UNDERSTANDING INTERDISCIPLINARY SCIENCE GRADUATE PROGRAMS AT THE UNIVERSITY OF DELAWARE

by

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An executive position paper submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Education in Educational Leadership.

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ABSTRACT

For more than a decade, interdisciplinary methods have been cited as instrumental in stimulating the innovation needed to solve today's complex scientific challenges. As such, there has been increasing emphasis on incorporating interdisciplinary training into graduate education. However, the traditional university infrastructure often creates barriers to interdisciplinary efforts and the path to solve these challenges is often unclear or even resisted from within. Despite several calls for reforms, many universities are still struggling with the implementation and practice of interdisciplinary approaches, especially in regard to interdisciplinary graduate education. The goal of this project was to better understand the challenges and barriers faced by interdisciplinary science graduate programs at the University of Delaware (UD) and provide recommendations for improving UD's administrative structure and support for interdisciplinary science graduate programs. The first step towards achieving this goal was to define what constitutes an interdisciplinary graduate program and create an inventory of existing interdisciplinary science graduate programs on campus, including their differences and similarities, as well as their strengths and challenges. This aided in the identification of opportunities and barriers presented by current policies and administrative infrastructure. The study revealed that faculty are eager to engage in interdisciplinary activities but faculty participating in interdisciplinary programs often face unnecessary impediments. This has created hurdles for interdisciplinary programs in many areas, such as program funding, curriculum development, and program administration. From this increased understanding of the specific challenges faced by interdisciplinary programs, eight recommendations were made to further promote and support interdisciplinary graduate

programs at UD. These recommendations focused on easing barriers and impediments, leveraging resources, and incorporating best practices into university policies and procedures.

Chapter 1

INTRODUCTION

1.1 Importance of Interdisciplinary Education

As humankind continues to grapple with complex scientific issues that affect the entire population, such as global warming, health care, and alternative energy, interdisciplinary approaches have become increasingly important. The innovations needed to solve the multifaceted problems facing the world today can only be achieved through interdisciplinary approaches (NSF, 2012). Such problems require individuals from different disciplinary perspectives to come together and share ideas, theories and practices to reach transformative solutions. Interdisciplinary approaches allow researchers to focus efforts on solving the problem without being confined by disciplinary boundaries. By working together, researchers from different disciplines combine knowledge from many different specialties and gain a deeper understanding of the problem (Brewer, 1999).

Both the National Academies of Sciences and the Association of American Universities have promoted the importance of interdisciplinary efforts. In 2005, both academic associations released reports touting the importance of interdisciplinary research and gave recommendations on how universities could facilitate successful interdisciplinary collaborations (Association of American Universities, 2005; National Academies, 2005). Additionally, the National Science Foundation's (NSF) strategic plan released in 2012 emphasized the need for interdisciplinary approaches in order to yield transformational results (NSF, 2012). Despite these efforts stressing the importance of

interdisciplinary work, academic institutions are still struggling to adequately support interdisciplinary research and education (Borrego et al., 2014). In fact, the 2014 Eighth Annual Global Summit on Graduate Education co-hosted by the Council of Graduate Schools and Memorial University of Newfoundland was focused on "Interdisciplinary Learning in Graduate Education and Research" (Council of Graduate Schools, 2014). The theme was chosen by an international steering committee who recognized the importance of interdisciplinary methods for solving complex societal issues and who understood that students must be trained to conduct research and collaborate beyond traditional academic disciplines. To promote interdisciplinary learning, summit participants shared their experiences in identifying and overcoming the organizational and administrative challenges facing interdisciplinary methods.

In addition to accelerating scientific discovery, interdisciplinary methods also benefit many academic stakeholders. Early-career researchers can benefit from interdisciplinarity because it can help broaden their understanding and expertise, as well as serve to strengthen their credentials (Bridle et al., 2013). Interdisciplinary activities also support the growth of research networks and facilitate non-traditional activities and partnerships. Additionally, it can increase the researcher's potential to secure funding, as more funding agencies are looking to fund interdisciplinary activities (Bridle et al., 2013). For students, interdisciplinary training prepares students to explore problems and solutions critically. Business and industry have reported their desire to hire graduates who have been trained across disciplines and who can meaningfully connect their work to that of others (Nyquist & Woodford, 2000). Gains are not limited to the researcher or student, as the academic institution also stands to benefit from interdisciplinary activities. Most notably is perhaps the expanded opportunity for recruitment and retention at both the faculty and student level.

1.2 Problem Statement

While interdisciplinary training has been increasingly considered an important component of graduate training, interdisciplinary graduate programs still face many challenges. The historical and often still standard University infrastructure creates disciplinary silos by keeping disciplines within a department. This arrangement poses significant challenges to the administration of interdisciplinary programs. Departments typically hold great power because of their control over faculty appointments, promotion, and tenure decisions. Furthermore, universities often use the collective achievements of their departments to measure success and prestige (Sá, 2008). This infrastructure creates challenges for interdisciplinary programs at every turn and leads to difficulties in managing their complexity. This structure also places a strain on students enrolled in interdisciplinary programs (Pfirman et al., 2011). Interdisciplinary programs often have unstable course offerings taught by faculty from across departments, a lack of facilities and community, and minimal support for student advisement and services.

Many of the challenges described above can be found at the University of Delaware (UD) and the quality of interdisciplinary graduate education at UD cannot improve until efforts are focused in understanding and reducing these barriers. The state of graduate and interdisciplinary education was a major discussion point when developing UD's Delaware Will Shine strategic plan in 2015 (University of Delaware, 2015). In their paper focusing on 'Graduate & Interdisciplinary Education', the Academic Organization Working group specifically noted the challenges associated with developing and implementing interdisciplinary graduate programs. Interviews conducted by the working group revealed a perception among the University community that current

University organizational infrastructure and policies obstruct creative and successful interdisciplinary programs. The University recently established a Graduate College and the bylaws address some of these concerns by including verbiage specifically related to the development and structure of interdisciplinary programs (University of Delaware, 2019c) (Appendix A).

While these efforts are a great start, it is clear we need to continue discussions and develop a more thorough understanding of the breadth of interdisciplinary programs on campus and the challenges they face. The Graduate College bylaws state "a cross-college interdisciplinary program is a course of graduate study composed of two or more departments across different colleges" (p. 8) (University of Delaware, 2019c).With no additional clarification in the documents, this basic definition could be interpreted in many ways and it's not clear what this means in practice. There was no consideration for the fact that there can be several interdisciplinary elements (e.g., teaching, curriculum, and/or research) in graduate programs with varying levels of integration. The definition minimizes the complexity of interdisciplinary programs on campus and has the potential to create misconceptions and inaccurate perceptions. Therefore, a more in-depth analysis is needed to build upon this momentum and put forth appropriate recommendations for the implementation and administration of interdisciplinary graduate programs at UD. During my tenure at UD, I was involved in interdisciplinary graduate education. This has given me a unique perspective on this topic and has allowed me to personally witness the encumbrances to interdisciplinary graduate education. Because of these experiences, I see a great opportunity to make a more meaningful impact and facilitate change by fully capturing the state of interdisciplinary science graduate programs at UD.

1.3 Project Design

The goal of this project is to better understand the challenges and barriers faced by interdisciplinary science graduate programs at UD and provide recommendations for improving UD's administrative structure and support for interdisciplinary science graduate programs (Table 1). Specifically, this was achieved through the following objectives:

Objective 1: Clearly define what constitutes an interdisciplinary science graduate program and identify known barriers and examples of best practices. There is an extensive amount of literature focused on defining interdisciplinary and related terms, and some consensus has even emerged in recent years (Klein, 2010; Borrego & Cutler, 2010; Borrego & Newswander, 2010). However, there is still much to be understood on what it means in theory or in practice. This objective focused first on defining interdisciplinary and related terms overall and then in the context of graduate education, specifically focusing on program elements and organization. This was achieved through an extensive review of literature targeting the importance of interdisciplinary activities within the higher education landscape. In addition, this review also encompassed gaining a better understanding of known administrative barriers, common challenges and examples of best practices. Additionally, the data collected here informed the foundation of an analytical framework for evaluating existing interdisciplinary graduate programs at UD.

Objective 2: Inventory UD's existing interdisciplinary science graduate programs. An inventory of existing interdisciplinary science graduate programs was created, and a document analysis was performed to achieve extensive program descriptions focusing on program elements and organization. This analysis cultivated a

deeper understanding of possible interdisciplinary components of graduate programs, which helped to further refine the definition developed in objective 1.

Objective 3: Explore and assess the current state of interdisciplinary science graduate programs at UD. To develop a comprehensive understanding of interdisciplinary graduate program administration and organization at UD, a subset of interdisciplinary graduate programs identified in objective two were further explored as case studies. Data was collected via interviews with various stakeholders, including graduate program directors, program faculty, and University administrators.

Objective 4: Provide recommendations for improving the administration and institutional support for interdisciplinary science graduate programs. To assess the operation and management of interdisciplinary programs at UD, programs at UD were measured against key features identified in the literature and this was used to guide recommendations for improving the state of interdisciplinary graduate programs at UD.

Table 1. Overview of Project Design

Project Objective	Data Source	Method of Analysis	Outcome
1. Define Interdisciplinary (ID), as well as identify common challenges and best practices for interdisciplinary campus activities.	Literature	Content analysis	Preliminary definition of Interdisciplinary graduate education. Clear list of known administrative barriers, common challenges and examples of best practices. Analytical framework.
2. Inventory Current Interdisciplinary Science Graduate programs at UD.	Publicly available documents (meeting minutes, agendas, material posted on-line for faculty/students). University, college, departmental, and program documents related to policies and administrative infrastructure.	Content analysis	List of programs that meet the definition of an interdisciplinary program as defined in Objective 1. Description of each program. Refined definition of interdisciplinary graduate education.
3. Explore and assess the current state of interdisciplinary science graduate programs at UD.	Interviews with graduate program directors, students and University administrators.	Grounded theory through case studies	Strengths and weaknesses of interdisciplinary programs at UD.
4. Provide recommendations for improving the administration and institutional support for interdisciplinary science graduate programs.	Results from Q3 and Q1. Electronic correspondence as follow-up to interviews.	Review the gap between best practices and the current structure at UD.	Recommendations for improving the administration and institutional support for Interdisciplinary Science Graduate programs at UD.

Chapter 2

INTERDISCIPLINARY AND HIGHER EDUCATION INSTITUTIONS

2.1 Defining Interdisciplinary and Associated Terms

Since the late nineteenth century, disciplines have dominated the organization and structure of Western academic institutions (Klein, 2010). Over the course of the last century, the increasing presence of cross-disciplinary activities has challenged this system. This proliferation of activities was the impetus behind the first major attempt at cross-disciplinary topologies published in 1972 by the Organization for Economic Cooperation and Development (OECD) (Apostel, 1972). Since that time, several topologies related to cross-disciplinary activities have been developed and this has created an array of confusing jargon (Klein, 2010). However, the most widely used terms for cross-disciplinary activities today are multidisciplinary, transdisciplinary and interdisciplinary. The key differences include (1) the degree of interaction individuals have outside of a single disciplinary community, (2) the degree of integration between the bodies of knowledge associated with the disciplines, and (3) the presence of a shared problem, topic or theme that drives collaboration (Figure 1) (Menken & Keestra, 2016; Putriene, 2015; Klaassen, 2018). Each of the three cross-disciplinary activities are defined and summarized in more detail below.

Multidisciplinary is less integrative than interdisciplinary and often is the result of weak or temporary contributions from multiple disciplines (Klein, 2010). Curricula and research projects may combine separate disciplinary approaches but there is no integration of efforts (National Academies, 2005; Holley, 2009; Holley 2017). Instead, it is characterized by disciplinary juxtaposition; thus, expanding the information, knowledge, and methods beyond one discipline but the disciplines remain separate and

retain their original identity. Many interdisciplinary programs are multidisciplinary assemblages of disciplinary courses, leaving curricular integration to the student (Klein 2010; Gantogtokh & Quinlan, 2017). While falling short of being fully interdisciplinary, multidisciplinary still plays a valuable role in helping to expand the scope of knowledge applied to a project or program (Klein, 2017).

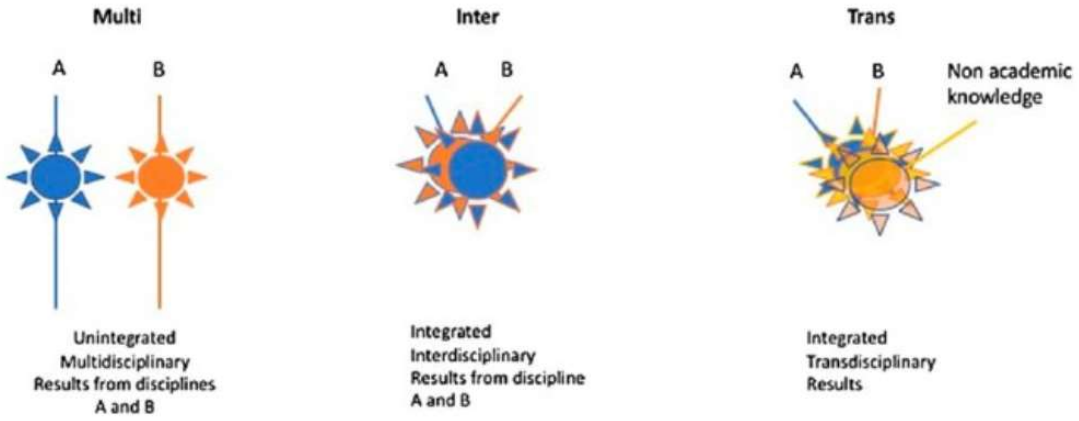


Figure 1. Levels of Disciplinary Integration (Menken & Keestra, 2016)

The definition of transdisciplinary has expanded over time. In the OECD typology, transdisciplinary was characterized by "a common system of axioms that transcends disciplinary worldviews through an overarching synthesis" (Klein, 2017). Similar to interdisciplinary efforts, transdisciplinary activities draw from different disciplines to address a common problem but instead of using existing frameworks from the disciplines, a new conceptual framework is developed (Rosenfield, 1992). In recent years, transdisciplinary has been refined even further to include a new mode of knowledge production that also includes non-academic stakeholders (Holley, 2017). It

combines both scientific and societal bodies of knowledge to identify sustainable solutions to complex societal problems (Lang et al., 2012). Transdisciplinary research is considered more an applied practice that evolves from current world problems. It is not attached to any established methods and designs but instead these will evolve through the collaboration of the various stakeholders.

