysis indicated a significant relationship at the $p < .001$ level [$F(1, 115) = 51.29$, p = .000], with 30.8 percent of the variance explained. Given the common theoretical foundation, this significant relationship between the two constructs demonstrates a level of validity for the new Faculty Capacity and Inclination Instrument. However, with an R^2 of 0.308, as anticipated, these constructs do appear to measure different aspects of an openness construct. As developed, the FCII construct of openness should be more situationally specific to the concept of transdisciplinary, team-taught, problem-based pedagogy.

Summary

This chapter details the research conducted during the qualitative, mixing, and quantitative phases of the study and the results arising from the subsequent analysis of the data. Qualitative evidence included in the document reflects exemplars of the data

collected, serving to demonstrate how the constructs came together in the analysis. Results from the qualitative analysis converged into 111 items for consideration on the instrument. Pilot testing by an expert panel served to reduce the items, refine several questions, and solidify the constructs. Including a short, reliable personality instrument as an embedded component of the instrument helped confirm that the FCII was identifying something different from personality with different measures for similar constructs, specifically openness.

The final version of the FCII produced for this study included 124 respondents, with diverse individual demographics (gender, academic discipline) and diversity in academic college participation. A linear regression performed between the TIPI openness scale and the openness score calculated from the FCII responses, indicate a significant correlation exists between the two, and an indication that the two scales are not measuring the same components of openness.

The final chapter will discuss a summary of the study, a discussion of findings, implications for practice, recommendations for further research, and conclusions.

Chapter 5

Discussion, Implications, and Conclusions

Introduction

In the preceding chapter, the presentation and analysis of data were reported according to the study's research plan. Chapter V consists of a summary of the study, discussion of findings, implications for practice, limitations of the study, recommendations for further research, and conclusions. The final sections will expand on the concepts studied and provide further insights into their possible influence on expanding transdisciplinary pedagogy through faculty recruitment implications for understanding leadership and developing leaders on campus. Finally, a synthesis of the study is offered to help capture the substance and scope of what has been accomplished in this research.

Summary of the Study

This chapter begins with a summary of the purpose and structure of the study and is followed by major findings related to the development of the Faculty Capacity and Inclination Instrument and the relationship with complex leadership theory. Concluding the study, implications for practice and recommendations for further research are considered and presented.

The purpose of this exploratory, sequential, mixed-methods study was to identify patterns and factors among faculty with experience teaching in hands-on, transdisciplinary methodology that might serve as predictive indicators in identifying others with the capacity and inclination to engage and persist in transdisciplinary pedagogy. Through the qualitative exploratory component, identify those key factors that

may translate to a quantitative instrument that reliably identifies faculty with the capacity and inclination to flourish as instructors in applied, transdisciplinary courses.

The Faculty Capacity and Inclination Instrument (FCII) developed through this study includes six constructs. The instrument was developed using an exploratory, mixed-methods approach that began with nine semi-structured interviews, analysis of the qualitative data, a mixing of methods to develop items reflecting the qualitative data, refinement and consolidation of items, and a review of the pilot instrument by a panel of experts. The product of the expert panel review was an instrument with 56 items covering six constructs that was disseminated to a sample population of faculty. With 124 valid responses, the instrument underwent a battery of factor analysis processes that indicates both validity and reliability. A demographic breakdown was provided for gender, ethnicity, rank, status, and years of education and service. The study included two research questions:

Qualitative research question: *What attributes describe faculty persistence and involvement in team-taught, problem-based, transdisciplinary courses?*

Quantitative research question: *To what extent can these faculty attributes be reliably and validly measured?*

The first question was answered qualitatively through data collected in the semi-structured interview and analysis process. Data were categorized, coded, and triangulated to identify likely faculty attributes that might be measured using a quantitative instrument. To answer the second question, a survey instrument was developed, reviewed by a panel of experts, refined, implemented on one target audience, and analyzed for validity and reliability using a series of exporatory factor analysis

procedures. Embedded in the instrument were constructs related to Complex Leadership Theory; faculty leadership perceptions, development, and conduct that were identified in qualitative data and throughout the theoretical underpinnings of transdisciplinary pedagogy as positive byproducts of that process. These attributes were identified and labeled as openness to new experiences, intrinsic motivation, learning partnerships, empathy, continuous learning, and complex leadership.

Results of the quantitative analysis indicate the items comprising the FCII reflect attributes that can be measured and are useful in distinguishing faculty with the capacity and inclination to teach using transdisciplinary pedagogical methods.

Discussion of Findings

Previous researchers have theorized and identified the benefits of transdisciplinary pedagogy for solving complex problems, improving research productivity and outcomes, amplifying student experiences, and opening opportunities for faculty growth and development (Apostel et al., 1970; Astin et al., 1974; Gibbons et al., 2002; Klein et al., 2001; Kockelmans, 1979) and called for the expansion of these approaches throughout higher education. In calling for change in the academy and the expansion of transdisciplinarity, these researchers theorized many of the attributes required by faculty to flourish in these unique settings. Calls for change in the production of doctoral candidates and change in the academy occur slowly and have not resulted in a significant or sustained expansion of transdisciplinary education opportunities. My objective was to suggest we undertake a different approach to expanding transdisciplinary pedagogy. Rather than start a transdisciplinary movement by changing the doctoral preparation program, the goal of my study was to develop an instrument that

would identify faculty already in the academy that might flourish as transdisciplinary educators.

The findings resulting from the qualitative research question indicate an ample variety of attributes exist among faculty with demonstrated persistence in teaching team and problem-based transdisciplinary courses. Further, through their work in preparing, collaborating, instructing, and coordinating their transdisciplinary courses, involved and persistent faculty are exposed to leadership challenges, experiences, and opportunities and made aware of the many complex leadership challenges that persist in academic institutions. Developing survey items that measure the many attributes identified, with the acceptable levels of reliability and validity, presented a distinct challenge that was accomplished in this study.

The final version of the FCII includes 56 items covering six constructs. Results of the factor analysis indicate that these are internally consistent, appropriately correlated, and sufficiently reliable constructs that align with the qualitative data as well as both transdisciplinary and Complex Leadership Theory from the literature. Statistical evidence supporting these conclusions is provided. Self-reported demographic data from respondents indicate a generally representative population of faculty responded, and the sample size was adequate for the purposes of this study. The factor analysis indicates that faculty attributes developed in the qualitative phase of the study can be measured reliably and validly using the developed FCII.

Among the six constructs, the concept identified as openness to new experiences was one of the most prevalent in the literature, consistent throughout the qualitative data, and well reflected in the quantitative results. The consistency exhibited helps solidify

this construct as one of the key attributes that differentiate the faculty being reviewed. The literature clearly indicates that faculty, maybe all humans, tend to practice the way they were prepared. Faculty are prepared and traditionally rewarded for developing a strong, narrow focus in a discipline-specific area, so the ability to identify faculty with broader interests, an openness to explore new processes, concepts, and the intersections of disciplines represents a new approach. The idea of working with those other disciplines to solve problems as the basis of a course rather than focusing on the traditional undergraduate approach of acquisition and transfer of knowledge represents a significant difference. Further, while the openness construct exists in many leadership and personality theories and corresponding instruments, the openness construct identified here is somewhat more specific to transdisciplinary education.

Although it emerged as an essential attribute in the qualitative and quantitative phases of the study, intrinsic motivation was not as clearly and directly identified in the literature as openness to new experiences. The literature, particularly from Briggs and Michaud (1972), identified intellectual curiosity as a likely attribute. In retrospect, the construct I've identified as intrinsic motivation is a better conceptual bridge between the openness, learning partnerships, and continuous learning constructs. The literature did not address the concept or need for connective tissue between constructs. Still, the data reflect an absolute need for an intrinsic force that propels people to act outside the disciplinary norms, take a professional risk, and take on significant additional work without the promise or expectation of an extrinsic reward, recognition, or acknowledgment.

Shifting professional relationships between students and faculty is a longstanding topic in education literature. Magolda (2004) specifically addressed the concept of learning partnerships, which focused on the relationship between students and faculty. Transdisciplinary courses rarely involve an expert at the front of the classroom, conveying facts and knowledge that must be memorized. Faculty grounded in traditional models demonstrate little interest or persistence in transdisciplinary courses where they become learning partners with their undergraduate students. Working on complex problems seems to exacerbate that identity conflict, as the multidisciplinary student teams quickly develop more comprehensive expertise around the problem than is often possible for any single faculty member. Beyond the relationship with students, this study revealed a common need to accommodate and revel in the opportunities for broader, deeper, and more diverse partnerships. Learning partnerships in the context of transdisciplinary pedagogy necessarily involve teams as well as students and faculty from multiple disciplines and non-academic stakeholders. Faculty experiences in the X-Labs include partnerships between government agencies, non-profit organizations, industry, and individuals at other academic institutions.

Blending concepts from the literature that included humility, searching for a common language, and the novel ability to accept teamwork mixed with what faculty described as empathy during the qualitative phase of the study. While it contributes to the model's ability to differentiate faculty, empathy was not as pronounced in the quantitative phase as a contributing construct. Its lack of power as a differentiating construct was surprising given the broad, general coverage it received in the literature and the qualitative data. Empathy exemplars reflected in Chapter 4 reveal how the construct

appears to influence the comprehensive culture needed to undertake intentional problem-solving (Mabel) as well as the application of tools like empathy mapping (Lee). However, one of the most impactful qualitative responses came from Dania. She noted the need to redefine empathy in its application to transdisciplinary pedagogy and how that impacted her disciplinary-based understanding and perspective.