Interdisciplinary is the most frequently used term in the higher education landscape and its meaning can vary across institutions. This diversity can make it difficult to formulate a definition that applies universally to interdisciplinary campus activities. However, a common theme is the level of increased integration and interaction between disciplines. The most widely cited definition is that proposed by noted interdisciplinarian Julie Thompson Klein (1990): "Interdisciplinarity is a means of solving problems and answering questions that cannot be satisfactorily addressed using single methods or approaches" (p. 196). It refers to the integration of knowledge from multiple disciplines to pursue an outcome that can't be achieved through a single disciplinary approach. Simply stated, interdisciplinary practices in higher education generally refer to the integration of two more disciplines or fields of study in relation to instruction, research and/or degree offerings (Jacob, 2015). For example, interdisciplinary curricula draw from various disciplines to create an integrative framework that helps achieve interdisciplinary understanding or outcomes (Holley, 2017).

There has been increasing importance placed on interdisciplinary training as a valuable component for graduate education and this has led to growth in the number of available interdisciplinary graduate programs (Borrego & Cutler, 2010). Despite the proliferation of interdisciplinary graduate programs, there is no universal definition or description. This is due to the overall complexity of the term, as well as the personalized variations that can occur within organizations. This lack of clarity can create confusion,

which can lead to conflict in the academic strata and further complicate the emergence of interdisciplinary programs (Klein, 2010). The goal is often to enhance the students' ability for cross-disciplinary thinking and to develop interdisciplinary research skills (Larson et al., 2011). However, many universities are implementing interdisciplinary graduate education without clear standards and guidelines for interdisciplinary activities. Therefore, it is important for any institution seeking to better support interdisciplinary activities to develop a comprehensive meaning for their campus (Klein, 2010).

Until recently, the University of Delaware had no publicly documented definition for interdisciplinary graduate programs. In Spring 2018, the University of Delaware Faculty Senate approved the creation of a Graduate College contingent upon the Senate approving draft bylaws. In February 2019, the faculty senate approved a draft version of the bylaws and the Graduate College was launched in July 2019. The bylaws state "a cross-college interdisciplinary program is a course of graduate study composed of two or more departments across different colleges" (p. 8) (University of Delaware, 2019c). This definition is overly simplistic and can still lend to confusion. Later in this study (Chapter 3), this definition will be refined after creating an inventory of existing interdisciplinary graduate programs at UD.

2.2 Common Challenges and Best Practices

There was a growth of interdisciplinary activities across the last decade of the twentieth century (Rosenfield, 1992), and this trend has continued into the twenty-first century (Holley, 2009; Klein, 2010; Crow & Dabars, 2017). Despite the widespread agreement in the power and importance of interdisciplinarity, many institutions still struggle with its actual practice and university administrators continue to grapple with incorporating these activities into the traditional institutional landscape. In order to create

successful and sustainable interdisciplinary activities, universities need to thoroughly examine their existing organizational culture and structure (Borrego et al., 2014). While interdisciplinary efforts are often associated with cutting-edge work, the university structure poses barriers at every turn (Martin & Pfirman, 2017). Many of the documented challenges relate directly to the disciplinary organizational structure. Even if the institution places high value on interdisciplinary practices, there is often tension between interdisciplinary efforts and traditional discipline efforts (Rhoten & Caruso, 2001; Holley, 2009; Borrego et al., 2014). Many administrative components of the contemporary university are aligned with the organizational structure of departments and colleges. The range of this influence is varied and extensive. Hiring, tenure and promotion, budgets, and physical space are just a few examples of items that are typically controlled by the organizational hierarchy of departments.

While they present challenges to interdisciplinary activities, academic departments are indeed important structures in higher education institutions and there are great benefits to such academic specialization (Tarrant & Thiele, 2017). There are currently over 30,000 peer-reviewed journals and this number continues to grow. The vast range of contemporary scholarship creates a need for dividing the intellectual terrain, even if the lines are often blurred and arbitrary (Jacobs, 2017). In addition to providing knowledge boundaries, disciplines are often the primary source of identify for faculty and students, and they help to shape communities of scholars. They are a form of social organization where members of the same field create a network of scholars who often share disciplinary language and norms (Holley, 2009).

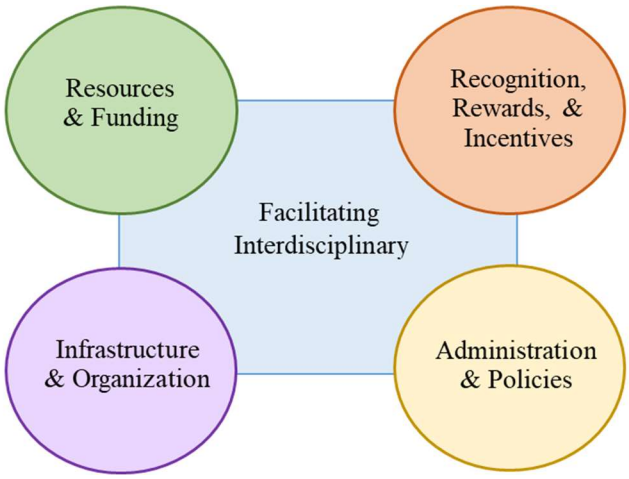
Disciplines should not be viewed in stark contrast to interdisciplinary. Institutions do not have to choose between them but must adapt to allow both to flourish. In addition to the growth of interdisciplinary, there has been explosive growth in the number of

knowledge fields and degree programs within the traditional disciplinary landscape. At the beginning of the twenty-first century, it was estimated that over nine thousand knowledge fields existed (Stehr & Weingart, 2000). Institutions are faced with the challenge of accommodating knowledge fields through traditional academic units and degree programs. Defining disciplines in strict and universally accepted boundaries is an impossible task (Holley, 2009). Universities offer an outstanding array of academic specializations and it is likely that few could offer an accurate estimate on the number of disciplines within their home institution (Tarrant & Thiele, 2017). The distinction between an academic discipline and an interdisciplinary field of study is increasingly becoming more challenging within the complexity of the modern university (Holley, 2009). Both systems could benefit from cultural shifts in the university structure and organization that would better support integrating this growing knowledge across the institution. This does not require the demise of disciplines but instead requires a reduction in the insular nature of disciplines (Tarrant & Thiele, 2017).

Fortunately, there has been a proliferation of literature focusing on the common administrative barriers and challenges faced by interdisciplinary activities, and strategies to overcome them (Klein 2010; Boden & Borrego, 2011; Holley, 2017). While the focus of this work is interdisciplinary science graduate programs, it is important to consider many aspects important to cultivating interdisciplinary activities in higher education institutions. For interdisciplinary graduate programs to thrive, there must be a supportive campus culture for a broad-range of interdisciplinarity. Therefore, a comprehensive literature review was performed to identify key target areas for fostering interdisciplinarity within the modern university. Through this analysis, four general themes emerged as important focus areas for enhancing and promoting interdisciplinarity: 1) resources and funding; 2) recognition, rewards and incentives; 3) infrastructure and

organization; and 4) administration and policies (Figure 2). These themes were heavily influenced by the work of Julie Thompson Klein (1999) but they were also inspired by the work of several articles in this area (Boden & Borrego, 2011; Borrego et al., 2014; Bridle et al., 2013; Dubrow & Harris, 2016; Jacobs, 2017; Holley, 2017). It is important to note that the thematic areas do not act in isolation and efforts can fall into more than area. The sections below will provide a more in-depth review of the common barriers and best practices within each theme.

Figure 2. Four Thematic Areas for Fostering Interdisciplinary Education



2.2.1 Resources & Funding

Finance and budgetary issues are at the center of many concerns related to interdisciplinary programs. With the current climate of reduced public investment in higher education, resource constraints can be felt across most organizations. Beyond this ubiquitous financial challenge, interdisciplinary programs face additional disadvantages caused by the conventional organization and fiscal structure of higher education

institutions. Most universities have adopted decentralization budget models and allocate funds based on the academic department. This means many interdisciplinary programs are not part of the formula-based funding models, and do not receive funding from central administration. Additionally, most institutions lack specific policies or procedures for funding interdisciplinary activities and without a single dean advocating for the program, the needs of the program can be overlooked (Welch-Devine et al., 2018). Leadership of interdisciplinary programs often spend valuable time securing resources and are forced to cobble funding together from multiple sources (Klein, 2010). One study noted that "it becomes difficult to imagine how institutions of higher education with goals of attracting large interdisciplinary research funding can do so with a decentralized budget strategy which emphasizes academic departments over the institution at large" (Boden & Borrego, 2011, p. 56). Therefore, institutions should strive to develop an allocation system for interdisciplinary programs that spans across traditional disciplinary boundaries (Holley, 2009).

There are various examples documented in the literature of how institutions successfully navigated budgeting challenges faced by interdisciplinary programs. Programs can negotiate to receive indirect cost returns from grants that are catalyzed by activities in the program (Holley, 2009). Faculty members can seek training grants to help support the development of new programs and/or start revenue generating master's or certificate programs (Welch-Devine et al., 2018). Strategic partnerships can be developed with industry or corporations to support student stipends or to engage in fundraising efforts. In cooperation with the development office, strategies can be implemented for fundraising and perhaps even build an interdisciplinary endowment (Klein, 2010). Institutions can provide funding through internal programs. For example, the Virginia Tech Graduate School developed a program that not only supports the

launch of new interdisciplinary programs but also provides them sustained, long-term funding. To apply for these funds, faculty members must come from at least two colleges and three departments. Successful applicants receive $100,000 per year for operating expenses and student funding, and they maintain this funding as long as they perform well (Welch-Devine et al., 2018). It is important to note that budget reform is highly personalized to the institution and it must take the individual characteristics of the institution into account (Klein, 2010).

In addition to direct financial hurdles, many interdisciplinary programs do not have their own faculty lines, and this creates challenges in maintaining the expertise required for teaching courses and mentoring students. If the interdisciplinary program is required to rely on the department to recruit and hire their faculty members, gaps may occur as it is left to compete with the needs of the department. Departments will often prioritize their own teaching obligations before allowing faculty to teach interdisciplinary courses and fulfilling interdisciplinary teaching requirements can be problematic. Faculty may only receive credit for departmental courses, leaving interdisciplinary courses to be done as overload (Welch-Devine et al., 2018; Boden & Borrego, 2011). This system can create tension between departments and interdisciplinary programs. To help reduce this conflict, policies should be developed that encourage departments to allow faculty to teach in interdisciplinary programs (Casey, 2010). Additionally, interdisciplinary programs should have their dedicated tenure-track faculty lines and stable appointments when at all possible (Klein, 2010).

Table 2. Barriers and Best Practices Related to Resources and Funding

RESOURCES AND FUNDING

Barrier	Best Practices
Inadequate funding and ongoing support for ID units/programs	Baseline funding for interdisciplinary studies and research; Alignment of interdisciplinary with capital campaigns at both campus and unit levels
Discipline- and department-based silos of budgetary and administrative categories	Program level control of budget and infrastructure
Inadequate number of faculty lines to support interdisciplinary studies and research	Dedicated tenure-track faculty lines and stable appointments in programs and centers
Restricted access to internal incentives and seed funds for ID research and curriculum development	Cross-department budgeting mechanisms
Competition for funds and faculty between departments and ID units	Flexible resources at the department level; Equitable credit allocations for team teaching, indirect cost recovery on external grants
Inadequate or no ID student assistantships or fellowships	Seed funding through internal special initiatives and regular programs; Systematic identification of external sources

2.2.2 Recognition, Rewards, & Incentives

Institutions must carefully consider the entire career life cycle of an interdisciplinary scholar and develop the appropriate processes and structures to support their efforts. This requires attention to hiring, tenure and promotion, and faculty development, especially since departments typically control these functions (Holley, 2009; Boden & Borrego, 2011; Klein, 2010). Without the appropriate supports in place, interdisciplinary faculty can be left to feel marginalized and invisible while they are forced to negotiate their own paths forward within existing institutional policies.

University leadership should gain a thorough understanding of the dynamics faced by those functioning as an interdisciplinary scholar within the traditional discipline-based institution and learn more about best practices in order to develop better support mechanisms.

To minimize the role and impact of individual departments in interdisciplinary hiring, many institutions have relied on cluster hiring to achieve desired interdisciplinary faculty hiring goals. This strategy involves creating multiple faculty positions around a designated theme and not necessarily individual units. In the mid-1990s, the University of Wisconsin-Madison pioneered the practice through the Cluster Hiring Initiative (CHI) (Sá, 2008; Holley, 2017). Through the course of five phases, 140 faculty lines were created in over forty-nine thematic areas. The University raised nearly $15 million in state and matching private funds which allowed salaries to be centrally funded. While not all cluster areas were effective, the initiative was considered a success as it helped to create cultural change on how interdisciplinary activities are perceived and administered on campus. Since then, many institutions have implemented cluster hiring initiatives as a mechanism for growing and fostering interdisciplinary research.

The National Academies report on interdisciplinary research identified increasing the number of joint appointments as a mechanism for universities to support interdisciplinary activities on campus. Joint appointments were defined as being between two or more departments, or between a department and an interdisciplinary center or institute (National Academies, 2005). While joint appointments are an effective strategy, care must be taken to ensure that faculty do not end up serving two masters and satisfying neither (National Academies, 2005). Joint appointments can create tension between the participating units. This can leave interdisciplinary faculty to struggle with how to simultaneously fulfill disciplinary responsibilities and the role of interdisciplinary

scholar. Faculty may only receive credit for research, service and teaching activity that falls within their primary department (Borrego & Newswander, 2010; Pfirman & Martin, 2011). With little to no recognition or reward for activities outside of their primary department, faculty often feel participation in interdisciplinary activities must be done in their "extra" time (Boden & Borrego, 2011). This can lead to the marginality of interdisciplinary activities and create a negative bias against interdisciplinary work.

To circumvent these challenges, expectations and arrangements for interdisciplinary faculty with joint appointments must be clearly outlined to avoid misunderstandings. A memorandum of understanding (MOU) should be drafted that clearly outlines expectations related to scholarship, teaching, mentoring, service, budget, space, and departmental and community participation (Klein, 2010). This should be developed before hiring and shared with potential candidates with the expectation that they can be modified slightly during negotiations for the new hire. It is recommended the hiring committee replicate the committee structure for pre-tenure and tenure review as much as possible (Klein, 2010). To minimize the burden on faculty, joint appointments need to reduce the departmental commitments, and this can create resentment between participating units. If a reduction occurs, institutions should consider how to adequately incentivize the units to participate. It could be as simple as enhancing the intellectual mission by extending the teaching and research offered by the unit (Association of American Universities, 2005).

Another important factor to consider with joint appointments is the tenure process. Interdisciplinary faculty seeking tenure can face additional challenges compared to their departmentally focused peers. Most joint appointments are between two or more departments or between a department and an interdisciplinary center or institute. It is rare that faculty members hold tenure within an interdisciplinary center (or unit). This can

lead to joint appointments either being held to the tenure standards of both departments or being evaluated primarily on departmental activities and contributions (Holley, 2017; Martin & Pfirman, 2017). Efforts must be made to ensure that the work of the interdisciplinary faculty member is valued and recognized within their primary department(s). For example, the tenure evaluation committee may not be adequately able to review the overall quality of work, as it falls outside their expertise. They may struggle with assigning the appropriate value to publications and with recognizing interdisciplinary journals.

The key actions to support interdisciplinary tenure and promotion include rewriting guidelines, establishing committee structures, defining appropriate criteria, and support for dossier preparation (Klein, 2010; Martin & Pfirman, 2017). Many universities have already modified their tenure policies to accommodate interdisciplinary faculty. For instance, some institutions allow for interdisciplinary tenure committees. Dean and department chairs are tasked with ensuring interdisciplinary areas are represented on the committee, and the committee may be co-chaired by someone from the home department and by an interdisciplinary representative. These procedures are then outlined in the faculty handbook (National Academy of Sciences, 2005). It also may be appropriate to extend the tenure clock for interdisciplinary faculty recognizing that additional time might be needed to establish performance across multiple dimensions (Welch-Devine et al., 2018).

Table 3. Barriers and Best Practices Related to Recognition, Rewards, and Incentives

RECOGNITION, REWARDS, AND INCENTIVES

Barriers	Best Practices
Lack of guidelines for interdisciplinary hiring, tenure and promotion, and salary	Policies for hiring, tenure and promotion, and salary
Reliance on volunteerism and overload	Counting service for committee work, mentoring and thesis and dissertation advising
Weak networking channels and communications forums	Annual forum of directors of programs, centers and institutes; unit level advisory boards of internal and external stakeholders
Ineligibility of interdisciplinary work for awards, honors, incentives, and faculty development programs	Awards and honors in existing system and new interdisciplinary specific competitions

2.2.3 Infrastructure and Organization

Disciplinary hierarchy also impacts the overall infrastructure and organization of the campus. Disciplinary groupings tend to define physical space on campus, with buildings dedicated to specific areas (Holley, 2017). This creates a physical footprint on campus defined by study areas. Scholars from engineering, business, and education are neatly divided in space and campus culture. This often leave interdisciplinary activities with no physical home or presence on campus. Ideally, interdisciplinary programs should have a shared space and this coordination will require high-level institutional authority that is outside of the typical departmental unit. This can occur through construction of new space or renovation of existing buildings. Providing dedicated space to interdisciplinary activities serves as a powerful symbol of the institutional commitment to such work (Klein, 2010; Holley, 2017).

In addition to physical space, organizational space within the institutional structure must also be considered and developed. Numerous models and approaches for

where to house interdisciplinary programs have been implemented within the landscape of interdisciplinary efforts. Interdisciplinary programs can be freestanding units reporting directly to central administration or located within an academic college. Many universities have relied on the creation of interdisciplinary centers and institutes to help circumvent the challenges associated with interdisciplinary research. This has led to a sharp growth in the number of centers across the United States (Association of American Universities, 2005; Sá, 2008; Boden & Borrego, 2011). While institutions and centers are effective on some levels, they are not sufficient in bringing about the organizational change needed to facilitate interdisciplinary activities in universities.

No matter the model chosen, it is important to ensure interdisciplinary programs do not exist in the interstitial spaces of the university hierarchy where traditional reporting and resourcing lines do not apply (Boden & Borrego, 2011). Without this, even simple issues such as how interdisciplinary program directors receive information that flows to deans to department heads or chairs can easily be overlooked (Welch-Devine et al., 2018). Addressing these challenges is often best done through central oversight. While interdisciplinary efforts are best driven from faculty interests, central oversight is crucial for successful systemic implementation. Initiatives thrive at the intersection of faculty buy-in and senior administrative backing (Klein, 2010). The presence of a central coordinating unit helps to build an institutional structure that can sustain interdisciplinary activities beyond programmatic leadership. It provides coordinated management and a stable anchor when there are changes in leadership, personnel or budget models. It gives interdisciplinary programs an advocate and a "seat at the table" in important administrative discussions. A central unit can also provide structure to coordinate and connect all interdisciplinary activities, including program, centers, and institutes (Casey,

2010). The most common locations for central offices are divisions of the provost, vice president for research or education, or a graduate school (Klein, 2010).

The central office should also play an essential role in helping to increase the visibility and legitimacy of interdisciplinary programs within the public face of campus. One recommended method for increasing visibility of interdisciplinary activities is through a central website (Klein, 2010). It can serve as a resource bank for all campus stakeholders and should include links to regularly updated news, calendar of events, interdisciplinary centers and institutes, and interdisciplinary programs. Both Duke University and Perdue University have long-standing exemplary interdisciplinary websites that were created in conjunction with an oversight body. A central office can also help with increasing the number of interdisciplinary experiences available to faculty and students, such as lectures, speaker series, and symposia (Welch-Devine et al., 2018). Not only do these activities increase the visibility of interdisciplinary activities on campus, they foster interdisciplinary scholarship by encouraging networking and collaboration.

Table 4. Barriers and Best Practices Related to Infrastructure and Organization

INFRASTRUCTURE AND ORGANIZATION

Barrier	Best Practices
Inadequate space and equipment and inflexible allotments of use	Dedicated space for interdisciplinary studies and research; Pooling and sharing of space, facilities, and equipment
Rigid organizational structure	Alternative administrative structures
Territoriality and turf battles over budget, ownership of curriculum and research	Central oversight body for interdisciplinary research and education
Invisibility and marginality of interdisciplinary research, teaching, service, advising and mentoring	Visibility on central website; Visibility in the public face of campus (for example, materials, advising, and recruiting systems); inclusion of interdisciplinarity in all annual reports; interdisciplinary unit level publications
Weak or no faculty development system	Faculty development programming (including graduate students and post-doctoral fellows)
Ignorance of ID literature and resources in national networks	Resource banking of interdisciplinary resources and literature

2.2.4 Administration & Policies

Universities have a variety of necessary policies and procedures related to academic systems and faculty governance. Most of these are sufficient for supporting traditional disciplinary activities effectively but unfortunately, many of these policies create barriers to fostering interdisciplinary research, education and training (National Academies, 2005). Significant changes in organizational policies and practices are needed to improve the climate for interdisciplinary activities within higher education

institution (Dubrow et al., 2009; Lindvig et al., 2017). While most institutions value interdisciplinary work and would like to support these activities, university leadership continue to struggle with implementing the transformative reform needed. Often, administrative policies to support interdisciplinarity are developed haphazardly as issues and challenges arise.

To create the systemic changes needed, there must be advocacy and endorsement of interdisciplinary campus activities by university leadership at all levels – president, provost, deans and head of graduate school. There is no lack of desire or motivation from faculty and students to participate in interdisciplinary work. Faculty are attracted to the innovative qualities of interdisciplinary teaching and research and gain substantial value from working with interdisciplinary students (Dubrow & Harris, 2006). Unfortunately, faculty are often left with the burden of navigating the barriers and hurdles related to participating in interdisciplinary activities.

Outdated institutional practices and policies do not recognize and account for different types of programs that might exist within the institution. To ease the burden on interdisciplinary programs, university leadership can work to develop common sense solutions to rigid practices (Welch-Devine et al., 2018). It is difficult to outline specific best practices here since university policies and procedures vary greatly between institutions. Instead it is recommended that institutions complete a comprehensive evaluation of university policies and procedures to identify practices that might hinder the success of interdisciplinary activities. Special attention should be paid to policies related to course and program approval, research management, and program evaluation (Dubrow & Harris, 2006; Klein, 2010).

Navigating and proposing solutions to these administrative challenges is another area where a central office focused on interdisciplinary activities can provide value.

Central leadership provides the necessary advocacy and can give greater voice to interdisciplinary activities overall (Sá, 2008; Klein, 2010). To help with discussions related to the administration of interdisciplinary activities, the central office should create an inventory of the various interdisciplinary programs and their associated structures. These examples should be made available to the campus community with an evaluation and discussion on the benefits and disadvantages of each method. Additionally, a central office should ensure that any new interdisciplinary program targets align with the strategic themes and initiatives of the institution.

In addition to the importance of leadership and guidance at the central level, the direct leadership of interdisciplinary efforts is critical to success. An entrepreneurial leader with a diverse array of attributes is needed and many are beyond the normal faculty role. A clear understanding of the required qualities is needed to ensure the right leaders are selected. In addition to strong intellectual capabilities, leadership will also need robust management and negotiation skills to navigate their unique institutional status. It can sometimes be challenging to find all the necessary qualities in one person (Association of American Universities, 2005; Casey, 2010). There are instances when one leader may have all the attributes needed to successfully launch and sustain an interdisciplinary venture but then succession can be problematic. It may be helpful to divide responsibilities among people, such as a director and associate director, so all aspects of leadership and administration are met (Association of American Universities, 2005). Due to the challenges in finding appropriate leaders, it is critical to plan and manage leadership transitions effectively, especially when considering many interdisciplinary programs rely on voluntary commitments of faculty effort (Dubrow & Harris, 2006).

Table 5. Barriers and Best Practices Related to Administration and Policies

ADMINISTRATION AND POLICIES

Barrier	**Best Practices**
Lack of support at department, college, or university levels	Top administrative support at the level of president, provost, and deans
Inflexible guidelines that inhibit approval of new programs and courses	Procedures to support the development of interdisciplinary courses and programs
Inadequate guidelines for grants management and research collaboration	Procedures for research management, such as sharing indirect cost recovery from external grants
Unfavorable (or lack thereof) policies for research and teaching evaluation, program review, learning assessment	Policies for research and teaching evaluation, program review, and learning assessment
Lack of experienced leaders	Strong and experienced leaders
Ambiguous status of interdisciplinary programs, centers and institutes	Inventory or activities, structures, and interests
No clear and authoritative report lines for interdisciplinary units	Report lines with designated responsibilities
Interdisciplinary activities do not align with institutional strategic themes	Alignment of interdisciplinarity with strategic plan themes

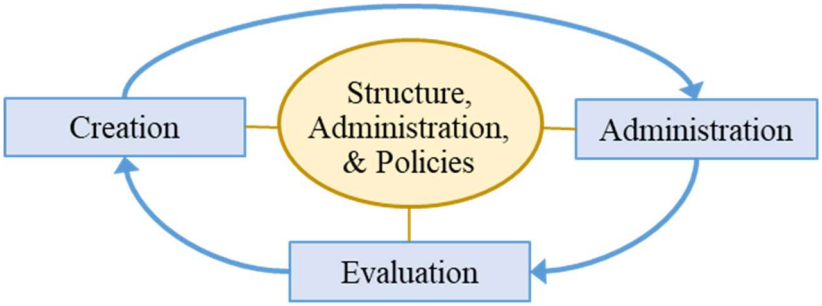
2.3 Analytical Framework

The review of best practices was used to develop an analytical framework to further inform the research design and data analysis for the next portion of this study. The barriers and best practices outlined above can impact interdisciplinary graduate programs at various phases, specifically program creation, administration, and evaluation. For example, resource and funding constraints are evident when establishing a program, as well as when managing a program. To better facilitate interdisciplinary graduate programs and increase the chances of success, it is important to identity possible funding

mechanisms for the launch of new programs, as well as sustained, long-term funding (Klein, 2010). Additionally, clear policies and procedures should exist for the creation, administration, and evaluation of interdisciplinary graduate programs (Welch-Devine et al., 2018). Best practices should be provided for how to design and configure the program, how to manage the program once it's established, and how to evaluate the program.

Therefore, I wanted to better understand how the thematic areas outlined in the previous chapter impact interdisciplinary graduate programs at UD during program creation, administration, and evaluation. To limit the scope of the project, it was determined the emphasis of this project would focus on two thematic areas: infrastructure and organization (Table 4), and administration and policies (Table 5). These two areas were selected because of my interest and experiences in these specific areas. When I was working at UD and involved with interdisciplinary graduate programs, I personally witnessed many of the barriers and challenges within these themes. The goal was to understand how UD compares against best practices within these thematic areas and how these areas impact the creation, administration and evaluation of science-related graduate programs at UD (Figure 3). Science-related degrees were defined as those covering science, technology, and engineering. Creation pertains to the establishment and implementation of the program. Administration refers to the management of the program once it has been launched. Evaluation relates to how the program will be reviewed and assessed in order to ensure program success.

Figure 3. Analytical framework



Note: Analytical framework for how the university structures, administration, and policies (orange) influence the various stages within the life cycle (blue boxes) of interdisciplinary science graduate programs.

Chapter 3

INTERDISCIPLINARY SCIENCE GRADUATE PROGRAMS AT UD

3.1 Assessing Interdisciplinary Science Graduate Programs

While much emphasis has been placed on defining interdisciplinary in terms of research, this has yet to translate to clear expectations and guidelines for the context of interdisciplinary graduate programs. Despite the increased emphasis on interdisciplinary training, there is no universal definition or description of what it means to be an interdisciplinary graduate program. This is due to the overall complexity of the term, as well as the personalized variations that can occur within organizations. Interdisciplinary practices in higher education generally refer to the integration of two or more disciplines or fields of study in relation to instruction, research and/or degree offerings (Jacob, 2015). However, this definition is too generic and does not consider the complexity and variation of integration among interdisciplinary graduate programs. It does not distinguish between the various types of interdisciplinary programs that may exist within an organization and it provides no clarification on how this pertains to working across an organization.

This complexity and variation can make it difficult to identify all interdisciplinary program offerings of a campus. Most members of campus will not be able to identify all programs and even a search of campus websites may not result in a comprehensive list. Therefore, it is imperative to perform a thorough inventory of campus interdisciplinary activities to fully understand the interdisciplinary environment (Klein, 2010). The inventory should capture the full extent of interdisciplinary activities on campus. Some activities are well-known and highly visible, but others exist in the shadow structures of the organization making them more difficult to capture. Interdisciplinary experiences are

widely varied ranging from single courses and seminars to professional master's and doctoral degrees; a thorough inventory will capture all these activities (Council of Graduate Schools, 2014). The inventory should also include a document gathering phase (Klein, 2010). All pertinent documents should be collected, including program proposals and policy documents, and deposited into a public repository. Surveys and/or interviews should be conducted and tailored to faculty, students, and staff. This will add to the awareness of interdisciplinary activities on campus and help minimize the reliance on individual's memories. Ideally, this inventory would be completed by a high-level administrative office that is charged with oversight of interdisciplinary activities.