The continuous learning construct represents a persistent state of mind among the faculty participating in the study's qualitative phase. This construct underscores how faculty that prosper in transdisciplinary courses tend to view complex problems in a way that differs significantly from their more traditional colleagues. Interdisciplinary and transdisciplinary literature is replete with examples of how to address complex and wicked problems. As individuals, faculty in the qualitative phase reflected on how continuous learning impacts their lives personally and professionally. They tended to seek out new languages or musical instruments to learn. Beyond the academy's confines, they demonstrated an interest in how systems work outside their home departments. They expressed a quest for answering discipline-spanning questions and learning to work on discipline-spanning teams to develop solutions. Although the overall construct resulted in the lowest Cronbach alpha score (0.49), two items reflected significant loading factors in the exploratory factor analysis (see Table 6).

Developing leaders that can excel in complex organizations and lead others in complex situations is an overarching benefit of transdisciplinary pedagogy and a method for accomplishing it. McGregor and Volckmann (2011) identified the many leadership forms required to implement transdisciplinary programming at a university. These include executive, scholar, researcher, and the collaborative leadership necessary to work

across disciplines, between discipline-based colleges, with industry stakeholders and government partners. Leadership positions for each form typically exist at the institutional level of most institutions, but transdisciplinary courses require these leadership practitioners at the course level. Working with such a variety of actors and stakeholders outside of one's department challenges faculty to experience a much broader perspective of the institution and its ecosystem. Often, such a revelation happens when a professor is promoted to a department or college leadership role, and often without much preparation. Transdisciplinary courses create opportunities for this to occur frequently, and often in unique ways with each course they experience. Forward thinking academic unit heads might be best suited to lead leadership development from the middle by encouraging faculty participation in transdisciplinary pedagogy and intentionally developing the next generation of institutional leaders. Brendan succinctly identified the X-Labs experience as a training ground for faculty leadership. Atticus's revelation that many of the rules he perceived as institutional were actually very specific to his department. Dania noted that her leadership confidence emerged from having the opportunity to lead faculty and student teams from multiple disciplines in X-Labs courses where she has had the opportunity to lead beyond the traditional classroom setting that consists of faculty-student relationships.

Implications for Practice

As an implication for operationalizing the promise of complexity leadership and transdisciplinarity theories, the Faculty Capacity and Inclination Index offers significant utility. From the review of literature, there is a distinct absence of tools or other quantitative resources available to aid in identifying faculty with these specific attributes.

If an institution aspires to establish the foundations of either transdisciplinary curriculum or complex leader development, the FCII offers an opportunity to identify those most likely to attain the ideals of both in the most efficient way possible; starting with the institution's current faculty. The relatively simple process of using the FCII to identify a pool of candidates well suited for transdisciplinary courses would eliminate one of the most significant barriers to implementation – people (Briggs & Michaud, 1972; Kockelmans, 1979).

Faculty might also use the FCII as a self-selection method, which by the very act of partaking in the instrument demonstrates some degree of inclination and intrinsic motivation. Certainly the goal of expanding transdisciplinary pedagogy opportunities would be enhanced if a high percentage of those attempting it proved to not only be good at it, but also found it enjoyable, professionally rewarding, and fulfilling.

Aside from aiding in the identification and recruiting of existing faculty, the FCII provides an opportunity for institutions to adapt their organization's very nature. If used as part of the recruiting process for new faculty, institutions with the intention to develop a more robust transdisciplinary curriculum could use the FCII to help differentiate and decide on new hires. This is particularly true when a subjective "fit" criteria is often the only real metric for the current hiring decisions at many institutions (White-Lewis, 2020). While fit remains a valid concern, the FCII might open a more inclusive dialogue and assist senior leaders in establishing the critical mass necessary to sustain a transdisciplinary transformation and thus implement an effective complex leadership development program.

Transdisciplinary pedagogy provides an academic pathway for innovation. Finding and curating complex, relevant problems as the foundation for an instructional system that enhances disciplinary knowledge holds promise in reforming higher education. Developing a pedagogical model that employs faculty and student teams to strengthen their disciplinary expertise while working on some of the most compelling and complex problems could help restore support for higher education among the general population and government stakeholders.

Transdisciplinary research and pedagogy are not new concepts. Regard for the approach as a critical component to solving complex problems has been growing among many higher education stakeholders at least since 1970 (Apostel et al., 1970; McGregor & Volckmann, 2011). Although rarely identified by name, political and industry leaders have called for innovations in higher education that point towards the transdisciplinary approach that would combine the current emphasis on acquiring disciplinary knowledge with a more practical approach that helps students acquire what are often referred to as 21st Century Skills (Association of American Colleges and Universities [AAC&U], 2018).

Transdisciplinary education sits at the confluence of this collection of 21st Century Skills concepts (National Research Council [NRC], 2014), and how these concepts intersect with students (Mayhew, Rockenbach, Bowman, Seifert, & Wolniak, 2016, p. 107), faculty and students (Magolda & King, 2004, Chapter 1), faculty, students, and institutions (Berger & Milem, 2000). Taken together, these concepts share two revelations of this study. First, higher education institutions are complex systems that tend to operate within multiple complex systems. Transdisciplinary courses, those based

in multidisciplinary teams of students and faculty and dedicated to working on complex or wicked problems, represent a microcosm of the larger higher education system (McGregor & Volckmann, 2011). Second, complex human systems are comprised of complex humans; relationships matter. Leading a large university is more complicated than leading a town. In Kezar's (2016) anthology that focuses on moving towards mission and learner-centered models of higher education, Austin and Trice (2016) noted the additional demands from societal stakeholders for heightened accountability and productivity, volatile fiscal constraints, a changing student body, the deepening knowledge of human learning, the burgeoning calls for pedagogies that encourage active learning, the possibilities of new technologies, the exponential rate of knowledge expansion, and the opportunities for global connections that enrich research and teaching (Austin & Trice, 2016, p. 58). And yet, as noted in Chapter 2 of this study, little has changed with respect to the methods of preparing or recruiting faculty for these increasingly complex institutional leadership roles. In addition to offering a transformative learning experience for students, the investment in transdisciplinary learning models may well serve as a developmental resource for preparing future institutional leadership.

A comprehensive approach to transdisciplinary education at the institutional level requires a complex mix of leadership abilities. Executive leadership to negotiate the turmoil associated with unsettling academic departments and established traditions, scholars to lead in building support for a new approach to research. It also requires an ability to lead and develop relationships with funding agencies, community and government organizations, industry, and other educational systems (McGregor &

Volckmann, 2011, p. 10). Montouri concludes his reflections on complexity and transdisciplinarity by saying they are ideas whose time has come. The role of complexity and transdisciplinarity theories is to organize the massive amount of information available, turn it into knowledge, and use the knowledge wisely (Montuori, 2013, p. 226).

Implications for Theory and Research

Transdisciplinary, problem-based pedagogy has held significant promise since the concept emerged or re-emerged at the first international conference on the topic in 1970 (Apostel et al., 1972). Despite its promise as a transformational approach to higher education that might bring the academy, society, and industry together, few practical examples have emerged. This study contributes to the theoretical models proposed or documented by Apostel et al. (1972) and Klein et al. (2001) by providing a pathway to finding the faculty needed to test their theories without first restructuring the doctoral preparation programs that produce them.

The survey items were grouped into constructs based on the literature and emergent data from the study's qualitative phase. Collectively, the items differentiated faculty in a normal distribution of scores. The study's purpose was to develop an FCII that could measure and reliably differentiate faculty on a set of attributes. While aiding in the discussion, naming these constructs in a definitive sense, and making claims about the precise psychometrics measured in the final instrument were beyond the study's scope. Future work should be undertaken to review the six constructs, with particular attention paid to the lower-loading items within each construct. Lower-loading items might be revised or eliminated without impacting the value of the instrument. Like the

embedded personality index (the TIPI), an abbreviated version of the FCII could be incorporated into existing faculty surveys, which would expedite implementation.

The complexity leadership theory, applied to higher education settings, warrants further research. Unlike the transformational leadership model that focuses on the transformational individual, the complexity leadership model focuses on preparing leaders who can lead complex organizations and complex circumstances. Given the gap in research centered on the selection and development of complex university leaders and the risk associated with making the wrong selection, this is one area that demands considerable attention. The qualitative protocols used for this study elicited compelling responses from the faculty interviewed. Those questions might be adapted for use in the interview and selection process to improve the objective evaluation of candidates and reduce the subjective importance of "fit" that tends to be arbitrary and perpetuates faculty homogeneity. With sufficient emphasis, a more deliberate quantitative complex leadership capacity instrument might be developed from this research line that would aid in identifying and selecting future higher education leader candidates that could participate in intentional leader development programs. Such a deliberate process could transform efforts to improve access and inclusion of more diverse institutional leaders. Again, this is likely most appropriate for mid-level leaders serving as academic unit heads that are seeking to develop the next generation of institutional leaders.

The study also revealed several interesting trends in responses that warrant further investigation. Analyzing the individual items associated with the constructs revealed differences in loading values that appear to be based on the perspective posed in the question. For example, items that began with "I am" or "I feel" versus "My colleagues"

or “My students.” In the openness construct, the loading factors were much higher on questions that began with “I” while those regarding “My colleague” attained the lower load values. Under learning partnerships, items beginning with “My students” loaded much higher than those beginning with “I” or “My colleagues.” Factors that attained the highest loading values under Learning Partnerships, all began with “My students” as one might expect. Regarding transdisciplinary capacity and inclination under the openness construct, it might prove important that faculty are more concerned with their own curiosities and ascribe less importance to the opinion of their colleagues. Similarly, faculty that hold the opinion of their students in high regard, might make better learning partners for the purpose of transdisciplinary pedagogical models. Future studies should be undertaken to determine the differences attributed to the perspective of self, student, and colleague under each of the constructs.