Currently, this type of extensive inventory and assessment has not been completed at the University of Delaware. Therefore, a primary goal of this study was to achieve a smaller scale inventory congruent with recommendations from the literature, followed by an assessment against best practices for facilitating interdisciplinary graduate programs (Council of Graduate Schools, 2014; Klein, 2010). The project focused on understanding how UD compares against best practices within the thematic areas outlined in the previous chapter and how these areas impact the creation, administration and evaluation of science-related graduate programs at UD. While it was ideal to evaluate all UD interdisciplinary graduate programs against all thematic areas, this was not a feasible scope for this project due to limitations in time and number of researchers. Therefore, this project focused on how science-related interdisciplinary graduate programs were performing in the thematic areas of infrastructure and organization (Table 4), and administration and policies (Table 5). Specifically, this chapter focuses on the following objectives:

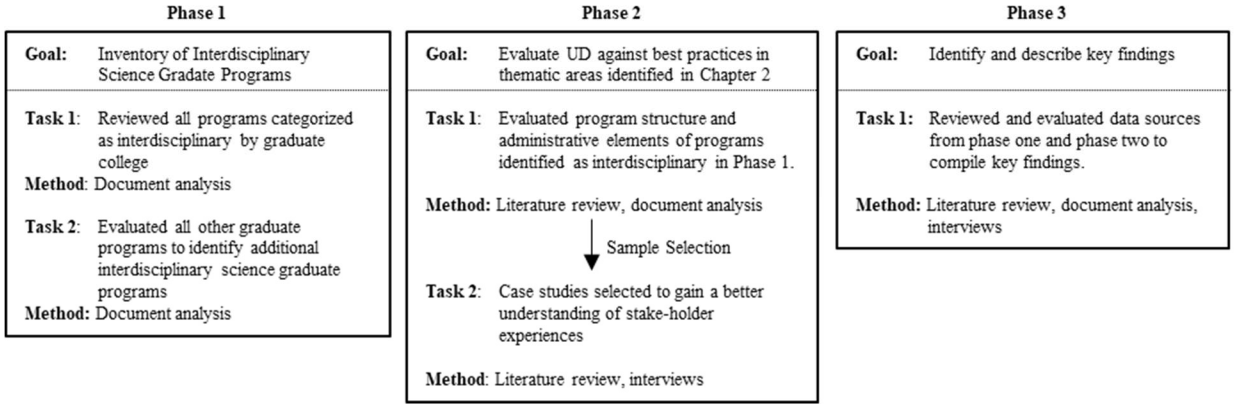
Objective 2: Inventory UD's existing interdisciplinary science graduate programs.

Objective 3: Explore and assess how existing administrative structures and policies impact interdisciplinary science graduate programs at UD.

3.2 Methods

To achieve these objectives, a qualitative study was conducted in three sequential phases (Figure 4). The first phase consisted of a thorough inventory of potential interdisciplinary science graduate programs by compiling program documents for all graduate programs. Programs were evaluated for their interdisciplinarity and whether the program was science related. The second phase of the study focused on evaluating UD against best practices related to thematic areas identified from the literature (Chapter 2). The specific thematic areas under review were infrastructure and organization (Table 4), and administration and policies (Table 5). This was achieved through a comprehensive document analysis, followed by case studies. In the final phase, data from the literature review, document analysis, and interviews were examined to reveal key findings related to how UD was performing against best practices presented in the literature for facilitating interdisciplinary graduate education. A more thorough explanation of the study phases is provided in the sections below.

Figure 4. Study Phases



3.2.1 Inventory of Interdisciplinary Science Graduate Programs

The main goal of the first study phase was to create a comprehensive inventory of science-related interdisciplinary graduate programs. The first step in this process was to identify which graduate programs could be categorized as interdisciplinary. This process began with reviewing the thirteen programs listed as interdisciplinary on the Graduate College website and performing a document analysis on each one. A document analysis is a systematic procedure for examining and analyzing publicly available documents to yield data related to the research question(s) (Bowen, 2009). The goal of this document analysis was to verify the interdisciplinarity of each program and documents reviewed included the graduate catalog pages and program webpages. Programs were included if they self-identified in any program documents as being interdisciplinary, if the source of the program curriculum extended beyond more than one college, and/or the program research advisors were housed in more than one college. After a thorough review, it was concluded that all thirteen programs were indeed interdisciplinary. The next step was to determine which programs were science related. For this research study, science-related programs were defined simplistically as programs whose core focus and curriculum encompassed science, technology, and/or engineering. Therefore, a second document analysis was performed, and program graduate catalog pages and webpages were reviewed to evaluate the curriculum of each program. Through this analysis, it was determined that eleven of these programs were science-related (Table 6).

To ensure other science interdisciplinary graduate programs were not missing from this list, all programs in the 2019-2020 Graduate Catalog were reviewed (University of Delaware, 2019a). The catalog pages for every graduate program were examined to determine if the program included science, technology, and/or engineering elements. Once a program was categorized as science-related, a deeper document analysis was

performed to determine if the program was interdisciplinary. Specifically, catalog listings and program webpages were collected and reviewed for interdisciplinary components, such as course offerings, program advisors and any information related to how the program is administered. Again, programs were included if they self-identified in any program documents as being interdisciplinary, if the source of the program curriculum extended beyond more than one college, and/or the program research advisors were housed in more than one college. Through this document review, five additional programs were identified as being potential interdisciplinary science graduate programs, bringing the total to sixteen program areas (Table 6).

Table 6. Interdisciplinary Graduate Programs

	ID PROGRAMS LISTED BY GRAD COLLEGE*	**SCIENCE-RELATED?**
1	Bioinformatics & Computational Biology MS, PSM	Yes
2	Bioinformatics Data Science PhD	Yes
3	Biomechanics & Movement Science PhD, MS	Yes
4	Biomedical Engineering PhD	Yes
5	Data Science MS	Yes
	Economic Education PhD	
	Financial Service Analytics PhD	
6	Leadership in Disability Services MA, CERT	Yes
7	Microbiology PhD, MS	Yes
8	MPH Epidemiology	Yes
9	MPH Health Policy and Management	Yes
10	Ocean Engineering PhD, MS	Yes
11	Water Science & Policy PhD, MS	Yes
	ADDITIONAL SCIENCE ID PROGRAMS	
12	Disaster Science & Management PhD, MS	Yes
13	Communication Sciences & Disorders PhD, MS	Yes
14	Robotics, MS	Yes
15	Energy & Environmental Policy PhD, MS	Yes
16	Engineering & Public Policy PhD	Yes

* As of 12/18/2019

3.2.2 Evaluation Against Best Practices

After establishing a complete list of all the science interdisciplinary graduate programs, efforts were then focused on understanding and evaluating how UD compares against best practices within the thematic areas of infrastructure and organization (Table 4), and administration and policies (Table 5). This was done through document analysis and case studies. This combination of qualitative research methods was chosen in order to ensure triangulation, meaning wherever possible findings were corroborated across methods to help reduce potential biases that can arise in single source data sets and from single source researcher studies (Bowen, 2009). Additionally, triangulation refers to studying a problem using different methods to gain a more comprehensive understanding (O'Cathian, 2010). Triangulation help strengthen reliability by verifying findings through multiple sources. Insights from the document analysis, as well as the literature review, helped to inform the design and selection of case studies. Likewise, the results of the case studies were used to inform the document analysis. For example, if a particular document was referenced during an interview, this document was collected and reviewed to corroborate or contradict statements made during the interviews. This type of cross referencing adds to the rigor of the study and helps to substantiate findings (Mathison, 1988).

To perform the document analysis as part of the second phase of this study, a more comprehensive collection of documents was gathered. These documents were explicitly collected and reviewed for information that would increase the understanding of items related to the thematic areas of infrastructure and organization (Table 4), and administration and policies (Table 5). This document analysis also helped to further refine the scope of this project. Due to the limitations of the data collected, not all items within the two thematic areas were addressed. Topics were selected based on the

documentation that was publicly available and the feasibility of collecting enough data to make informed conclusions. (Table 7).

Table 7. Summary of Documents Reviewed

THEME: ADMINISTRATION AND POLICIES	
Best Practices	**Documents Collected**
Top administrative support at the level of president, provost, and deans	N/A
Procedures to support the development of interdisciplinary courses and programs	Program policy templates, procedures for submitting new proposals, program approval checklist, Graduate College bylaws
Procedures for research management, such as sharing indirect cost recovery from external grants	N/A
Policies for research and teaching evaluation, program review, and learning assessment	Permanent status review policies, academic program review (APR) policies, faculty handbook
Strong and experienced leaders	Graduate College bylaws, Program proposals, program policy documents, program change documents, program webpages
Inventory or activities, structures, and interests	Program proposals, program policy documents, program change documents, program webpages
Report lines with designated responsibilities	N/A
Alignment of interdisciplinarity with strategic plan themes	Program proposals, program policy documents, program change documents, university strategic plan
THEME: INFRASTRUCTURE AND ORGANIZATION	
Best Practices	**Documents Collected**
Dedicated space for interdisciplinary studies and research; Pooling and sharing of space, facilities, and equipment	N/A
Alternative administrative structures	Graduate catalog listing, program proposals, program policy documents, program change documents, program webpages
Central oversight body for interdisciplinary research and education	Graduate College bylaws, University webpages, including provost pages
Visibility on central website; Visibility in the public face of campus	University webpages, including Graduate College and provost pages
Faculty development programming (including graduate students and post-doctoral fellows)	N/A
Resource banking of interdisciplinary resources and literature	University webpages, including Graduate College and provost pages

During the document analysis, attention was given to documents related to the sixteen interdisciplinary science graduate programs. During the previous study phase, program catalog pages and webpages were collected and reviewed. Additional documents collected and reviewed for this study phase included program proposals, materials posted online for students and faculty, policy and procedure documents, and program change proposals. This review was particularly beneficial for learning more about program leadership, identification and selection of new programs, and various programmatic elements. Data related to leadership and alignment with strategic themes included who initiated the development of the program (faculty or administration), when was the degree launched, what unit administers the program, and how is the faculty director selected (Table 8). Data related to various programmatic elements included which colleges provide curriculum and faculty advisors, does the program have its own rubric and what unit awards the degree (Table 9). Unfortunately, there are gaps in the data because this information could not be found in publicly available documents for all programs.

Table 8. Administrative Elements of Interdisciplinary Graduate Programs

Program	Who	When	Administrative Home	Policies for Program Director Home	Current Director Home	Director Term
Bioinformatics & Computational Biology MS, PSM	Not found	Launched: 2010 Permanent: 2017	Center for Bioinformatics & Computational Biology (CBCB)	Rotating position, starting in Computer & Information Sciences	Computer & Information Sciences	"Rotating position"
Bioinformatics Data Science PhD	Not found	Launched: 2012 Permanent: 2018	Center for Bioinformatics & Computational Biology (CBCB)	Rotating position, starting in Computer & Information Sciences	Computer & Information Sciences	"Rotating position"
Biomechanics & Movement Science PhD, MS	Faculty	Launched: 1994 Permanent: 2000	Kinesiology & Applied Physiology	Not found	Not found	Not found
Biomedical Engineering PhD	Not found	Launched: 2012 Permanent: 2019	Biomedical Engineering	Biomedical Engineering	Biomedical Engineering	Three-year renewable term
Communication Sciences & Disorders MS, PhD*	Not found	Launched: 2014	College of Health Sciences	Not found	Communication Sciences & Disorders	Not Found
Data Science MS	Faculty	Launched: 2018	Mathematical Sciences	Elected by Executive Committee	Mathematical Sciences	Three-year term
Disaster Science & Management MS, PhD*	Provost established committee	Launched: 2010 Permanent: 2017	Biden School of Public Policy & Administration	Not found	Biden School of Public Policy & Administration	Not found
Energy & Environmental Policy PhD, MS*	Not found	Launched: 1997 Permanent: 2003	College of Arts & Sciences	Appointed by the Dean of the College of Arts & Sciences	Materials Science & Engineering	Three-year renewable term
Engineering & Public Policy PhD*	Not found	Launched: 2019	Civil & Environmental Engineering	Appointed by the Chairs of Civil & Environmental Engineering and School of Public Policy & Administration	Civil & Environmental Engineering	"Fixed term"

Table 8. Administrative Elements of Interdisciplinary Graduate Programs (Continued)

Program		Who	When	Administrative Home	Policies for Program Director Home	Current Director Home	Director Term
Leadership in Disability Services MA, CERT		Faculty	Launched: 2017	Jointly between College of Health Sciences (CHS) & College of Education & Human Development (CEHD)	Appointed by Deans of CEHD and CHS for a term of two years	Human Development & Family Science	Two years
Master Public Health	Epidemiology	Dean initiated cross-college planning committee	Launched: 2019	College of Arts & Sciences (CAS) and College of Health Sciences (CHS)	Professional staff or faculty member affiliated with program, typically from CAS or CHS. Department chairs of affiliated faculty make recommendation	Epidemiology Program	Three years
	Health Policy & Management Concentration		Launched: 2019			Biden School of Public Policy & Administration	
Microbiology PhD, MS		Faculty	Launched: 2019	Not found	Not found	Co-Directors: Civil & Environmental Engineering and Plant & Soil Sciences	Not found
Robotics, MS		Faculty	Launched: 2019	Mechanical Engineering	Not found	Mechanical Engineering	Not found
Ocean Engineering PhD, MS		Not found	Launched: 2007	Not found	Not found	Co-Directors: School of Marine Science & Policy and Civil & Environmental Engineering	Not found
Water Science & Policy PhD, MS		Faculty	Launched: 2011 Permanent: 2015	College of Agriculture and Natural Resources	Not found	Plant & Soil Sciences	Not found

Table 9. Structural Elements of Interdisciplinary Programs

Program		Core Curriculum - College Source	Other Curriculum - College Source	Faculty Advisors	Program Rubric	Unit that Awards Degree
Bioinformatics & Computational Biology MS, PSM		CANR, CAS, COE	CANR, CAS, CEOE, CHS, COE	CANR, CAS, CEOE, CHS, COE, LCBE	Yes	COE
Bioinformatics Data Science PhD		CANR, CAS, COE	CANR, CAS, CEOE, CHS, COE	CANR, CAS, CEOE, CHS, COE, LCBE	Yes	College of Advisor
Biomechanics & Movement Science PhD, MS		No Core	CANR, CAS, CEHD, CHS, COE, LCBE	CAS, CHS, COE	Yes	CHS
Biomedical Engineering PhD		CAS, COE	CANR, CAS, COE	CAS, CHS, COE	Yes	COE
Communication Sciences & Disorders MS, PhD		Not found	Not found	Not found	Yes	CHS
Data Science MS		CANR, CAS, COE	CANR, CAS, COE	All 7 Colleges	No	Student can select with advisor
Disaster Science & Management MS, PhD		CAS	CANR, CEHD, CHS, COE, LCBE	CANR, CEHD, CHS, COE, LCBE	Yes	Not found
Energy & Environmental Policy PhD, MS		CAS	CAS, CEOE, COE,	CAS, CEOE, COE,	Yes	Not found
Engineering & Public Policy PhD		CAS, COE	CAS, COE	CAS, COE	No	COE
Leadership in Disability Services MA		CEHD, CHS	CEHD, CHS	CEHD, CHS	No	Student selects (with advisor)
Master Public Health	Epidemiology Concentration	No core	CANR, CAS, CHS	CANR, CAS, CEHD, CEOE, CHS,	No	CHS
	Health Policy & Management Concentration	No core	CANR, CAS, CHS	CANR, CAS, CEOE, CEHD, CHS,	No	CAS
Microbiology PhD, MS		CANR, CAS, CEOE	CANR, CAS, CEOE, CEO	Not found	No	Not found
Robotics, MS		CANR, COE	COE	COE, CANR	No	COE
Ocean Engineering PhD, MS		No Core	CEOE, COE	CEOE, COE	No	COE
Water Science & Policy PhD, MS		No Core	CANR, CAS, CEOE, COE	CANR, CAS, CEOE, COE	No	College of Advisor

Key	
CANR	Agriculture & Natural Resources
CAS	Arts & Sciences
CEHD	Education & Human Development
CEOE	Earth, Ocean, & Environment
CHS	Health Sciences
COE	Engineering
LCBE	Lerner College of Business & Economics

The identification and review of programs in the document analysis provided the basis for selecting programs that served as case studies. Additionally, selection of cases was performed in line with grounded theory's use of the constant comparative analysis, which seeks to compare different people's views, situations, actions, accounts and experiences (Glaser & Strauss, 1967; Corbin & Strauss, 1990). Developed by Glaser & Strauss in 1967, grounded theory is a research methodology that drives theories through systematic research and the analysis of data. A critical feature of constant comparative analysis is engaging in a process termed theoretical sampling, whereby the researcher is continually collecting and analyzing data, and this analysis is used to inform what data should be collected next.

Programs were selected for further review to gain an adequate understanding of interdisciplinary programs. Case studies were selected through purposeful sampling, where participants are selected based on their ability to provide an informed understanding or unique perspective of the issue (Maxwell, 2008). To understand how facilitation of interdisciplinary science programs may have changed over time, both newly launched, and more mature programs were selected. The document review revealed that the administrative home of programs can vary between centers, departments and colleges. Therefore, programs were selected to ensure each administrative structure was included. The document analysis also revealed that several colleges were involved in interdisciplinary programs and programs were selected to ensure adequate representation of programs from various colleges.

Data was collected through semi-structured formal interviews, which are guided by the researcher and designed to provide an in-depth examination of the interviewee's understandings on the topic. Semi-structured interviews are guided by a set of

questions, but the researcher is able to probe into areas that arise during the interview process in an effort to gain fresh insights and perspectives (Merriam, 1998; Hatch, 2002). An interview protocol was developed (Appendix B) and approval was obtained from the University of Delaware Institutional Research Board (IRB) (Appendix C). The initial set of interview topics and questions were guided by the literature review of best practices in Objective One. Interviews were conducted in the Spring 2019 semester, and interviews were digitally recorded and later transcribed.

For this study, it was important to interview those most involved with interdisciplinary graduate education, including high-level administrators, program directors and participating faculty. A total of twelve interview requests were sent out to collect information from participants representing half of the identified interdisciplinary science graduate programs. One request was declined, two requests went unanswered and scheduling difficulties prevented two more. Therefore, a total of seven interviews were conducted and a total of six interdisciplinary science graduate programs were represented. It is important to note that most faculty and administrators were involved in more than one interdisciplinary program. Therefore, one participant could provide prospective on multiple programs. While six programs were represented, there were often multiple faculty perspectives regarding that individual program.

Interviews were transcribed and uploaded into a qualitative software program (Dedoose). Coding categories were developed through an evolving process that required the data to be repeatedly read through to find meaningful words and phrases (Bogdan & Bilken, 1997). The earliest coding structure was based off the analytical framework presented in Chapter 2 (Figure 2) and interviews were initially coded based on four high-level categories: definition, creation, administration, and evaluation. While it was

suspected the Graduate College could have a major impact on interdisciplinary graduate education, there was little information publicly available regarding this new college when the interview protocol and the initial coding categories were developed. However, the Graduate College was quickly identified as another important high-level category after just a short number of interviews because the topic repeatedly surfaced during the interview process, despite not being specifically included in the interview design. As more data was reviewed, other codes began to emerge within each of the five broad categories. As codes began to develop and evolve, transcripts were recoding as necessary. The finalized coding scheme is presented in Table 11.

After the interview coding scheme was finalized, the document collection was re-evaluated by applying this coding scheme. Additionally, if any documents or policies were mentioned during the interview process, an effort was made to add these or related documents to the document collection. For example, the Graduate College bylaws were mentioned by several interview participants. Therefore, the Graduate College bylaws were added to the document analysis to verify the validity of statements made during the interviews. This was done in order to achieve triangulation and corroborate findings across the data sets (Bowen, 2009). Additionally, this triangulation was able to highlight points of convergence and divergence regarding how various stakeholders described and understood their experiences with interdisciplinary graduate programs. The value of this triangulation is important for determining whether case study participants' experiences and beliefs align with university policies and procedures.

3.3 Findings

To identify recommendations to improve the facilitation of interdisciplinary programs, data from the various qualitative research methods used in the study design

were examined to reveal key findings related to how UD was performing against best practices presented in the literature. This combination of qualitative research methods afforded a more comprehensive understanding and provided triangulation.

3.3.1 Defining Interdisciplinary Graduate Programs

The complexity and variation of interdisciplinary educational programs has made it challenging to identify a universal definition or description that fits most academic institutions. The goal is often to enhance the students' ability for cross-disciplinary thinking and to develop interdisciplinary research skills (Larson et al., 2011). However, many universities are implementing interdisciplinary graduate education without clear standards and guidelines for interdisciplinary activities. This can create confusion and cause tension among academic units, complicating the emergence of interdisciplinary programs (Klein, 2010). Institutions seeking to better support interdisciplinary activities should develop a comprehensive meaning for their campus. Therefore, a goal of this project was to better understand whether an institutional definition for interdisciplinary graduate programs existed at UD, and if this definition was communicated and well understood among the university community.

Table 10. Finalized Coding Schematic

Category: Definition		
Code	**Child Codes**	**Definition**
Personal Definition	No child codes	Statements related to how the interviewee defines interdisciplinary graduate programs.
Institutional Definition	No child codes	Statements related to the interviewee's understanding of how UD defines interdisciplinary graduate programs.
# of programs	No child codes	Statements related to the number of STEM interdisciplinary graduate programs at UD.
Category: Creation		
Code	**Child Codes**	**Definition**
Program Identification	- Decision makers - Student recruitment - Strategic themes	Statements related to how potential new ID programs are identified and selected for development.
Program Structure	- Program policy development - Curriculum development - Academic home	Statements related to how decisions are made during the development phase regarding the program structure. This includes program policies and curriculum development.
Approval Process	- Policies to guide process - Curriculog - Champion to guide through process	Statements related to the internal procedures for receiving institutional approval for launching a new program.
Resources	- Funds/Budget - Faculty/Staff time	Statements related to the resources needed and available for the development and implementation of interdisciplinary programs.
Category: Program Administration		
Code	**Child Codes**	**Definition**
Program Structure	- Academic home - Policies for administration - Curriculum management	Statements related to the administration of the program.
Faculty Experiences	- Negotiation/Interaction - Appointments/Evaluation - Faculty Mentoring	Statements related to faculty experiences that occur when participating in an interdisciplinary program.
Resources	- Funds/Budget - Faculty/Staff time - Sustainability	Statements related to the resources needed to administer an interdisciplinary program.
Category: Evaluation		
Code	**Child Codes**	**Definition**
Evaluation	- Central Administration Oversight - Evaluating body - Frequency	Statements related to how programs are currently being evaluated at the institutional level.
Category: Graduate College		
Code	**Child Codes**	**Definition**
Graduate College	- Power (negotiations) - Lack of funding - Potential impact - Confusion	Statements mentioning the newly formed Graduate College.

Key finding #1: There is no clearly communicated and understood definition for interdisciplinary graduate programs and this creates confusion within the campus community.

In an effort to understand how the community defined interdisciplinary activities, each interviewee was asked to define what it meant to be an 'interdisciplinary graduate program' at UD. Participants agreed that there was no clear institutional definition or description for interdisciplinary programs. Furthermore, participants expressed concern that there are no examples of how to seamlessly and productively collaborate between administrative units. One participant's frustration in this area was clearly evident in their response of "the administrative definition would be having to beg people for money." Two participants expressed concern that some programs labeled as interdisciplinary don't really have interdisciplinary elements. One participant stated, "I'm involved in a few interdisciplinary programs and some of them to me don't feel all that interdisciplinary." Another declared, "students in the program aren't really trained in an interdisciplinary way."

When asked to provide their personal definition of what it meant to be an interdisciplinary graduate program, most participants struggled to articulate a definition. While participants were asked not to focus on defining interdisciplinary research but instead define what it means to be an interdisciplinary graduate program, the faculty participants struggled to get beyond a research-focused definition. The only participant to provide a more functional definition was a senior administrator who described interdisciplinary programs as "programs that reach across multiple different departments." The faculty participants began with a research emphasized definition but would recognize their answer was not targeting the interview question and made efforts

to adjust their response. It was evident faculty participants could not clearly and easily articulate what it meant to be an interdisciplinary graduate program. This was especially interesting since all faculty participants have been actively engaged and involved in interdisciplinary programs.

Despite the challenges participants encountered answering the question, two types of definitions emerged. The first definition was described as a way to administratively bring people together who do similar types of research but have different departmental homes. In other words, the same methods are being applied across different disciplines. However, it was noted that this doesn't necessarily result in interdisciplinary training for students. The second definition that emerged was the ability to engage different approaches from multiples disciplines, which allows for bringing people together around a different identity. This lack of consensus on how to define an interdisciplinary graduate program also translated to inconsistent responses when asked how many science-related interdisciplinary programs exist on campus. Answers ranged from two to thirty and everything in between. One participant mentioned that there was a Graduate College webpage that listed all interdisciplinary graduate programs, but it had not been updated for some time.

The first documented science-related interdisciplinary graduate program at UD was developed in 1994; however, UD had no publicly documented definition until February 2019. A definition was provided in the approved bylaws for the newly formed Graduate College (University of Delaware, 2019c):

> A Cross-College Interdisciplinary Graduate Program is a course of graduate study composed of two (2) or more departments across different colleges. The following bylaws are for the development, administration, approval, and assessment of Cross-College Interdisciplinary Graduate Programs (herein after

> Interdisciplinary). These programs should balance their coursework across multiple departments within the program. (p. 8)

While this is great start, the definition is overly simplistic and can still lend to confusion. For example, it's not clear on what elements of the graduate study must consist of "two or more departments". The statement that "programs should balance their coursework across multiple departments" suggests coursework is the primary driver for defining interdisciplinary graduate programs. However, it would seem that defining a program as interdisciplinary would require more than having coursework across multiple departments.

3.3.2 Establishing Interdisciplinary Graduate Programs

Universities have a variety of necessary policies and procedures that provide the authority and structure to the University governance and operations. Most of these are sufficient for supporting traditional disciplinary activities effectively but unfortunately, many of these policies create barriers to fostering interdisciplinary research, education and training (National Academies, 2005). Universities continue to struggle with how to update these policies to more effectively integrate and support interdisciplinary activities (Welch-Devine et al., 2018). This study sought to understand how existing university policies and procedures at UD were facilitating or hindering the development of new interdisciplinary graduate programs.

Key Finding #2: Faculty are considered the primary impetus for identifying and developing new interdisciplinary graduate programs.

The decision to create an interdisciplinary graduate program is mostly driven by faculty who feel there is a need for a particular program. This finding was supported in both the document analysis and interviews. When program documents included

information regarding how the program topic was identified, most program themes were identified and founded by small groups of faculty. Additionally, the newly approved Graduate College bylaws recognized the importance of faculty leadership in this area (University of Delaware, 2019c):

> Interdisciplinary graduate programs should be faculty-initiated and developed by those faculty directly involved in the areas to be included in terms of scholarship, education, and research, etc. (p. 9)

Since faculty were typically the main impetus for creating new interdisciplinary graduate programs, it was not a priority to align new programs with institutional strategic themes. When faculty participants were asked if efforts were made to align new interdisciplinary programs to the institutional strategic plan, faculty felt that there were no clear guidelines or procedures in place for how to do this. One faculty noted that "upper administration is not terribly open on how to do that." However, this was not considered disadvantageous by participants as faculty engagement was considered crucial to program success, as "these academic matters have to be driven by faculty." One participant even recalled an unsuccessful attempt to launch a new interdisciplinary program that was driven by a previous provost. There was very little support at the faculty level and the program never materialized. However, faculty participants agreed that once an aspirational program has been identified by faculty, upper administration needs to provide some support for program development. As one participant explained:

> The faculty members that are already involved in the interdisciplinary research would be the first driver. But then it would be helpful if the university had some people that would jump in because faculty members are not good administrators in general.

One common motivation for faculty to develop a new graduate program is the desire to recruit better or more appropriate students. Since the work of interdisciplinary

faculty often falls outside of the traditional departmental discipline, students recruited by the department may not be the best match. Moreover, the required departmental coursework may require students to take unnecessary coursework, while leaving gaps in interdisciplinary coursework. One faculty felt that even if a student was successfully recruited into his/her lab, the student is left in a vulnerable position because if it is decided not to be a good match, the student has very limited options within the department. Additionally, there was a belief that interdisciplinary programs often attract higher quality students, as one faculty commented, "we realized that we were not attracting good students in our individual programs." Therefore, an interdisciplinary program is seen as a mechanism to define a specific research area, which allows for more effective recruitment and training of students. Developing a new program also helps to break down silos and brings together students "who tend to be isolated in individual departments."

Key Finding #3: There has been an increase in the number of interdisciplinary science graduate programs initiated on campus.

One interesting finding of the document analysis was the revelation that half of the existing interdisciplinary science graduate programs have been developed in the last three years and analysis of the interview data provided some insight into possible reasons. One participant noted that "it's kind of like springtime and interdisciplinary things are just blooming everywhere." Faculty participants felt that upper administration has made it clear that interdisciplinary efforts are a key target area for the university. This is supported by the current draft strategic plan that was released in Fall 2019. This strategic plan highlights five key priority areas, one of which is to

"strengthen our interdisciplinary and global programs (University of Delaware, 2019e)."