Of particular note was the vibrant role of disciplinary diversity that emerged from the rich, qualitative data. The qualitative data reflected that working with multidisciplinary teams of faculty and students and diversity of thought among team members were highly valued aspects of the transdisciplinary experience. However, during the pilot test, faculty scored the diversity items consistently and uniformly as “extremely high” importance. With consistent high scores, these items lacked variance, failed to contribute to the model, and were eliminated from the final version of the FCII released to faculty. Given the vital role diversity of thought held in the qualitative data, future research should be undertaken to clarify the role of diversity and develop items that are better able to discriminate along this important construct and contribute additional power to the instrument.

The study exposes a potentially powerful new approach for expanding transdisciplinary or convergence pedagogy. Transforming the FCII into its full potential as an inferential instrument would require a longitudinal, multi-institutional study. If high scores on the FCII produce a strong correlation with faculty involvement and persistence over time, it would be possible to validate the instrument as a reliable predictor of faculty capacity and inclination for transdisciplinary pedagogical experiences.

Limitations of the Study

It is important to note that the purpose of the study was limited to identifying attributes of faculty with demonstrated involvement and persistent experience teaching in team-based and problem-based transdisciplinary courses and translate those attributes to survey items and theoretical constructs grounded in the appropriate theory. The study did not establish that these attributes alone are necessary and sufficient to guarantee faculty success in a transdisciplinary pedagogical experience or as future leaders in complex systems. Further, there are no claims made that the identified attributes represent an exhaustive depiction of the attributes required or that might appear among faculty with these or similar successful experiences.

While factor analysis can provide strong indications that appropriate correlations exist, evidence of validity and reliability, it does not provide insight into the quality of the items and constructs or evidence that they are necessarily producing the desired metrics of the intended attribute. These are noted limitations that must be explored but are well beyond the scope of this study. As such, it is important to note that the study is reflective and the instrument is not yet appropriate for inferential applications. To address the

predictive nature of the instrument, a deliberate, long-term study should be conducted using the FCII as a pretest. By correlating FCII scores with faculty outcomes over time, it would be possible to validate the instrument's predictive value and operationalize the goal of advancing transdisciplinary education with existing faculty.

Finally, the FCII was employed and tested at one institution with a well established transdisciplinary course model. The instrument needs to be tested and validated at numerous institutions varying by size and type.

Conclusions

In chapter one, I set an ambitious goal of accomplishing three research aims; identify and understand attributes that distinguish faculty with transdisciplinary persistence and involvement, develop those distinguishing factors into a quantitative instrument that demonstrates potential as a valid and reliable measure of those attributes, and demonstrate the leader development potential of transdisciplinary work. Accomplishing those objectives opens additional lines of necessary research while simultaneously opening a new pathway to begin scaling transdisciplinary work expeditiously.

The transformative potential of transdisciplinary education has remained an open question since its inception. Rather than waiting until the academy changes the way it prepares doctoral faculty and subsequently adopts a transdisciplinary undergraduate curriculum, the FCII offers the necessary tool for identifying existing faculty with the capacity and inclination to start the transdisciplinary revolution now, and at a relatively low cost. With higher education being challenged from all sides to adapt, the FCII offers real potential in initiating that transformation.

Appendix A

Initial Qualitative Protocol

1. *Describe how you think X-Labs classes differ from your discipline-based classes*. This is a general, open-ended informational question seeking to identify key characteristics of courses in the context of the faculty participants.
2. *Describe your involvement in any research work or publications that occurred outside your discipline*. This question is designed to elicit evidence of humility, open-mindedness, and intellectual curiosity that transcend disciplinary bounds.
3. *Describe any experiences you have studying, teaching, or traveling abroad*. *Have you ever led a semester abroad program?* This question is designed to look at other aspects of humility, open-mindedness, curiosity, and by extension, a capacity for assimilation.
4. *Have you ever led a semester abroad program?* This question is to determine the level of commitment and engagement as faculty.
5. *Describe any experiences you may have in learning to play an instrument or speak a foreign language*. This question seeks to identify evidence of the construct - search for a common language.
6. *Describe any experiences you may have as a voluntary participant on a team that required significant effort*. Beyond a willingness to work on a team, this question is designed to identify behavior patterns that indicate evidence of the construct – accept teamwork.

7. *When participating on an academic team, how would you characterize your most valued contribution?* This question is designed to probe self-reflection from a team perspective.
8. *What best describes your research motives: to seek new levels of comprehension; to seek predictive power and parsimony; or to find results that are viable, workable, and show impact?*
9. *Can you share examples to illustrate?*
10. *Describe your perceptions of faculty as leaders*.
11. *Has your role or perspective changed since your first experience teaching in X-Labs courses?* This question is designed to gauge the perceptions and potential impact that team-taught, problem-based, transdisciplinary courses have on the individual faculty member and how they are perceived in their discipline/department.
12. *Have the methods used to interact with students in X-Labs classes influenced how you interact with faculty in your department?*
13. *How would you describe your mental model or process for making meaning from new concepts?*
14. *If you needed help from someone outside your discipline, how would you identify and recruit that expert?*
15. *If you were leading a research team, what would you do if one member was toxically disruptive?*

Appendix B

Initial Instrument Draft Considered by Expert Panel

Openness

1. My colleagues would say that I am comfortable teaching topics where I have knowledge but am not an expert
2. My colleagues often wonder about the focus of my research being outside my disciplinary norms
3. My colleagues would say that I enjoy trying new pedagogical approaches
4. My colleagues would say that I enjoy using multiple modalities
5. My colleagues would say that I frequently engage in research that cannot be satisfactorily addressed by my discipline alone
6. My colleagues would say that I enjoy learning to use new classroom technology
7. I am comfortable seeking help from among my close colleagues within my discipline
8. I am comfortable seeking help from among my close colleagues outside my discipline
9. I am comfortable seeking help from professional colleagues within my discipline
10. I am comfortable seeking project collaborators through my extended network
11. I enjoy seeking a common language with colleagues outside my discipline
12. I have no problem asking others for help
13. My colleagues would say that I often come up with creative solutions
14. It's OK for me not to have all the answers
15. I like to incorporate new technology into my instructional processes
16. I feel encouraged to expand my research agenda beyond traditional boundaries

Motivation

17. My main focus in research is to increase understanding
18. My main focus in research is to create impact
19. My main focus in research is to improve predictive power

20. My colleagues would say that I enjoy developing new curriculum
21. My students would say that I challenge them to reflect on their future careers
22. My students would say I put nearly as much effort into developing them as in delivering content
23. I enjoy the challenges of working on complex problems
24. My colleagues would often describe me as a change agent in our department
25. I think there is significant overlap between research and teaching
26. I enjoy taking an unconventional approach to teaching
27. I think it's important to demonstrate the impact of an unconventional approach to research or pedagogy
28. I have significant work experience outside of academia
29. I think students have a lot of untapped potential
30. I enjoy the challenge of inspiring students to find their potential
31. I feel empowered to execute my vision and values
32. I would rather work with creative, more challenging students than uncreative, easy students
33. I enjoy working with students from different perspectives
34. My students would say that I push them to try things they don't know
35. Demonstrated experiences in processes of innovation should make graduates in my discipline more valued members of future teams in academia or industry
36. Demonstrated experiences in creative problem solving should make graduates in my discipline more valued members of future teams in academia or industry
37. I see professional value in working on multidisciplinary teaching teams
38. I feel encouraged to explore new course electives that address emerging concepts in my discipline

Partnerships

39. My colleagues would say that I enjoy working with colleagues from other disciplines
40. My colleagues would say that I enjoy expanding my network outside of my discipline
41. My students would say I am comfortable learning along with them

42. My students would say I am comfortable working with them on projects with uncertain outcomes
43. My students would say I am comfortable when they develop a deeper understanding of a particular problem than me
44. My students would say that I am comfortable learning something from them
45. My students would say that I deliver more than content through my teaching style
46. My students keep in touch with me about their work even when they are no longer in my class
47. I am frequently asked by my colleagues to use my network to help them solve problems
48. I typically seek knowledge from non-academic sources when working on a problem
49. I am confident about collaborating in a network of experts to work on challenging problems
50. I am comfortable calling on my network to help me work through challenging matters
51. I like to work on teams where I enjoy the members of the team outside of the work we're doing
52. My colleagues would say that I am good at working on complex problems
53. Diverse student groups coming together to work on relevant projects might improve the level of interest or motivation
54. When working on complex problems, we can't afford to exclude people that are able to contribute to solutions
55. Working on problems with teams comprised of multiple disciplines from different colleges has the potential to be very productive
56. Working on complex problems with colleagues from different disciplines presents many interesting opportunities
57. From my experience, diverse teams are the strongest teams
58. My students would say that I allow them to fail safely their projects
59. Working in multidisciplinary teams with real clients where the focus is on solving complex problems is an interesting method for teaching my disciplinary knowledge more deeply

60. Considering future employment opportunities for our students, demonstrated mastery of a complex process may be as valuable as mastering content knowledge
61. Focusing on applying content knowledge towards solving real, relevant problems might differentiate education from training

Empathy

62. I am good at understanding problems from the end user or client's perspective
63. I am good at understanding problems from the perspective of my students
64. I am a good listener
65. I consider teaching students to interview with empathy an important skill for students in my discipline
66. I enjoy working with colleagues I can trust
67. I am willing to be vulnerable when working with colleagues I trust
68. I am willing to take risks when working with colleagues I trust
69. Humility is an important aspect of working on teams

Continuous Learning

70. My research agenda is closely tied to my teaching
71. My students would say I am interested in supporting them in applying in-class learning to problems outside of class
72. I learn by challenging myself in new roles
73. My colleagues would say I am a lifelong learner
74. My colleagues would say that if I had the opportunity to completely redesign the general education core curriculum, it would look a lot like it does now
75. If I had the opportunity to completely redesign my discipline's curriculum, it would look a lot like it does now
76. Our curriculum should be more visionary taking into account what our graduates will do
77. As faculty, we should focus on where we want to be in ten years
78. My students would say that designing projects and problems that appeal to a broad audience is one of my core values
79. I see pedagogical value in working on multidisciplinary teaching teams

80. I feel well supported in my efforts to adapt course and curricular objective to meet the needs of my students

Complex Leadership

81. My colleagues would say that I enjoy working on teams when the outcome is unknown or uncertain
82. My students would say I am comfortable giving them direct, meaningful feedback
83. I am good at understanding group dynamics
84. I am good at understanding the different perspectives of complex problems
85. I am good at balancing the needs of others when working on complex problems
86. When serving on committees, I tend to focus on results over procedures
87. When dealing with disruptive individuals, I try to refocus them on the shared outcomes
88. I understand how to give direct, meaningful feedback
89. The freedom to give and receive feedback are necessary components of a productive culture
90. While I may not enjoy it, I can give direct, meaningful feedback to colleagues
91. My colleagues would say that I try to help other members of a team make valued contributions
92. Building a highly functioning team requires knowing the strengths and interest of the team members
93. I think developing common meaning among all team members is an essential component of leadership in complex problem solving
94. My colleagues would say I am a good professional coach
95. My colleagues would say I am a very diplomatic problem solver
96. My colleagues would say I challenge them to think differently
97. My colleagues would say I am good at taking a systems approach to understanding things
98. My colleagues would say that I try to bring order to chaos
99. My colleagues would say that I am comfortable with ambiguity
100. My colleagues would say that I enjoy working on complex problems

101. I feel more productive when I am involved in the larger context of a problem
102. I am open to taking on leadership opportunities outside the classroom
103. I am open to taking on leadership opportunities outside my department
104. Getting things done is important
105. Learning to form diverse, balanced teams is an important skill for leaders
106. Faculty leaders also tend to be strong teachers
107. I enjoy synthesizing information and finding solutions from multiple perspectives
108. Diversity of thought is an important component when working on complex problems
109. I consider helping students learn how to work in multidisciplinary teams to be an important responsibility in their higher education experience
110. I feel supported by my department to collaborate with colleagues across campus on my scholarly activities
111. Collaborating on research teams with a variety of experts presents opportunities to address more complex problems

Appendix C

Transition Mapping – Expert Panel to Released Instrument

Coding	Quantitative Item	Expert Panel Feedback
1. Openness	My colleagues would say that I am comfortable teaching topics where I have knowledge but am not an expert	include
1. Openness	My colleagues often wonder about the focus of my research being outside my disciplinary norms	unclear
1. Openness	My colleagues would say that I enjoy trying new pedagogical approaches	include
1. Openness	My colleagues would say that I enjoy using multiple modalities	include
1. Openness	My colleagues would say that I frequently engage in research that cannot be satisfactorily addressed by my discipline alone	perceived redundant
1. Openness	My colleagues would say that I enjoy learning to use new classroom technology	unclear
1. Openness	I am comfortable seeking help from among my close colleagues within my discipline	include
1. Openness	I am comfortable seeking help from among my close colleagues outside my discipline	include
1. Openness	I am comfortable seeking help from professional colleagues within my discipline	perceived redundant
1. Openness	I am comfortable seeking project collaborators through my extended network	include
1. Openness	I enjoy seeking a common language with colleagues outside my discipline	perceived redundant
1. Openness	I have no problem asking others for help	include
1. Openness	My colleagues would say that I often come up with creative solutions	include
1. Openness	It's OK for me not to have all the answers	perceived redundant
1. Openness	I like to incorporate new technology into my instructional processes	unclear
1. Openness	I feel encouraged to expand my research agenda beyond traditional boundaries	demographic
2. Motivation (intrinsic)	My main focus in research is to increase understanding	include
2. Motivation (intrinsic)	My main focus in research is to create impact	include
2. Motivation (intrinsic)	My main focus in research is to improve predictive power	include

2. Motivation (intrinsic)	My colleagues would say that I enjoy developing new curriculum	include
2. Motivation (intrinsic)	My students would say that I challenge them to reflect on their future careers	include
2. Motivation (intrinsic)	My students would say I put nearly as much effort into developing them as in delivering content	include
2. Motivation (intrinsic)	I enjoy the challenges of working on complex problems	perceived redundant
2. Motivation (intrinsic)	My colleagues would often describe me as a change agent in our department	include
2. Motivation (intrinsic)	I think there is significant overlap between research and teaching	include
2. Motivation (intrinsic)	I enjoy taking an unconventional approach to teaching	include
2. Motivation (intrinsic)	I think it's important to demonstrate the impact of an unconventional approach to research or pedagogy	include
2. Motivation (intrinsic)	I have significant work experience outside of academia	perceived redundant
2. Motivation (intrinsic)	I think students have a lot of untapped potential	perceived redundant
2. Motivation (intrinsic)	I enjoy the challenge of inspiring students to find their potential	include
2. Motivation (intrinsic)	I feel empowered to execute my vision and values	unclear
2. Motivation (intrinsic)	I would rather work with creative, more challenging students than uncreative, easy students	unclear
2. Motivation (intrinsic)	I enjoy working with students from different perspectives	unclear
2. Motivation (intrinsic)	My students would say that I push them to try things they don't know	include
2. Motivation (intrinsic)	Demonstrated experiences in processes of innovation should make graduates in my discipline more valued members of future teams in academia or industry	include
2. Motivation (intrinsic)	Demonstrated experiences in creative problem solving should make graduates in my discipline more valued members of future teams in academia or industry	include
2. Motivation (intrinsic)	I see professional value in working on multidisciplinary teaching teams	include
2. Motivation (intrinsic)	I feel encouraged to explore new course electives that address emerging concepts in my discipline	demographic
3. Partnerships	My colleagues would say that I enjoy working with colleagues from other disciplines	perceived redundant
3. Partnerships	My colleagues would say that I enjoy expanding my network outside of my discipline	include

3. Partnerships	My students would say I am comfortable learning along with them	include
3. Partnerships	My students would say I am comfortable working with them on projects with uncertain outcomes	include
3. Partnerships	My students would say I am comfortable when they develop a deeper understanding of a particular problem than me	perceived redundant
3. Partnerships	My students would say that I am comfortable learning something from them	include
3. Partnerships	My students would say that I deliver more than content through my teaching style	include
3. Partnerships	My students keep in touch with me about their work even when they are no longer in my class	perceived redundant
3. Partnerships	I am frequently asked by my colleagues to use my network to help them solve problems	perceived redundant
3. Partnerships	I typically seek knowledge from non-academic sources when working on a problem	include
3. Partnerships	I am confident about collaborating in a network of experts to work on challenging problems	include
3. Partnerships	I am comfortable calling on my network to help me work through challenging matters	include
3. Partnerships	I like to work on teams where I enjoy the members of the team outside of the work we're doing	perceived redundant
3. Partnerships	My colleagues would say that I am good at working on complex problems	include
3. Partnerships	Diverse student groups coming together to work on relevant projects might improve the level of interest or motivation	unclear
3. Partnerships	When working on complex problems, we can't afford to exclude people that are able to contribute to solutions	unclear
3. Partnerships	Working on problems with teams comprised of multiple disciplines from different colleges has the potential to be very productive	unclear
3. Partnerships	Working on complex problems with colleagues from different disciplines presents many interesting opportunities	unclear
3. Partnerships	From my experience, diverse teams are the strongest teams	unclear
3. Partnerships	My students would say that I allow them to fail safely their projects	include
3. Partnerships	Working in multidisciplinary teams with real clients where the focus is on solving complex problems is an interesting method for teaching my disciplinary knowledge more deeply	unclear

3. Partnerships	Considering future employment opportunities for our students, demonstrated mastery of a complex process may be as valuable as mastering content knowledge	unclear
3. Partnerships	Focusing on applying content knowledge towards solving real, relevant problems might differentiate education from training	include
4. Empathy	I am good at understanding problems from the end user or client's perspective	perceived redundant
4. Empathy	I am good at understanding problems from the perspective of my students	include
4. Empathy	I am a good listener	include
4. Empathy	I consider teaching students to interview with empathy an important skill for students in my discipline	perceived redundant
4. Empathy	I enjoy working with colleagues I can trust	perceived redundant
4. Empathy	I am willing to be vulnerable when working with colleagues I trust	include
4. Empathy	I am willing to take risks when working with colleagues I trust	include
4. Empathy	Humility is an important aspect of working on teams	unclear
5. Continuous learning	My research agenda is closely tied to my teaching	perceived redundant
5. Continuous learning	My students would say I am interested in supporting them in applying in-class learning to problems outside of class	include
5. Continuous learning	I learn by challenging myself in new roles	include
5. Continuous learning	My colleagues would say I am a lifelong learner	include
5. Continuous learning	My colleagues would say that if I had the opportunity to completely redesign the general education core curriculum, it would look a lot like it does now	include
5. Continuous learning	If I had the opportunity to completely redesign my discipline's curriculum, it would look a lot like it does now	perceived redundant
5. Continuous learning	Our curriculum should be more visionary taking into account what our graduates will do	unclear
5. Continuous learning	As faculty, we should focus on where we want to be in ten years	unclear
5. Continuous learning	My students would say that designing projects and problems that appeal to a broad audience is one of my core values	unclear
5. Continuous learning	I see pedagogical value in working on multidisciplinary teaching teams	include