Additionally, faculty commented that the lack of clarity around the new University budget model has helped to facilitate the growth of interdisciplinary programs. The University of Delaware adopted a new budget model within the past year, but it is not yet finalized, as it continues to be refined during the implementation phase (Ruth, 2019). During a Spring 2019 general faculty meeting, the University of Delaware President Dennis Assanis presented the new budget model. He remarked that, "there are some details to still be worked out, particularly if you look at interdisciplinary education (UDaily Staff, 2019)." One area that remains uncertain under this new budget model is if and how graduate tuition revenue will flow. Information released to the university community regarding the details of the new budget has been limited, which has helped to foster the confusion and uncertainty. To help provide some clarity, a town hall meeting was held in December 2019 to specifically discuss the budget (University of Delaware, 2019g). The documents provided some details on how revenue will be distributed among campus units but again, it was still not clear how interdisciplinary programs would fit into this model.

The lack of clarity around the budget model has translated to a belief among faculty that now is an ideal time to develop interdisciplinary programs. For example, one participant specifically noted how faculty are taking advantage of this period of uncertainty and pushing through initiatives. The participant felt the previous Responsibility Based Budgeting (RBB) model did not appropriately incentivize units or faculty participating in interdisciplinary activities, stifling the development of new graduate interdisciplinary programs. RBB was a decentralized model of financial

management that couples academic authority to financial responsibility (Scarborough, 2009). Participants felt the RBB model inhibited the development of interdisciplinary programs because the flow of funds emphasized traditional academic departments and colleges. While it is not clear how the new budget model might encourage or inhibit interdisciplinary graduate programs, this participant was optimistic that it does not include the same "silo building incentives" as RBB. In the absence of explicit awards and strong directives, the faculty noted that "sometimes you can just do what you want."

Key Finding #4: The process for obtaining program approval is cumbersome, laborious, and unclear.

Documents related to new program development policies and procedures can be found in three places within the university website: the Graduate College, faculty senate, and the registrar's office. The Graduate College provides information on procedures to develop a new program proposal and provides an outline that should be followed to develop the program policy documents. The faculty senate webpages provide a program approval checklist, but it pertains mainly to newly proposed undergraduate majors or minors. The information provided on the registrar's office webpage is focused on providing instructions for Curriculog, the university's web-based curriculum management software. The registrar's office provides a 'graduate new program step-by-step' form but its purpose is to help users navigate the Curriculog software. None of these pages link to each other so those interested in developing new programs must search around the university website to find all the relevant information for proposing new programs.

It is clear from the Graduate College website that all programs must submit a program proposal document, which includes a program policy statement. There is a program policy template posted on the Graduate College website to help guide the creation of policy documents, but it is geared towards traditional programs (Appendix D). One faculty director commented, "there are no policies for interdisciplinary programs; it's just one size fits all." One participant noted, "that could leave people feeling like every time they do this, they're creating their own path as opposed to having at least a framework." Those with experience in writing founding program documents indicated the value of using other interdisciplinary program documents as models. However, there is no central repository for these documents. Faculty must either ask the program for their documents or search for them in the faculty senate meeting minutes. There was optimism that the newly formed Graduate College may be able to help streamline this process and provide examples of program policies unique to interdisciplinary programs. However, one participant expressed concern that this type of support was not specifically mentioned in the Graduate College by-laws:

> Theoretically, the Grad College should do that. You tell me in their document where there's a policy that says they will help streamline this. I read it. There is nothing.

Several faculty participants also commented on the need for greater clarity on the overall process and procedures. Many felt that the process outlined in the procedures for developing new programs was not consistently upheld with no clear justification or explanation. While there was consensus that some flexibility is valuable, the approval process could benefit from more structure and greater transparency. One interdisciplinary program director commented:

> I think it's the sort of thing where if you're charismatic enough, you can bend those rules to what you need them to be, which on the one hand is a little helpful

> because it means that the rules aren't getting in the way of what these things can be. On the other hand, it's exactly the opposite of helpful because it means that there's no clear path forward.

Additionally, this lack of consistency on following the procedures for program approval appears to be distressing to some faculty. As one participant noted:

> And the flexibility is important, but also having some agreed upon rules for this process is good to, because you don't want to do these things and either feel like you're open to the judgment that you're creating a junk program or do these things and not have some confidence that the process was set up to help you figure out whether it was going to be successful before you launched it. So, I would feel more comfortable if the rules were a little more rigid.

An example of inconsistent enforcement of the policies and procedures was provided by one faculty director. The faculty shared that he/she knew of at least one program proposal that was submitted and approved without what he/she believed where the required letters of approval from participating units. However, the posted policies and procedures do not clearly outline what approvals are needed for interdisciplinary programs. While it is clear the interviews revealed a belief that there were discrepancies in how the Graduate College enforces the policies and procedures for new program development, it is not clear whether this belief was justified or was simply the result of incomplete and unclear directions provided for the approval process, resulting in different interpretations of meaning.

Key Finding #5: Minimal guidance is provided on best practices for the administrative structures of interdisciplinary science graduate programs.

The procedures for submitting proposals for new graduate programs provides minimal information on possible administrative structures and governance of interdisciplinary graduate programs (University of Delaware, 2019d). Numerous models and approaches for where to house interdisciplinary activities have been

implemented within the landscape of interdisciplinary efforts. Interdisciplinary programs can be freestanding units reporting directly to central administration or located within an academic college. Many universities have relied on the creation of interdisciplinary centers and institutes to help circumvent the challenges associated with interdisciplinary research. This has led to a sharp growth in the number of centers across the United States (Association of American Universities, 2005; Sá, 2008; Boden & Borrego, 2011). All these models are valid structures for interdisciplinary programs and each institution should assess which model best suites their institutional structure and organization (Sa, 2008; Klein, 2010; Welch-Devine et al., 2018).

This variability in program structures can be seen in the interdisciplinary science programs at UD (Tables 8 and 9). Within existing interdisciplinary science graduate programs, there is variation in the administrative home of the program, policies around the program director, and which unit awards the degree. The administrative home of the program provides support for admissions, advisement, administrative paperwork, and other operational program components. The administrative home of existing UD science interdisciplinary graduate programs varies between centers, departments and colleges. Program directors are critical to the success of interdisciplinary programs. It is important to consider how the director is appointed and what department and/or units can be the primary home of the director. For example, in some cases the director is appointed by an executive committee or deans of the participating colleges and the director must be selected from faculty within a specific unit or department. The unit that awards the degree refers to how the conferring college is selected. For some programs, it is static and does not change. For others, the conferring college is based on

the majority source unit of curriculum or the student can select with approval from advisor.

It is unclear on whether this variation is beneficial or harmful to facilitating interdisciplinary graduate programs. On one hand, it provides developing programs with multiple models of program structures to choose from. However, no information is available on the advantages and disadvantages of each model to assist faculty in identifying the structure that best suits their program needs. Additionally, programs are not required to define the program structure in the program proposal. The following items are required for all new programs as per the Graduate College website (University of Delaware, 2019d):

- The Academic Program Approval that includes a rationale and explanation of the proposed program or changes to existing programs; new courses required; steps to submit new courses for the Registrar's process for the challenge process are included;
- Must attach a copy of current Graduate Program Policy Document and the new Graduate Program Policy Document that has been developed in compliance with the Template located at http://www1.udel.edu/gradoffice/forms/ppstatement.pdf
- For new programs, attach a Resolution.

The absence of a requirement in the approval procedures to include details of the program structure has led to inconsistencies as to what information is defined and included in program documents. While this may not be important for traditional departmental programs, the variety of approaches available to interdisciplinary programs means the program structure should be considered and outlined at the time of program development.

The data exposed a specific example of how the lack of guidance available on the various administrative structures has created some misconceptions within the faculty

community. The document review revealed that programs can be housed in academic departments, research centers, or colleges. However, nowhere in the procedures for submitting proposals for new graduate programs is there information regarding how to select the appropriate academic home (University of Delaware, 2019d). One program director shared that the founding faculty felt strongly that the degree should be awarded by a college and not a department. Therefore, they choose to not have a departmental administrative home for their program:

> There were several faculty who really felt the same way and they wanted the degree conferred by the College so it currently doesn't have a departmental home and that was really done by consensus. But it was, it was contentious because there were a few people who strongly pushed for having it have a home.

However, another faculty interviewee was under the impression that all graduate degrees at the University of Delaware are awarded by a college, regardless of whether the program has a departmental home. Additionally, there are examples of interdisciplinary graduate programs where the unit that awards the degree is not contingent upon the administrative home. For instance, the Bioinformatics Data Science doctorate degree is awarded by the college of the student's primary advisor. Consequently, the benefits of purposefully not selecting an academic home is unclear and the founding faculty may have struggled with this issue unnecessarily. Interestingly, this program does appear to have an unofficial administrative home within the college of the program director, as this college is providing some staff administrative support and helping to manage their budget and purpose code.

Key Finding #6: Curriculum development and management varies between programs and best practices are not being followed.

Curriculum development is another area that varies between interdisciplinary science graduate programs. There are some programs who develop new courses under a program-specific rubric, the four-letter abbreviation for a subject area. All courses begin with a four-letter rubric to help identify the departmental or unit origin of the course. For example, a course derived in biology would contain the BISC rubric. While others feel developing and owning their own courses is not advantageous because it disincentives departments from working with the interdisciplinary program. Responsibility Based Budgeting (RBB) models tie accounting practices to student enrollment causing units to protect student credit hours from leaving the unit (Shandas & Brown, 2016). The previous RBB budget model implemented at UD appears to have stifled interdisciplinary course development. Instead one faculty director noted that his program is specifically "trying to spread student enrollment out of that program across many different departments under their four-letter rubric."

The development of interdisciplinary courses was also limited by available resources. If a program is going to build new courses, this usually requires shifting instructional resources away from existing courses. With limited resources for teaching, one faculty noted the importance of leveraging existing courses:

> They tend to rely on a mix of courses because it's very difficult, uh, for, so most programs don't have a surfeit of faculty members and the courses that they're teaching already are going to be required for other things. So for a person to take on a new additional course, they usually have to give up something they're already teaching and that's usually not possible.

One faculty specifically commented on how more could be done in this area to support developing programs, "if the university really wanted to support such an initiative, then they would find a way to buy out the faculty time from their home department to allow them to design courses specifically for this program."

One area that can be particularly challenging for administrators of interdisciplinary programs is curriculum management. Interdisciplinary programs are often dependent upon other units on campus, complicating the process of organizing and planning courses. Many of the faculty interviewed expressed frustration regarding the lack of control over their curriculum. One program director stated, "I am trying to organize people to cooperate on these courses basically all over campus without an office for it and it's pretty weird". It can make planning for course offerings to "feel like guesswork." One solution implemented by several programs was to make the required curriculum very flexible. Required categories are defined by the program but each category has multiple course offerings to select from. This flexibility reduces the dependency on any particular course and minimizes the impact on the program if a course is no longer offered or available.

The risk with this method is that the student may not be participating in integrated interdisciplinary learning but instead be participating in a potpourri of courses that draw only from the home discipline with no effort to integrate the curriculum. When developing interdisciplinary curriculum, the whole sequence should be designed with interdisciplinary principles and should focus on integration of perspectives to produce novel insights (Shandas & Brown, 2016). Faculty experiences on efforts to ensure course integration occurs varied between programs. Some faculty noted cases where potential courses were identified by reviewing the course catalog and then the founding program faculty sought permission through emails to add courses to the program curricula. The unit that owned the course provided approval based solely on whether the course could support more enrollments. This approval was often documented in the program application via a commitment letter from the unit granting

approval. However, the letters were very simplistic and did not contain any information pertaining to efforts on integration. Faculty expressed concern that there was no attempt to ensure the curriculum was cohesive and that the appropriate content was being delivered. As one faculty cautioned, "you can list it, but no intention at all of changing what they're teaching to match the needs in the slightest, which is not the best." While this approach appears to be less common, at least one interdisciplinary program made efforts to strengthen the curriculum by bringing key stakeholders together:

> People got in the room and said, here's the classes I'm teaching, here's the content. And then everybody started thinking, how does this fit together? How can we shift what's being taught to make it fit together a little bit better? And that at least was the first layer.

While this path obviously takes more effort, these types of discussion have the potential to create a more cohesive and integrated curriculum.

Key Finding #7: Staff support was considered the most valuable and lacking resource for developing new interdisciplinary science graduate programs.

Developing a new interdisciplinary graduate program requires a significant amount of time. One program director explained, "it's an enormously time-consuming task and you're reasonably confident that people aren't reading 99% of what you're writing anyway so it's a wasted effort." Another commented, "most faculty members consider that sort of administrative work to be something from the seventh circle of hell that we would like to avoid if at all possible." Two of the participating programs were able to secure administrative staff support for the approval process and both expressed gratitude, as the staff person was able to significantly reduce the time burden on the faculty. The staff were provided by academic units that had an interest in launching the

program, such as interdisciplinary centers and institutes. One program director noted the value of having staff support to help navigate the approval process:

> There are definitely policies. They're not easy to find. And that's actually one of the biggest things I needed the staff member for was to figure out what the hell was required for this.

Another commented, "you really need, you need a staff member to help you with this." Additionally, it was noted how administrative support would be beneficial for all emerging programs, "if this is something the upper administration wants to make happen, then they should… give you at least a half-time administrator to help do the leg work of making the paperwork happen." This is another area where the Graduate College was seen as a potential solution as described by one faculty member, "even if it [Graduate College] doesn't provide any like major cash money, it would be really good if it could provide some administrative support." However, there is no indication in the Graduate College bylaws that the Graduate College will provide any administrative support during the approval process for interdisciplinary programs.

3.3.2 Administration of Interdisciplinary Graduate Programs

The previous section of this study focused on how existing university policies and procedures were facilitating or hindering the *development* of new interdisciplinary graduate programs. However, it is also important to consider their impact on the *administration* of interdisciplinary graduate programs. It is important to ensure that outdated practices and policies are not placing unnecessary burdens on faculty or students (Welch-Devine et al., 2018). Therefore, this study sought to understand how existing university policies and procedures were impacting the administration of interdisciplinary graduate programs.

Key Finding #8: Minimal guidance is provided on best practices for the governance and administration of interdisciplinary science graduate programs.

The struggles of interdisciplinary graduate programs persist well after the development phase. All the faculty interviewed in this study shared the belief that policies do not exist to help guide the administration of interdisciplinary programs. As one faculty director stated, "I don't think there's any explicit document that says anything about how to do this". Another stated, "there is little to no guidance". While there is often some form of an executive committee comprised of program faculty to help guide the program, these faculty have no institutional documents to inform their decisions. This can create another time sink as faculty explained:

> Every single incident of depth is the first time its happened and you need to not just come with an answer but come up with the justification for the answer and a policy document to make sure it's consistent the next time it happens.