5. Continuous learning	I feel well supported in my efforts to adapt course and curricular objective to meet the needs of my students	demographic
6. Complex leadership	My colleagues would say that I enjoy working on teams when the outcome is unknown or uncertain	include
6. Complex leadership	My students would say I am comfortable giving them direct, meaningful feedback	include
6. Complex leadership	I am good at understanding group dynamics	include
6. Complex leadership	I am good at understanding the different perspectives of complex problems	perceived redundant
6. Complex leadership	I am good at balancing the needs of others when working on complex problems	include
6. Complex leadership	When serving on committees, I tend to focus on results over procedures	include
6. Complex leadership	When dealing with disruptive individuals, I try to refocus them on the shared outcomes	unclear
6. Complex leadership	I understand how to give direct, meaningful feedback	include
6. Complex leadership	The freedom to give and receive feedback are necessary components of a productive culture	perceived redundant
6. Complex leadership	While I may not enjoy it, I can give direct, meaningful feedback to colleagues	perceived redundant
6. Complex leadership	My colleagues would say that I try to help other members of a team make valued contributions	perceived redundant
6. Complex leadership	Building a highly functioning team requires knowing the strengths and interest of the team members	perceived redundant
6. Complex leadership	I think developing common meaning among all team members is an essential component of leadership in complex problem solving	perceived redundant
6. Complex leadership	My colleagues would say I am a good professional coach	perceived redundant
6. Complex leadership	My colleagues would say I am a very diplomatic problem solver	perceived redundant
6. Complex leadership	My colleagues would say I challenge them to think differently	include
6. Complex leadership	My colleagues would say I am good at taking a systems approach to understanding things	perceived redundant
6. Complex leadership	My colleagues would say that I try to bring order to chaos	perceived redundant
6. Complex leadership	My colleagues would say that I am comfortable with ambiguity	perceived redundant
6. Complex leadership	My colleagues would say that I enjoy working on complex problems	include
6. Complex leadership	I feel more productive when I am involved in the larger context of a problem	unclear

6. Complex leadership	I am open to taking on leadership opportunities outside the classroom	include
6. Complex leadership	I am open to taking on leadership opportunities outside my department	include
6. Complex leadership	Getting things done is important	include
6. Complex leadership	Learning to form diverse, balanced teams is an important skill for leaders	unclear
6. Complex leadership	Faculty leaders also tend to be strong teachers	include
6. Complex leadership	I enjoy synthesizing information and finding solutions from multiple perspectives	perceived redundant
6. Complex leadership	Diversity of thought is an important component when working on complex problems	no statistical value
6. Complex leadership	I consider helping students learn how to work in multidisciplinary teams to be an important responsibility in their higher education experience	include
6. Complex leadership	I feel supported by my department to collaborate with colleagues across campus on my scholarly activities	demographic
6. Complex leadership	Collaborating on research teams with a variety of experts presents opportunities to address more complex problems	unclear

Appendix D

FCII instrument items released to faculty

Openness

1. My colleagues would say that I am comfortable teaching topics where I have knowledge but am not an expert
2. My colleagues would say that I enjoy trying new pedagogical approaches
3. My colleagues would say that I enjoy using multiple modalities
4. I am comfortable seeking help from among my close colleagues within my discipline
5. I am comfortable seeking help from among my close colleagues outside my discipline
6. I am comfortable seeking project collaborators through my extended network
7. I have no problem asking others for help
8. My colleagues would say that I often come up with creative solutions

Motivation

9. My main focus in research is to increase understanding
10. My main focus in research is to create impact
11. My main focus in research is to improve predictive power
12. My colleagues would say that I enjoy developing new curriculum
13. My students would say that I challenge them to reflect on their future careers
14. My students would say I put nearly as much effort into developing them as in delivering content
15. My colleagues would often describe me as a change agent in our department
16. I think there is significant overlap between research and teaching
17. I enjoy taking an unconventional approach to teaching
18. I think it’s important to demonstrate the impact of an unconventional approach to research or pedagogy
19. I enjoy the challenge of inspiring students to find their potential
20. My students would say that I push them to try things they don’t know

21. Demonstrated experiences in processes of innovation should make graduates in my discipline more valued members of future teams in academia or industry
22. Demonstrated experiences in creative problem solving should make graduates in my discipline more valued members of future teams in academia or industry
23. I see professional value in working on multidisciplinary teaching teams

Partnerships

24. My colleagues would say that I enjoy expanding my network outside of my discipline
25. My students would say I am comfortable learning along with them
26. My students would say I am comfortable working with them on projects with uncertain outcomes
27. My students would say that I am comfortable learning something from them
28. My students would say that I deliver more than content through my teaching style
29. I typically seek knowledge from non-academic sources when working on a problem
30. I am confident about collaborating in a network of experts to work on challenging problems
31. I am comfortable calling on my network to help me work through challenging matters
32. My colleagues would say that I am good at working on complex problems
33. My students would say that I allow them to fail safely their projects
34. Focusing on applying content knowledge towards solving real, relevant problems might differentiate education from training

Empathy

35. I am good at understanding problems from the perspective of my students
36. I am a good listener
37. I am willing to be vulnerable when working with colleagues I trust
38. I am willing to take risks when working with colleagues I trust

Continuous Learning

39. My students would say I am interested in supporting them in applying in-class learning to problems outside of class

40. I learn by challenging myself in new roles
41. My colleagues would say I am a lifelong learner
42. My colleagues would say that if I had the opportunity to completely redesign the general education core curriculum, it would look a lot like it does now
43. I see pedagogical value in working on multidisciplinary teaching teams

Complex Leadership

44. My colleagues would say that I enjoy working on teams when the outcome is unknown or uncertain
45. My students would say I am comfortable giving them direct, meaningful feedback
46. I am good at understanding group dynamics
47. I am good at balancing the needs of others when working on complex problems
48. When serving on committees, I tend to focus on results over procedures
49. I understand how to give direct, meaningful feedback
50. My colleagues would say I challenge them to think differently
51. My colleagues would say that I enjoy working on complex problems
52. I am open to taking on leadership opportunities outside the classroom
53. I am open to taking on leadership opportunities outside my department
54. Getting things done is important
55. Faculty leaders also tend to be strong teachers
56. I consider helping students learn how to work in multidisciplinary teams to be an important responsibility in their higher education experience

Embedded TIPI

57. I see myself as extroverted, enthusiastic.
58. I see myself as critical, quarrelsome.
59. I see myself as dependable, self-disciplined.
60. I see myself as anxious, easily upset.
61. I see myself as open to new experiences, complex.
62. I see myself as reserved, quiet.

63. I see myself as sympathetic, warm.

64. I see myself as disorganized, careless.

65. I see myself as calm, emotionally stable.

66. I see myself as conventional, uncreative.

Demographics

67. I feel supported by my department to collaborate with colleagues across campus on my scholarly activities.
68. I feel encouraged to explore new course electives that address emerging concepts in my discipline.
69. I feel well supported in my efforts to adapt course and curricular objective to meet the needs of my students.
70. I feel encouraged to expand my research agenda beyond traditional boundaries

71. What is your gender? [female, male, non-binary, prefer no answer]

72. Which category describes you? (multiple OK)
    a. American Indian or Alaska Native - for example, Navajo Nation, Blackfeet Tribe, Mayan, Aztec
    b. Asian - for example, Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese
    c. Black or African American - For example, Jamaican, Haitian, Nigerian, Ethiopian, Somalian
    d. Hispanic, Latino or Spanish Origin - For example, Mexican, or Mexican American, Puerto Rican, Cuban, Salvadoran, Dominican, Colombian
    e. Middle Eastern - For example, Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian
    f. Native Hawaiian or Other Pacific Islander - For example, Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, Marshallese
    g. White - For example, German, Irish, English, Italian, Polish, French
    h. Some other race, ethnicity, or origin
    i. I prefer not to answer

73. Select the box that represents the range of your age in years:

74. The rank that best describes my current situation is:
    a. Adjunct
    b. Lecturer
    c. Assistant professor
    d. Associate professor

e. Professor
f. Administrator
g. Staff
h. Other

75. The highest degree I've earned is:
    a. High school
    b. Two-year
    c. Four-year baccalaureate
    d. Masters
    e. Doctorate
    f. Professional
    g. Other

76. The situation that best describes my tenure status is:

77. How many years of service do you have at this institution?

78. The majority of my current academic assignment is to which college?
    a. Arts and Letters
    b. Business
    c. Education
    d. Health and Behavioral Studies
    e. Integrated Science and Engineering
    f. Science and Mathematics
    g. Visual and Performing Arts
    h. Honors
    i. The Graduate School

Appendix E

Communalities and Structure Matrix – Loading for Component 1 Exploratory Factor Analysis With Oblimin Rotation and Kaiser Normalization

Item	Structure Matrix for Component 1	Communalities
3-My students would say that I deliver more than content through my teaching style.	0.783	0.746
3-My students would say I am comfortable learning along with them.	0.772	0.818
3-My students would say that I am comfortable learning something from them.	0.759	0.818
2-My students would say I put nearly as much effort into developing them as in delivering content.	0.733	0.782
5-My students would say I am interested in supporting them in applying in-class learning to problems outside of class.	0.712	0.797
2-My students would say that I challenge them to reflect on their future careers.	0.625	0.857
6-My students would say I am comfortable giving them direct, meaningful feedback.	0.515	0.777
3-My students would say I am comfortable working with them on projects with uncertain outcomes.	0.459	0.828
2-I enjoy the challenge of inspiring students to find their potential.	0.425	0.743
3-My students would say that I allow them to fail safely their projects.	0.398	0.772
5-My colleagues would say I am a lifelong learner.	0.380	0.771
1-My colleagues would say that I am comfortable teaching topics where I have knowledge but am not an expert.	0.345	0.752
2-My colleagues would often describe me as a change agent in our department.	0.334	0.851
1-My colleagues would say that I enjoy trying new pedagogical approaches.	0.313	0.857
6-My colleagues would say I challenge them to think differently.	0.307	0.792

1-My colleagues would say that I often come up with creative solutions.	0.292	0.816
1-My colleagues would say that I enjoy using multiple modalities.	0.284	0.767
1-I have no problem asking others for help.	0.269	0.840
6-I am good at understanding group dynamics.	0.265	0.781
3-My colleagues would say that I enjoy expanding my network outside of my discipline.	0.254	0.814
6-I consider helping students learn how to work in multidisciplinary teams to be an important responsibility in their higher education experience.	0.253	0.800
3-I am confident seeking non-academic sources when working on a problem.	0.247	0.788
2-I think it's important to demonstrate the impact of an unconventional approach to research or pedagogy.	0.244	0.833
6-I am good at balancing the needs of others when working on complex problems.	0.225	0.841
1-I am comfortable seeking project collaborators through my extended network.	0.216	0.819
2-I enjoy taking an unconventional approach to teaching.	0.212	0.871
1-I am comfortable seeking help from among my close colleagues outside my discipline.	0.199	0.812
2-I see professional value in working on multidisciplinary teaching teams.	0.190	0.876
3-My colleagues would say that I am good at working on complex problems.	0.187	0.881
2-My students would say that I push them to try things they don't know.	0.186	0.786
6-My colleagues would say that I enjoy working on teams when the outcome is unknown or uncertain.	0.186	0.861
3-I am comfortable calling on my network to help me work through challenging matters.	0.184	0.872
4-I am good at understanding problems from the perspective of my students.	0.183	0.855

5-I see pedagogical value in working on multidisciplinary teaching teams.	0.182	0.818
5-I learn by challenging myself in new roles.	0.180	0.780
2-My colleagues would say that I enjoy developing new curriculum.	0.170	0.857
2-My main focus in research is to increase understanding.	0.164	0.775
2-Demonstrated experiences in creative problem solving should make graduates in my discipline more valued members of future teams in academia or industry.	0.152	0.802
6-My colleagues would say that I enjoy working on complex problems.	0.147	0.820
6-I understand how to give direct, meaningful feedback.	0.144	0.852
4-I am a good listener.	0.137	0.757
6-When serving on committees, I tend to focus on results over procedures.	0.134	0.828
4-I am willing to be vulnerable when working with colleagues I trust.	0.124	0.888
6-I am open to taking on leadership opportunities outside my department.	0.116	0.857
4-I am willing to take risks when working with colleagues I trust.	0.105	0.891
3-Focusing on applying content knowledge towards solving real, relevant problems might differentiate education from training.	0.105	0.807
1-I am comfortable seeking help from among my close colleagues within my discipline.		0.825
2-Demonstrated experiences in processes of innovation should make graduates in my discipline more valued members of future teams in academia or industry.		0.753
2-I think there is significant overlap between research and teaching.		0.815
2-My main focus in research is to create impact.		0.819
2-My main focus in research is to improve predictive power.		0.790

3-I am confident about collaborating in a network of experts to work on challenging problems.	0.783
5-Curriculum_Redesign	0.824
6-Faculty leaders also tend to be strong teachers.	0.857
6-Getting things done is important.	0.781
6-I am open to taking on leadership opportunities outside the classroom.	0.868

Appendix F

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	13.505	24.116	24.116	13.505	24.116	24.116	5.860
2	4.034	7.204	31.320	4.034	7.204	31.320	4.553
3	2.829	5.051	36.371	2.829	5.051	36.371	4.580
4	2.463	4.399	40.770	2.463	4.399	40.770	4.187
5	2.319	4.140	44.910	2.319	4.140	44.910	4.033
6	2.267	4.048	48.958	2.267	4.048	48.958	4.538
7	2.009	3.587	52.545	2.009	3.587	52.545	2.869
8	1.731	3.091	55.636	1.731	3.091	55.636	3.800
9	1.559	2.785	58.421	1.559	2.785	58.421	2.118
10	1.511	2.699	61.119	1.511	2.699	61.119	3.000
11	1.469	2.623	63.742	1.469	2.623	63.742	2.230
12	1.374	2.453	66.195	1.374	2.453	66.195	2.713
13	1.173	2.095	68.291	1.173	2.095	68.291	3.029
14	1.099	1.963	70.254	1.099	1.963	70.254	2.835
15	1.053	1.880	72.133	1.053	1.880	72.133	1.915
16	1.029	1.838	73.972	1.029	1.838	73.972	3.815

References

Amey, M. J. (2006). Leadership in higher education. *Change: The Magazine of Higher Learning*, *38*(6), 55-58. http://dx.doi.org/10.3200/CHNG.38.6.55-58

Amey, M. J., & Brown, D. F. (2004). *Breaking out of the box: Interdisciplinary collaboration and faculty work*. [Google Play Books]. Retrieved from https://play.google.com/store/books/details?id=kPknDwAAQBAJ&rdid=book-kPknDwAAQBAJ&rdot=1&source=gbs_vpt_read&pcampaignid=books_booksearch_viewport&pli=1

Apostel, L., Berger, G., Briggs, A., & Michaud, G. (Eds.). (1970). *Interdisciplinarity: Problems of teaching and research in universities*. *Organization for Economic Cooperation and Development*. Paris, France: OECD Publications.

Association of American Colleges and Universities. (2018). *Fulfilling the American dream: Liberal education and the future of work*. Retrieved from https://www.aacu.org/sites/default/files/files/LEAP/2018EmployerResearchReport.pdf

Astin, A. W., Comstock, C., Epperson, D. C., Greeley, A. M., Katz, J., & Kauffman, J. F. (1974). *Faculty development in a time of retrenchment*. New Rochelle, NY: Change Publications.

Augsburg, T. (2014, August 15). Becoming transdisciplinary: The emergence of the transdisciplinary individual. *World Futures*, *70*(3-4), 233-247. http://dx.doi.org/10.1080/02604027.2014.934639

Austin, A. E., & Trice, A. G. (2016). Core principals for faculty models and the importance of community. In A. J. Kezar & D. Maxey (Eds.), *Envisioning the*

faculty for the 21st Century (pp. 58-80). New Brunswick, NJ: Rutgers University Press.

Balsiger, J. (2014). Transdisciplinarity in the class room? Simulating the co-production of sustainable knowledge. *Futures, 65*, 185-194. http://dx.doi.org/10.1016/j.futures.2014.08.005

Becher, T., & Trowler, P. R. (2001). *Academic tribes and territories* (2nd ed.). Philadelphia, PA: The Society for Research into Higher Education.

Berger, J. B., & Milem, J. F. (2000). Organizational behavior in higher education and student outcomes. In J. C. Smart, & W. G. Tierney (Eds.), *Higher education: Handbook of theory and research. Association for Institutional Research and Association for the Study of Higher Education* (pp. 268-338). Retrieved from

Bergmann, M., Brohmann, B., Hoffmann, E., Loibl, M. C., Rehaag, R., Schramm, E., & Voss, J. (2005). *Quality criteria of transdisciplinary research* (ISOE-Studientexte, No 13/English Version ISSN 0947-6083). Washington, DC: Government Printing Office.

Bergquist, W. H., & Pawlak, K. (2008). *Engaging the six cultures of the academy*. San Fransisco, CA: Jossey-Bass.

Blank, S., & Dorf, B. (2012). *The startup owner?s manual*. Pescadero, CA: K&S Ranch.

Borman, W. C., Penner, L. A., Allen, T. D., & Motowidlo, S. J. (2001, March/June). Personality predictors of citizenship performance. *International Journal of Selection and Assessment*, *9*(1/2), 52-69. http://dx.doi.org/10.1111/1468-2389.00163

Briggs, A., & Michaud, G. (1972). Problems and solutions. In L. Apostel, G. Berger, A. Briggs, & G. Michaud (Eds.), *Interdisciplinarity: Problems of teaching and research in universities* (pp. 185-251). Paris, France: OECD.

Britos Cavagnaro, L., & Fasihuddin, H. (2016, Spring). A moonshot approach to change in higher education: Creativity, innovation, and the redesign of academia. *Liberal Education*, *102*(2). Retrieved from https://www.aacu.org/liberaleducation/2016/spring/cavagnaro

Brooks, J., Fox, D. P., Okagbue-Reaves, J., & Lukomski, A. (2009, August 7). Best practices for an interdisciplinary team-taught course. *Education Gerontology*, *35*(9), 818-830. http://dx.doi.org/10.1080/03601270902821350

Brown, F. W., & Moshavi, D. (2002, Winter). Herding academic cats: Faculty reactions to transformational and contingent reward leadership by department chairs. *The Journal of Leadership Studies*, *8*(3), 79-93. http://dx.doi.org/10.1177/107179190200800307

Brown, V. A., Harris, J. A., & Russell, J. Y. (Eds.). (2010). *Tackling wicked problems through transdisciplinary imagination*. Washington, DC: Earthscan.