This can be a challenge for all new programs – traditional or interdisciplinary. However, traditional programs can rely more on the policy documents already developed within the home department. Interdisciplinary programs can be left to navigate a solution that functions across multiple participating units. There is some indication that the Graduate College may provide some support in this area, as the bylaws include a section on "operational information for establishment of a new interdisciplinary graduate program" (p. 10). However, the section currently simply states "to be provided as forms." Further information regarding these forms could be not be located so the value of this section is unclear at this time.

Key Finding #9: Faculty leaders of interdisciplinary science graduate programs must be skilled negotiators, and identification of replacement leaders can be challenging.

The lack of policies and guidance for administering interdisciplinary programs can leave faculty leaders constantly negotiating on behalf of the program. As one program director stated, "you are constantly negotiating with everybody throughout the course of this and having to argue for resources." In addition to the interdisciplinary scientific knowledge, one participant noted how successful program leaders must also possess strong negotiation and team building skills, "those kinds of soft skills, the negotiating skills and the team building skills and those sorts of things, you need those on top of what you're normally used to." Successful leaders must be highly politically savvy and maintain sensitivity to a variety of stakeholders. They must negotiate resources while recognizing the importance of not competing directly with departments. This requires faculty leadership to maintain a delicate balance in order to keep the various constituents happy. One participant noted how these talents are beyond what is required for success in the typical faculty career path and faculty receive no explicit training in these areas, "I'm not sure where you learn that skill set – some people just have it."

Due to the unique skill set needed to navigate the unconventional demands of interdisciplinary graduate program, many faculty are either unwilling or unable to take on this responsibility and this can make it difficult to identify replacement faculty leadership. This is demonstrated by the comments of one participant when discussing the challenges of securing resources for interdisciplinary programs, "who would want to be program director at that point when you're going to have to go hat in hand to five different deans and say please may I have another." Additionally, some interdisciplinary program directors take on this extra responsibility for no monetary reward:

> I'm really doing this for free in terms of just my service thing. So I think the Dean is very happy that he doesn't have to pay extra for me being the director. And I think when other folks find out, they're like, Okay. No, we don't want to be doing this for free. We don't want to do it and I understand that.

While this information is not required in program proposal documents, some interdisciplinary programs include information regarding the identification process and term limits for the program director. However, one program that participated in this study noted how it has been difficult to identify a replacement program director and the founding director has remained in place much longer than intended. With no clear policies or mechanisms for identifying replacement faculty leaders, programs place themselves in a vulnerable position. The sustainability of the program could be in jeopardy every time key leadership departs from the program.

A statement on leadership of interdisciplinary graduate programs is included the newly approved Graduate College bylaws (University of Delaware, 2019c):

> Cross-College Interdisciplinary Graduate Programs will be initiated and overseen by a Program Director and an Associate or Assistant Program Director. These will serve in a leadership capacity for the program and are charged with drafting the operational program information (see below), soliciting and securing faculty participation from the various departments and colleges participating in the program. (p. 9)

There is nothing novel in the overall responsibilities outlined for interdisciplinary program leaders; however, it is interesting to note that all programs will be overseen by a program director and an associate or assistant program director. Currently, all interdisciplinary science graduate programs have a program director but only one existing interdisciplinary graduate program has an Associate or Assistant Program Director. While most programs would welcome and benefit from additional administrative support, they are financially unable to support these positions. While this seems like an attractive goal, it is not clear how these positions would be supported.

Key Finding #10: While some recent progress has been made, there remains difficulty accurately assessing and rewarding faculty efforts in interdisciplinary programs.

Cluster hiring is considered an effective strategy to hire multiple positions across departmental units around a central topic and allows universities to build interdisciplinary research teams (Flaherty, 2015; EAB, 2107). This approach has been used by the University of Delaware and most recently, interdisciplinary faculty cluster-hire searches were launched in the areas of biopharmaceutical discovery, disaster research and education, and coastal water security (Bailey, 2018). Although cluster hiring is a valuable strategy, too many efforts fail due to poor planning (EAB, 2017). Most administrators do not fully appreciate the wide-spread shift in policies and procedures that is needed to effectively enact cluster hires. Specifically, universities must develop clear communication and transparent policies about faculty expectations, including the tenure and promotion process (EAB, 2017).

Participants in this study noted that there are no consistent arrangements or guidelines on how to participate in an interdisciplinary graduate program. The faculty interviewed in this study agreed that the most common method for faculty to participate in an interdisciplinary program is "the faculty have a home department and they have privileges in the interdisciplinary program." In the most simplistic terms, this means faculty can advise students in the program with no formal responsibilities in the program. In this scenario, only one departmental entity is responsible for evaluating the faculty. Faculty participants considered this a positive arrangement because it allows them to recruit students outside of the faculty's home department with minimal risk or effort.

Some interdisciplinary faculty have joint appointments between departments. Joint appointments are defined per the University of Delaware Faculty Handbook as "an academic appointment made to someone with a primary academic appointment in another unit" (Section 4.1.2) (University of Delaware, 2019b). To reduce any potential tension between the units providing the joint appointments, formal agreements need to be in place that specifically outline the faculty's responsibilities in each department. Per the faculty handbook, all joint appointments involving joint workload require the development of a Memorandum of Understanding (MOU). The primary unit retains responsibility for all evaluation and promotion activities, but the MOU should outline how input from the minority unit will be obtained. The MOU should also address how workload will be assigned.

Faculty participants cautioned against joint appointment because of the challenges associated with ensuring all expectations are clearly outlined. As one participant noted, interdisciplinary faculty need to ensure "it's very clear who is your boss and who evaluates you for tenure because those different entities are going to have different evaluation criteria." This is especially important in the tenure and promotion process. Participants in this study were aware of existing guidance related to the tenure and promotion process for interdisciplinary faculty but many felt it wasn't enough:

> It's a dangerous place to put yourself in. So there is definitely guidance for that. But that guidance, uh, it's fine that there's a document that says, okay, well we're going to put together a promotion and tenure committee for you built out of people taken from these departments and things like that. But it's a bad position to put yourself into where six years from now you're going to be judged by a committee of people that you won't even know their committee makeup until a couple of years before you're going up. You can't get feedback from the people that are going to be making the decision on your case. It's a dangerous thing to put yourself in.

Furthermore, participants expressed concern that an MOU still leaves interdisciplinary faculty in a vulnerable position. One participant noted, "it's one thing to have that kind of MOU, but it's another thing to have the MOU and then still have your home department not really appreciating what you're doing for the program so it's not a fix." Additionally, one faculty shared a recent conversation in his home department around a faculty who was part of a cluster hire. While the hiring documents highlighted the percent effort expectations within each department, there was still some confusion on how to put this into practice and the department was struggling with how to ensure the person was evaluated fairly. While it is helpful that existing documentation "lays the groundwork", more work needs to be done to protect and recognize the efforts of interdisciplinary faculty.

Key Finding #11: *Resources for supporting interdisciplinary science graduate programs are limited, and there are no clear policies on how they are managed or distributed.*

Interdisciplinary programs are disadvantaged by the standard fiscal structure of higher education institutions which route funding to college and departmental units. Participants provided several examples of needed resources, including monies for advertising, one-month faculty summer salary, student funding, and s-contracts for teaching. Currently, there is no central office charged with the responsibility of allocating the needed resources to manage and sustain interdisciplinary graduate programs on campus. This is evident by the lack of information and guidelines regarding interdisciplinary graduate programs in the policies and procedures of central units across campus. For example, the allocation of resources for interdisciplinary

programs is not discussed in the current documentation regarding the newly implemented university budget model, nor is any information available on the Graduate College website. Additionally, all participants agreed that there are no existing guidelines or policies to allocate resources to support interdisciplinary program.

The lack of available resources often results in faculty founders being forced to generate their own path forward for obtaining funds to support the program. This can leave faculty feeling like they are constantly cobbling together funding from multiple sources in order to meet the budget needs of their program. The frustration regarding the lack of a clear funding mechanism for interdisciplinary science graduate programs can be seen in this participant's comments:

> If the program has got sufficient enrollment, then it's going to need staff support. If you are paying for staff support off of research grants, that gets untenable really quickly. Uh, and at the very least it requires that you should be able to get overhead to pay for that sort of thing. But that's a very fragile model for running a program. Uh, and if you're not a department, uh, then it's not clear where your budget comes from or who negotiates for that. And it seems to be done on a very program by program basis.

This was identified as an area where the university could provide more support. As one faculty director commented, "there should be a collaboration between faculty and administration to figure out how to support it if there is a joint agreement that this is valuable to the university."

Since program faculty are left to negotiate for program funds, there has been inconsistencies and inequities in the support of interdisciplinary graduate programs. Several examples regarding mechanisms to support interdisciplinary graduate programs emerged during the interviews. One program director of a recently developed program was able to negotiate funding support from the deans of the participating colleges. The funds provided staff support for program administration, advertising monies, and

summer salary for the program director. However, these funds were provided on an annual basis only, requiring the director to continually negotiate on behalf of the program. The program director explained that an MOU will eventually be developed but it is not feasible at this time due to the uncertainty surrounding the newly implemented budget model. Another recently developed program was able to secure UNIDEL funds to support the establishment of the program. These funds will be used to provide half-time staff support for three years. The program director felt that staff support was essential because having faculty provide the administrative support would "require reorganization of workloads in a way that chairs aren't willing to do."

While some founding members have been fortunate enough to secure internal institutional funds for program development, there is not a dependable mechanism for funding interdisciplinary initiatives. One administrator even recognized that institutional funds are not available on a consistent basis, so they are not a reliable source of funding. In fact, no information could be found on the university website on the various methods faculty might pursue in order to obtain funding support for an interdisciplinary program. In fact, the only information related to interdisciplinary funding that could be found on the university website was related to a funding initiative for supporting program development. The Graduate College Innovation Grants program provides up to $40,000 to support the development of new graduate programs. Funding can be used to support: planning meetings; market research; integration of online or hybrid learning modes; faculty time for development of courses, certificates, or degree programs; bringing external experts to campus to advise on program development; global outreach efforts; or other reasonable costs (University of Delaware, 2019f). The website outlining the call for proposals states that there will be

repeated calls for proposals throughout the academic year but no further information regarding future availability was provided.

During the interviews, there was some discussion regarding the use of a Memorandum of Understanding (MOU) between participating units that would outline how the program would be financially supported. One administrator mentioned a MOU that was developed between four participating colleges regarding the support and administration of a specific interdisciplinary program and this has served as a model for other interdisciplinary programs. However, the faculty perspective on the value of the MOU was not as positive, as it was noted that "those (MOUs) are only as good as the willingness of whoever." One faculty member expressed a belief that at any point a dean can decide not to participate in the MOU, leaving the program "to go back hat in hand, and figure out a new agreement." This model can cause interdisciplinary programs to feel exposed and at the mercy of the participating Deans. Furthermore, several faculty participants noted that previous MOU templates are no longer valid due to the new budget model and new MOU templates for interdisciplinary graduate programs need to be developed.

Interestingly, the bylaws of the newly founded Graduate College contain some verbiage related to MOU's for interdisciplinary programs. There is one sentence that simply states, "MOU's or other agreement mechanisms should be developed by the Graduate Council and sent to the relevant deans for consideration" (p. 9). The graduate council is the primary governing body of the Graduate College and it consists of thirty-five faculty members who are to represent the graduate programs within the academic colleges (University of Delaware, 2019c). No further information is available on how

this will be done but it is encouraging that the Graduate College will provide support in this area.

Budget model uncertainty adds to the confusion, as the University of Delaware adopted a new budget model within the past year. For those that programs that generate graduate tuition revenue, it is unclear how this money will flow under the new budget model. One participant commented, "I can't tell you how many times people sort of throw up their hands and say, I don't know where the money is coming from and where it's going." However, one program director expressed relief that monies would not be directly returned to the program. The participant questioned whether interdisciplinary program directors should have that type of budget responsibility and whether the correct oversight structure was in place. However, the program director acknowledged that this means interdisciplinary programs are in a position where they must "figure it out every year and ask somebody" and rely heavily on departmental support.

3.3.3 Evaluation of Interdisciplinary Graduate Programs

If an institution is going to invest in growing interdisciplinary graduate programs, effective mechanisms for evaluating the outcomes of their investments is critical to determine success (National Academies, 2005). There is a variety of data that can be measured to evaluate interdisciplinary programs. Potential sources of data can range from easily tracked elements, such as enrollment data, job placement, graduation statistics and publication data, to more complex items, such as curriculum integration, learning outcomes and research practices (Carr et al., 2018). Therefore, one project aim was to learn more about when and how interdisciplinary graduate programs were being evaluated at UD.

Key Finding #12: There are limited requirements for internal assessment and no requirements for an external assessment of program performance.

Participants agreed that oversight on all graduate programs is generally minimal, and even less so with interdisciplinary graduate programs. Faculty agreed that programs are evaluated at time of program development and then not again until the program is reviewed for permanent status (5 years for MS programs and 7 years for PhD programs):

> It's faculty Senate centric. So basically when you institute a new, uh, when you were approved by the faculty senate, you're basically told, hey, go for it than operate and come back in five years and tell us how you're doing.

Participants felt this arrangement provided little oversight with one faculty commenting, "nobody's telling us what to do at the moment." Another participant commented, "it's nobody, it's not on anyone's radar." One faculty director agreed that evaluation was important but admittedly "hadn't seriously though about this yet." Another participant noted that deans and chairs could potentially track success of interdisciplinary programs but "interdisciplinary programs for the most part are a small part of what the department does and so they don't probably get too much attention." Participants agreed that this lack of supervision hasn't resulted in inferior programs or "degree factories", and interdisciplinary programs were considered to have the same or more stringent standards than traditional departmental graduate programs. However, this did not minimize the importance of evaluation, as one participant noted, "someone needs to be paying attention and evaluating these programs in some well-defined way." Additionally, a few participants even recognized that this would result in increased efforts on part of the program leadership but felt it was worth it to ensure program quality.

As mentioned previously, one program in this study previously had a memorandum of understanding (MOU) for several years. One participant expressed the opinion that programs operating under an MOU would be evaluated at the end of the agreement term, as those colleges participating in the MOU (and potentially providing resources) would have an interest in how the program was performing. However, one participant did not believe this was happening with any frequency:

> Every time you come to the end of one of these MOU's, you're supposed to have a sit down and have a conversation about it. Um, I think a lot of the time they just kind of keep moving without really thinking too much about it.

Therefore, the presence of an MOU did not guarantee program assessment and evaluation remains a valid concern.

One major mechanism for evaluating educational programs at the University of Delaware is the Academic Program Review (APR). According to the Academic Review Guidelines (University of Delaware, 2016), the goal of the APR is to:

> Provide academic departments and programs with the opportunity to assess the quality of their teaching, research, and engagement activities, evaluate the effectiveness of their use of resources, and determine their progress toward meeting the unit's goal, as well as those of their college and the University of Delaware (p. 1)

The APR process was developed for traditional departments and programs causing faculty participants to express concern that interdisciplinary programs were not captured in the APR process. Participants elaborated that if no department claims ownership of the program, it risks being excluded from the APR process. As one faculty participant noted, interdisciplinary program could easily "fall through the cracks."