Bruce, A., Lyall, C., Tait, J., & Williams, R. (2004). Interdisciplinary integration in Europe: the case for the Fifth Framework programme. *Futures*, *36*, 457-470. http://dx.doi.org/10.1016/j.futures.2003.10.003

Bryman, A. (2007). Effective leadership in higher education: A literature review. *Studies in Higher Education*, *32*(6), 693-710. http://dx.doi.org/10.1080/03075070701685114

Cai, Y. (2017, Summer). From an analytical framework for understanding the innovation process in higher education to an emerging research field of innovations in higher education. *The Review of Higher Education, 40*(4), 585-616. http://dx.doi.org/10.1353/rhe.2017.0023

Campbell, J., Smith, D., Boulton-Lewis, G., Brownlee, J., Burnett, P. C., Carrington, S., & Purdie, N. (2001, August 25). Students? perceptions of teaching and learning: The influence of students? approaches to learning and teachers? approaches to teaching. *Teachers and Teaching, 7*(2), 173-187. http://dx.doi.org/10.1080/13540600120054964

Clauset, A., Arbesman, S., & Larremore, D. B. (2015, February 12). Systemic inequality and hierarchy in faculty hiring networks. *Science Advances*. http://dx.doi.org/10.1126/sciadv.1400005

Committee for Economic Development. (2003). *Learning for the future: Changing the culture of math & science education to ensure a competative workforce: a statement of national policy*. Retrieved from https://www.ced.org/pdf/Learning-for-the-Future.pdf

Committee on Convergence. National Research Council of the National Academies. (2014). *Convergence: Transdisciplinary integration of life sciences, physical sciences, engineering and beyond*. Washington, DC: The National Academies Press.

Creswell, J. W. (2015). *A concise introduction to mixed methods research*. Thousand Oaks, CA: Sage Publications.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2 ed.). Thousand Oaks, CA: Sage Publications.

Davis, J. R. (1995). *Interdisciplinary courses and team teaching: New arrangements for learning*. Phoenix, AZ: American Council on Education, Oryx Press.

DiStefano, C., Zhu, M., & Mindrila, D. (2009, October). Understanding and usiing factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation*, *14*(20), 1-11. http://dx.doi.org/10.7275/da8t-4g52

Duhigg, C. (2016, February 25). What Google learned from its quest to build the perfect team. *The New York Times Magazine*. Retrieved from https://www.nytimes.com/2016/02/28/magazine/what-google-learned-from-its-quest-to-build-the-perfect-team.html

Dyball, R. (2010). Human ecology and open transdisciplinary inquiry. In V. A. Brown, J. A. Harris, & J. Y. Russell (Eds.), *Tackling wicked problems through the transdisciplinary imagination* (pp. 273-284). Washington, DC: Earthscan.

Fagerberg, J., Martin, B. R., & Andersen, E. S. (Eds.). (2013). *Innovation studies: Evolution & future challenges*. New York, NY: Oxford University Press.

Fullan, M. (2001). *Leading in a culture of change*. [Google Play Books]. Retrieved from https://books.google.com/books?id=Cy7qAgAAQBAJ&dq=leading+in+a+culture+of+change&lr=

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (2002). *The new production of knowledge: The dynamics of science and research in contemporary societies*. Thousand Oaks, CA: Sage Publications.

Gibbs, P. (Ed.). (2015). *Transdisciplinary professional learning and practice*. [Apple iBook version]. http://dx.doi.org/10.1007/978-3-319-11590-0

Golde, C. M., & Dore, T. M. (2001). *At cross purposes: What the experiences of today?s doctoral students reveal about doctoral education*. Retrieved from Pew Charitable Trust: https://eric.ed.gov/?id=ED450628

Gray, B. (2008, August). Enhancing transdisciplinary research through collaborative leadership. *American Journal of Preventive Medicine*, *35*(2), S124-S132. http://dx.doi.org/10.1016/j.amepre.2008.03.037

Grohman, M. G., Silvia, P., Ivcevic, Z., & Kaufman, S. B. (2017, November). The role of passion and persistence in creativity. *Psychology of Aesthetics, Creativity, and the Arts*, *11*(4), 376-385. http://dx.doi.org/10.1037/aca0000121

Groves, R. M., Fowler, Jr., F. J., Couper, M. P., Lepkowski, J. M., Singer, E., & Tourangeau, R. (2011). *Survey methodology*. Germany: Wiley.

Guimaraes, M. H., Pohl, C., Bina, O., & Varanda, M. (2019, July 18). Who is doing inter- and transdisciplinary research, and why? An emperical study of motives, attitudes, skills, and behaviours. *Futures*, *112*. http://dx.doi.org/10.1016/j.futures.2019.102441

Holley, K. A. (2009). *Understanding interdisciplinary challenges and opportunities in higher education* (ASHE Higher Education Rep. No. 35-2). San Fransisco, CA: Jossey-Bass.

Jacobs, I. M., & Nienaber, S. (2011). Waters without borders: Transboundary water governance and the role of the transdisciplinary individual in Southern Africa. *Water SA*, *37*(5), 665-678. http://dx.doi.org/10.4314/wsa.v37i5.4

Jahn, T., Bergmann, M., & Keil, F. (2012, July). Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics, 79*(), 1-10. http://dx.doi.org/10.1016/j.ecolecon.2012.04.017

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika, 39*(), 31-36. http://dx.doi.org/10.1007/BF02291575

Klein, J. T. (1990). *Interdisciplinarity: History, theory, and practice*. Detroit: Wayne State University Press.

Klein, J. T. (1996). *Crossing boundaries: knowledge, disciplinarity, and interdisciplinarities*. Charlottesville, VA: University Press of Virginia.

Klein, J. T. (2004). Prospects for transdisciplinarity. *Futures, 36*, 515-526. http://dx.doi.org/10.1016/j.futures.2003.10.007

Klein, J. T. (2008). Evaluation of interdisciplinary and transdisciplinary research: A literature review. *American Journal of Preventive Medicine, 35*, S116-S123. http://dx.doi.org/10.1016/j.amepre.2008.05.010

Klein, J. T., Grossenbacher-Mansuy, W., Haberli, R., Bill, A., Scholz, R. W., & Welti, M. (Eds.). (2001). *Transdisciplinarity: Joint problem solving among science, technology, and society*. Basel, Switzerland: Birkhauser Verlag.

Kockelmans, J. J. (Ed.). (1979). *Interdisciplinarity and higher education*. University Park, PA: The Pennsylvania State University Press.

Larson, E. L., Landers, T. F., & Begg, M. D. (2011, February 23). Building interdisciplinary research models: A didactic course to prepare interdisciplinary scholars and faculty. *Clinical and Translational Science, 4*(1), 38-41. http://dx.doi.org/10.1111/j.1752-8062.2010.00258.x

Lattuca, L. R. (Ed.). (2001). *Creating interdisciplinarity: Interdisciplinary research and teaching among college and university faculty*. Nashville, TN: Vanderbilt University Press.

Lattuca, L. R., Voigt, L. J., & Fath, K. Q. (2004, Fall). Does interdisciplinarity promote learning? Theoretical support and researchable questions. *The Review of Higher Education*, *28*(1), 23-48. http://dx.doi.org/10.1353/rhe.2004.0028

Lawrence, R. J. (2014, November 21). Advances in transdisciplinarity: Epistemologies, methodologies, and processes. *Futures*, *65*, 1-9. http://dx.doi.org/10.1016/j.futures.2014.11.007

Lepczyk, B., Wagner, T., & Cennamo, K. S. (2018, November 5). Choreography as design. *Journal of Dance Education*, *18*(4), 143-153. http://dx.doi.org/10.1080/15290824.2017.1377344

Lichtenstein, B. B., Uhl-Bien, M., Marion, R., Seers, A., Orton, J. D., & Schreiber, C. (2006, November). Complexity leadership theory: An interactive perspective on leading in complex adaptive systems. *Emergence: Complexity & Organization*, *8*(4), 2-12. Retrieved from https://www.researchgate.net/publication/259828753_Complexity_Leadership_Theory_An_Interactive_Perspective_on_Leading_in_Complex_Adaptive_Systems/link/5445955a0cf2f14fb80f002f/download

Maasen, S., & Lieven, O. (2006, July). Transdisciplinarity: a new mode of governing science. *Science and Public Policy*, *33*(6), 399-410. http://dx.doi.org/10.3152/147154306781778803

Magolda, M. B., & King, P. M. (Eds.). (2004). *Learning partnerships: Theory and models of practice to educate for self-authorship*. Sterling, VA: Stylus Publishing.

Makinen, E. I. (2018). Complexity leadership theory and the leaders of transdisciplinary science. *Informing Science: the International Journal of an Emerging Transdiscipline, 21,* 133-155. http://dx.doi.org/10.28945/4009

Malloch, K. (2014). Beyond transformational leadership to greater engagement: Inspiring innovations in complex organizations. *Nurse Leader,* 60-63. http://dx.doi.org/10.1016/j.mnl.2014.01.004

Mattson, K. (2005, Jan-Feb). Why ?Active Learning? can be perilous to the profession. *Academe*, *91*(1), 23-26. Retrieved from https://www.jstor.org/stable/40252732

Mayhew, M. J., Rockenbach, A. N., Bowman, N. A., Seifert, T. A., Wolniak, G. C., Pascarella, E. T., & Terenzini, P. T. (2016). *How college affects students: 21st century evidence that higher education works* (3rd ed.). [Kindle for iPad]. Retrieved from https://www.amazon.com/How-College-Affects-Students-Education-ebook-dp-B01KZHY1O8/

Mayhew, M. J., Simonoff, J. S., Baumol, W. J., Selznick, B. S., & Vassallo, S. J. (2016, October). Cultivating innovative entrepreneurs for the Twenty-First Century: A study of the U.S. and German students. *The Journal of Higher Education, 87*(3), 420-455. http://dx.doi.org/10.1080/00221546.2016.11777408

McFadden, S. H., & Perlman, B. (1989, December). Faculty recruitment and excellent undergraduate teaching. *Teaching of Psychology*, *16*(4), 195-198. http://dx.doi.org/10.1207/s15328023top1604_6

McGregor, S. L., & Volckmann, R. (2011). *Transversity*. Tucson, AZ: Integral.

McKeon, M. (1994). The origins of interdisciplinary studies. *Eighteenth-Century Studies, 28*(1), 17-28. Retrieved from https://www.jstor.org/stable/pdf/2739220.pdf

McMurtrie, B. (2019, February 15). No textbooks, no lectures, and no right answers. Is this what higher education needs? *The Chronicle of Higher Education, LXV*(22), 14-16, 18.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). San Fransisco, CA: Jossey-Bass.

Montuori, A. (2013, July 12). Complexity and transdisciplinarity: Reflections on theory and practice. *World Futures, 69*(4-6), 200-230. http://dx.doi.org/10.1080/02604027.2013.803349

Monuori, A. (2013, July 12). Complexity and transdisciplinarity: Reflections on theory and practice. *World Futures*, *69*(4-6), 200-230. http://dx.doi.org/10.1080/02604027.2013.803349

Moore, A. J. (1987, January-February). Selecting outstanding faculty: Indicators of quality. *Journal of Teacher Education*, *38*, 43-47. http://dx.doi.org/10.1177/002248718703800108

National Research Council. (2014). *Convergence: Facilitating transdisciplinary integration of life sciences, physical sciences, engineering, and beyond*. Retrieved from National Academy Press: http://nap.edu/18722

National Science Foundation. (2019). *Innovation Corps: Biennial report in accordance with public law 114-329*. Retrieved from https://www.nsf.gov/news/special_reports/i-corps/pdf/I-CorpsReport--6_4_19FINAL_508.pdf

Newell, W. H. (2008). . *The intertwined history of interdisciplinary education and the associationo for integrative studies: An insider?s view*, *26*(), 1-59. Retrieved from https://oakland.edu/Assets/upload/docs/AIS/Issues-in-Interdisciplinary-Studies/2008-Volume-26/03_Vol_26_pp_1_59_The_Intertwined_History_of_Interdisciplinary_Undergraduate_Education_and_the_Association_for_Integrative_Studies_An_Insider?s_View_(William_Newell).pdf

Newell, W. H. (2013). The state of the field: Interdisciplinary theory. *Issues in Interdisciplinary Studies*, *31*(), 22-43. Retrieved from http://hdl.handle.net/10323/4478

Newell, W. H., & Davis, A. J. (1988, September). Education for citizenship: The role of progressive education and interdisciplinary studies. *Innovative Higher Education*, *13*(1), 27-37. http://dx.doi.org/10.1007/BF00898129

Newell, W. H., & Green, W. J. (1982). Defining and teaching interdisciplinary studies. *Improving College and University Teaching*, *30*(1), 23-30. Retrieved from https://www.jstor.org/stable/27565474

Newell, W. H., & Klein, J. T. (1996). Interdisciplinary studies into the 21st Century. *The Journal of General Education*, *45*(2), 152-169. Retrieved from https://www.jstor.org/stable/27797297

Nicolescu, B. (1999). The transdisciplinary evolution of learning. In , . Symposium conducted at the Centre International de Recherches et d?Etudes Transdisciplinaires (CIRET), Montreal, Canada. Retrieved from http://www.learndev.org/dl/nicolescu_f.pdf

Nicolescu, B., Morin, E., & de Freitas, L. (1994). The charter of transdisciplinarity. In B. Nicolescu (Chair), *The charter of transdisciplinarity*. Symposium conducted at the First World Congress of Transdisciplinarity, Arrabida, Portugal. Retrieved from http://inters.org/Freitas-Morin-Nicolescu-Transdisciplinarity

Niehaus, E., & O?Meara, K. (2015). Invisible but essential: The role of professional networks in promoting faculty agency in career advancement. *Innovative Higher Education*, *40*, 159-171. Retrieved from https://digitalcommons.unl.edu/cehsedadfacpub/36/

Nowotny, H., Scott, P., & Gibbons, M. (2003, September). Mode 2 revisited: The new production of knowledge. *Minerva*, *41*(3), 179-194. http://dx.doi.org/10.1023/A:102550552

O'Meara, K. (2007). Stepping up: How one faculty learning community influenced faculty members? understanding and use of active-learning methods and course design. *Journal on Excellence in College Teaching*, *18*(2), 97-118. Retrieved from https://eric.ed.gov/?id=EJ901631

Oreg, S. (2003). Resistance to change: Developing an individual differences measure. *Journal of Applied Psychology*, *88*(4), 680-693. http://dx.doi.org/10.1037/0021-9010.88.4.680

Osborne, J. W. (2014). *Best practices in exploratory factor analysis*. Retrieved from https://www.researchgate.net/publication/209835856_Best_Practices_in_Exploratory_Factor_Analysis_Four_Recommendations_for_Getting_the_Most_From_Your_Analysis

Osterwalder, A., Pigneur, Y., Bernarda, G., & Smith, A. (2014). *Value proposition design*. Hoboken, NJ: John Wiley & Sons.

Poli, D., & Stoneman, L. (2018, August 7). Capturing the transdisciplinary dragon: Creating a crossover natural history-art exhibit. *Atlas Journal*, 44-56. http://dx.doi.org/10.22545/2018/00101

Quinlan, K. M. (2014). Leadership of teaching for student learning in higher education : What is needed? *Higher Education Research & Development*, *33*(1), 32-45. http://dx.doi.org/10.1080/07294360.2013.864609

Ries, E. (2011). *The lean startup: How today?s entrepreneurs use continuous innovation to create radically successful businesses*. [Kindle]. Retrieved from https://www.amazon.com

Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Science*, *4*(2), 155-169. http://dx.doi.org/10.1007/BF01405730

Robinson, J. (2007, July 29). Being undisciplined: Transgressions and intersections in academia and beyond. *Futures*, *40*(), 70-86. http://dx.doi.org/10.1016/j.futures.2007.06.007

Selznick, B. S., & Mayhew, M. J. (2018). Measuring undergraduates' innovation capacities. *Research in Higher Education*, *59*(6), 744-764. http://dx.doi.org/10.1007/s11162-017-9486-7

Selznick, B. S., McCarthy, S., Ludwig, P., Swayne, N., & Lewis, E. (2019, August). *University innovation and innovators: A response-able conceptual model*. Paper presented at the The European Higher Education Society, Leiden, The Netherlands.

Shymansky, J. A., Hedges, L. V., & Woodworth, G. (1990, February). A reassessment of the effects of inquiry-based science curricula of the 60?s on student performance. *Journal of Research in Science Teaching*, *27*(2), 127-144. http://dx.doi.org/doi.org/10.1002/tea.3660270205

Smart, J. C., Feldman, K. A., & Ethington, C. A. (2000). *Academic disciplines: Holland?s theory and the study of college students and faculty* (1st ed.). Nashville, TN: Vanderbilt University Press.

Spendlove, M. (2007). Competencies for effective leadership in higher education. *International Journal of Education Management*, *21*(5), 407-417. http://dx.doi.org/10.1108/09513540710760183

Stauffacher, M., Walter, A. I., Lang, D. J., Wiek, A., & Scholz, R. W. (2006). Learning to research environmental problems from a functional socio-cultural constructivism perspective: The transdisciplinary case study approach. *International Journal of Sustainability in Higher Education*, *7*(3), 252-275. http://dx.doi.org/10.1108/14676370610677838

Thomas, J. R. (1997). Vision and leadership for selecting and mentoring new faculty in higher education. *Journal of Physical Education, Recreation & Dance*, *68*(5), 41-46. http://dx.doi.org/10.1080/07303084.1977.10604945

Thompson, M. A., Owen, S., Lindsay, J. M., Leonard, G. S., & Cronin, S. J. (2017, May 12). Scientist and stakeholder perspectives of transdisciplinary research: Early attitudes, expectations, and tensions. *Environmental Science and Policy*, *74*(), 30-39. http://dx.doi.org/10.1016/j.envsci.2017.04.006

Uhl-Bien, M., Marion, R., & McKelvey, B. (2007, August). Complexity leadership theory: Shifting leadership from the industrial age to the knowledge era. *The Leadership Quarterly*, *18*(4), 298-318. http://dx.doi.org/10.1016/j.leaqua.2007.04.002

Vaill, P. (1998, January 1). The learning challenges of leadership. *Journal of Applied Manufacturing Systems*, *9*(2), 37-44. Retrieved from http://explore.bl.uk/primo_library/libweb/action/display.do?tabs=detailsTab&gathStatTab=true&ct=display&fn=search&doc=ETOCRN056437563&indx=1&recIds=ETOCRN056437563

von Manen, M. (2001, November). Transdisciplinarity and the new production of knowledge. *Qualitative Health Research*, *11*(6), 850-852. http://dx.doi.org/10.1177/104973201129119442

Wagner, T. (2012). *Creating innovators*. New York, NY: Scribner.

Weber, E. P., & Khademian, A. M. (2008, March/April). Wicked problems, knowledge challenges, and collaborative capacity builders in network settings. *Public Administration Review*, *68*(2), 334-348. http://dx.doi.org/10.1111/j.1540-6210.2007.00866.x

Weber, E. P., Lach, D., & Steel, B. S. (Eds.). (2017). *New strategies for wicked problems*. Corvallis, OR: Oregon State University Press.

Wenger-Trayner, B., & Wenger-Trayner, E. (2019). *Designing for change*. Middletown, DE: Learning 4 a Small Planet.

White-Lewis, D. K. (2020, July 9). The facade of fit in faculty search processes. *The Journal of Higher Education*, 1-25. http://dx.doi.org/10.1080/00221546.2020.1775058

Wraga, W. G. (2012, July 11). The interdisciplinary imperative for citizenship education. *Theory & Research in Social Education*, *21*(3), 201-231. http://dx.doi.org/10.1080/00933104.1993.10505702