In addition to the frequency of assessment, another concern was the lack of a required external evaluation. The current process for permanent status review has

programs prepare their own evaluation documentation. One faculty felt strongly that this could lead to programs presenting information in a way that suites their needs best:

> And as far as I know on the books, there is no requirement for an external evaluation, which to me, so okay, then you're left cherry picking whatever ranking. Cherry picking whatever rankings you happen to look good and or defining yourself in such a way that there is no national ranking. And so you can say we're number one of one.

External evaluations can be useful for providing a more objective review of the program. External evaluators have less of an investment in the success of a program and they tend to be less susceptible to internal politics.

One participant shared that he felt improving the evaluation of graduate programs was "on the radar of the Graduate College" but wasn't sure how this would translate into practice. Indeed, the current bylaws for the Graduate College include specific language regarding interdisciplinary program assessment when establishing new programs (University of Delaware, 2019c):

> In the establishment of new interdisciplinary programs, the proposed director(s) must outline their outcome goals for the program, in terms of target numbers of graduate students trained, the level of this training (e.g., non-thesis, Master's or Doctorate), the level of faculty involvement (numbers, departments, positions). For example, what would their successful program look like in 5 (M.A./M.S.) or 7 (Ph.D.) years? This outline would be completed in consultation with the Dean of the Graduate College and would set mutually agreed upon annual goals for recruitment, retention, and degree progress/completion. (p. 11)

The bylaws also stipulated a new annual review process that is to occur during the provisional period (University of Delaware, 2019c):

> <u>Preliminary Assessment (during provisional 5 year approval):</u> Director(s) of a program must provide to the Graduate College Dean an annual statement of number of students matriculating into the program, the number of faculty advisers within the program, the progress of students in the program (in terms of degree completion milestones), and the numbers of presentations and publications made by students and faculty specific to this program. These data will be collected by the office of the Dean of the Graduate College and will be

> followed by a verbal and written appraisal each year to assess progress of the program. (p. 11)

These new requirements increase the oversight during the provisional status period; however, the permanent status approval process remains unchanged and external evaluation is still not required at any stage. Furthermore, it does not identify or clarify a process for evaluation after the program is awarded permanent status.

3.3.4 Potential of Graduate College

Due to the timing of this study, the Graduate College was not originally included as a major thematic area. While it was suspected the Graduate College would have a major impact on interdisciplinary graduate education, there was little information publicly available regarding this new college at the time of the study design, as the draft bylaws of the Graduate College were released just prior to beginning the interviews. While this timing prevented the information in the bylaws from being included in the interview protocol design, the bylaws were repeatedly referenced and mentioned by interview participants. Therefore, the Graduate College was identified as a major thematic area and integrated into the remaining study design.

Key Finding #13: The Gradate College is poised to play an important role in facilitating interdisciplinary graduate education but its function and value is uncertain at this time.

The mission and vision statement of the Graduate College includes "facilitate innovative, high-quality excellent interdisciplinary programs." To that end, the bylaws of the Graduate College contain a considerable amount of information specific to cross-college interdisciplinary programs. While the timing of this study prevented the graduate college establishment and bylaws from being more formally integrated into the

project design, it is clear that the Graduate College is poised to play an important role in facilitating interdisciplinary graduate education, making the Graduate College a significant component of this work. One faculty noted, "the Grad College is going to be instrumental in facilitating this interdisciplinary stuff." Another commented, "we are all hoping that the Graduate College would be able to help."

It is evident that participants believe there is great potential for the Graduate College to improve the support of interdisciplinary programs, but it is unclear how this will translate into practice. As one faculty stated, "I think the Grad College is progress, but it's not clear how much." An example of an area that generated questions is the understanding that all future interdisciplinary graduate programs will be housed within the Graduate College. This created confusion on who would be responsible for providing the administrative support for the program, who would be responsible for the program budget, and how do faculty participate in the program. The bylaws state that "faculty of the Graduate College shall consist of all full-time faculty members of the University who hold primary appointments in the other colleges, and appointment to the Graduate College will be considered secondary" (p. 1) (University of Delaware, 2019c). While there is no verbiage to specifically support this in the Graduate College bylaws, one faculty commented that all faculty participating in an interdisciplinary program housed within the Graduate College will have a joint appointment with the Graduate College. The faculty was quick to express his frustration with this policy, "I don't even understand what a joint appointment in the Graduate College will actually mean."

3.3.5 Summary of Key Findings

There has been a proliferation of interdisciplinary initiatives across the higher education landscape, and the University of Delaware is no exception to this trend. This

study revealed that faculty are eager to engage in interdisciplinary activities and the increase in interdisciplinary graduate programs has been the result of faculty determination and perseverance. They recognize the advantages of these programs to their research, student training and the overall institution at large. Several successful interdisciplinary graduate programs currently exist on campus. Most seem to have developed organically from passionate faculty, not as the result of University strategy. Listening to the voices in this study, the frustration of faculty on the front lines of interdisciplinary graduate education is unmistakable. The interviews revealed a general theme of underappreciation as interdisciplinary programs place demands on faculty that exceed traditional programs. Faculty felt these additional demands are not readily appreciated or understand by university leadership, including chairs, deans, and provosts, leaving faculty in a vulnerable position.

Faculty developing interdisciplinary programs often face unnecessary impediments to success that exist because of the traditional higher education organizational structure being divided by disciplines and departments. This has created hurdles for interdisciplinary programs in many areas, such as program funding, curriculum development, and program administration. The success of the program often relies heavily on the negotiating skills of the faculty leader and this has resulted in uneven support for interdisciplinary programs. Overall, faculty do not feel recognized for their efforts and that upper administration does not appreciate the extent of resources required to successfully launch and sustain an interdisciplinary program.

3.4 Limitations

The major limitations of this study were: 1) the selection of a narrow range of thematic areas for facilitating interdisciplinarity 2) sampling procedures; and 3) data

sources. This study specifically focused on gaining a better understanding of how administrative practices and policies impact the success of interdisciplinary science graduate programs. The scope of the project was limited due to time constraints and number of researchers. For example, the literature review identified four thematic areas as important focus areas for enhancing and promoting interdisciplinarity: 1) resources and funding; 2) recognition, rewards and incentives; 3) infrastructure and organization; and 4) administration and policies (Figure 2). This study focused specifically on understanding how UD was performing in items related to two thematic areas: infrastructure and organization, and administration and policy. Future studies should assess the current barriers and facilitating mechanisms within all four general themes. This would provide a more thorough understanding of how UD could improve its support of interdisciplinary programs.

In order to achieve a more comprehensive understanding, future studies should increase the number of participants beyond science programs, as well as the type of participants. Findings in this study are limited to a small number of faculty and administrators involved in the establishment and administration of interdisciplinary programs. All respondents had experience in navigating aspects of interdisciplinary graduate education. Therefore, they were well positioned to identify institutional practices that support or challenge interdisciplinary initiatives. However, this selection does not cover all stakeholders, as such it may contain some biases. It would be beneficial to expand the number of faculty participants, as well as include student perspectives. Increasing faculty participants broadens the analysis of interdisciplinary activities and can improve the level of confidence in the data. An increased sample size could reveal more subtle and less prevalent challenges to interdisciplinary graduate

programs. In addition to faculty viewpoints, listening to student perspectives is important to gain a better understanding of the student experience with interdisciplinary programs. There is literature to support that students may also encounter obstacles and challenges when participating in interdisciplinary programs (Keck et al., 2017). Therefore, student input will provide a more comprehensive understanding of the interdisciplinary campus culture.

To accommodate a larger sampling size, data sources should be expanded to include survey data, as well as interview data. Surveys can be distributed to an entire campus, with variants targeting specific groups. Additionally, pertinent documents should be collected beyond interdisciplinary science programs to include all potential interdisciplinary graduate programs. The increased sampling size and expanded data sources will allow for a more inclusive understanding of how interdisciplinary graduate programs are performing on campus, how the same issues are handled across campus, and increase the understanding of possible solutions.

Chapter 4

RECOMMENDATIONS FOR SUPPORTING INTERDISCIPLINARY PROGRAMS AT UD

Interdisciplinary inquiry is widely perceived to hold the key for solving today's complex scientific challenges. Funding agencies have expanded programing to encourage interdisciplinary research and interdisciplinary graduate training (Committee on Facilitating Interdisciplinary Research, 2004, National Science Foundation, 2012) and the number of interdisciplinary graduate training programs have multiplied (Welch-Devine et al., 2018). Despite this proliferation, many universities continue to struggle with efforts to integrate interdisciplinary education into the institutional framework and culture. The University of Delaware is no exception. One of the major aims of this study was to gain a better understanding of the challenges and opportunities of interdisciplinary science graduate education at the University of Delaware and make recommendations for improving the facilitation of interdisciplinary graduate programs. Based on the key findings of this report, eight recommendations were developed for enhancing interdisciplinary science graduate education at UD. The recommendations provided are an attempt to address the challenges and barriers faced by interdisciplinary programs that were identified through this work.

Recommendation 1: Adopt an administrative definition of an interdisciplinary graduate program and clearly communicate it to the campus community.

There is no widely accepted definition or description pertaining to interdisciplinary graduate programs. This is mainly due to the overall complexity of the term, as well as the personalized variations that occur within organizations. It is important for any institution seeking to better support interdisciplinary activities to

develop a comprehensive meaning for their campus in order to avoid implementing interdisciplinary graduate education without clear standards and guidelines for success. Those interviewed as part of this study agreed that a clearly articulated institutional definition for interdisciplinary graduate programs did not exist. Additionally, some felt there were inconsistencies in identifying programs and questioned the validity of some interdisciplinary programs. To reduce this tension and confusion, it is important that UD develop a more comprehensive description of interdisciplinary graduate programs.

Until recently, the University of Delaware had no publicly documented definition for interdisciplinary graduate programs. In February 2019, the faculty senate approved a draft version of bylaws for a newly created Graduate College that was launched in July 2019. The bylaws state "a cross-college interdisciplinary program is a course of graduate study composed of two or more departments across different colleges" (p. 8) (University of Delaware, 2019c). The bylaws also state that "programs should balance their coursework across multiple departments within the program" (p. 8). This definition is too simplistic and leaves many questions unanswered. It is not exactly clear what is meant by a "course of graduate study composed of two or more departments" and no further explanation is given on how to identify programs who meet this criteria. What element(s) of the program need to be composed of two or more departments? The challenges with the current definition become particularly evident when trying to apply the definition to current graduate programs within UD.

If curriculum is to be evaluated, two of the interdisciplinary programs selected for this study had core curriculum that resided in only one college: Disaster Science & Management and Energy & Environmental Policy (Table 9). However, the remaining curriculum is sourced from several colleges. Is it enough to have elective courses across

colleges or must the core curriculum be cross-college? The Master's program in Civil Engineering has elective course options across colleges but this is not considered an interdisciplinary degree. There is also the possibility that a program could design its curriculum using a program owned rubric. For example, while the core curriculum of the Disaster Science & Management program resides in one college, it was developed under a program specific rubric. While this has the potential to yield better integration of course content, it is not clear if this would meet the definition of being a course of study across two or more departments.

Program administration is another possible program element to consider. This refers to the program management and governance. There are several widely accepted interdisciplinary programs who do not appear to meet this definition because they are not composed of two or more departments. For example, Bioinformatics Data Science doctorate program is administered by the Center for Bioinformatics & Computational Biology and resides within the department of Computer & Information Sciences. Is this considered a program across two or more departments? Furthermore, the Biomedical Engineering doctorate program resides in and is administered by the Biomedical Engineering department. Would this be considered an interdisciplinary program under UD's existing definition?

Additionally, the proposed institutional definition does not consider cross departmental programs as being interdisciplinary. While each will have their own unique needs, cross-college and cross-departmental programs face similar challenges. Cross-departmental programs do not have to negotiate across colleges, but they will need to navigate through obtaining resources across various departments. This study did not identify any cross-departmental science related interdisciplinary graduate programs

but there is the possibility that non-science cross-departmental programs already exist. Even if one does not currently exist, it is easy to conceptualize how one might be developed in the future, especially in Colleges that contain a wide breadth of disciplines such as Arts and Sciences. In fact, the departments of Mathematical Sciences and Biological Sciences currently collaborate to offer an undergraduate interdisciplinary Quantitative Biology program.

This study highlights the complexity and variation of interdisciplinary graduate programs within the University of Delaware landscape and underscores the challenges in developing an institutional definition. The findings suggest a simple, structural definition is inadequate, and that institutions need to think deeply about the interdisciplinarity of various program components. While the scope of this work doesn't support generating a definition that captures all dimensions of an interdisciplinary program, a definition can be developed that meets the goals of this report. This project sought to better understand the challenges and barriers faced by interdisciplinary graduate programs and provide recommendations for seeding and sustaining interdisciplinary graduate programs. In order to achieve this, a working definition was developed with the purpose of distinguishing interdisciplinary programs.

The following definition is meant to provide the university community with a first-generation description that will aid in the identification of interdisciplinary programs. An interdisciplinary program seeks to educate students across traditional disciplines and departments, and collaboration between two or more departments or units is necessary in order to adequately train students. To translate this into practice it requires development of interdisciplinary curriculum and requires faculty participation

from across units on campus. Therefore, the following criteria are common components and can aid in the classification of interdisciplinary programs:

- The majority of the program curriculum consists of courses across departments, or courses specific to the interdisciplinary topic are developed and offered through a program-specific rubric.
- Program faculty reside in two or more departments and/or units across campus.

It is important to note that while most interdisciplinary graduate programs at UD build their curriculum by using existing courses from across departments, ideally courses should be developed specifically for the interdisciplinary program to ensure integration of perspectives is achieved across the curriculum sequence (Shandas & Brown, 2016).

This definition is not intended to capture and recognize all dimensions of interdisciplinary programs, such as student learning, training outcomes, and team science (Borrego & Newswander, 2010; Shandas & Brown, 2016). These are just a few examples of other potential interdisciplinary program elements and there is the possibility future research could uncover more. Additionally, the working definition provided here does not speak to program quality. It simply serves to identify programs who may fall outside of the traditional administrative structure of the university and are at risk for experiencing unnecessary challenges and barriers.

Recommendation 2: Develop policies and procedures for providing appropriate assistance to faculty seeking to develop new interdisciplinary graduate programs.

Universities have a variety of necessary policies and procedures related to academic systems and faculty governance. Most of these are sufficient for supporting

traditional disciplinary activities effectively but unfortunately, many of these policies create barriers to fostering interdisciplinary research, education and training (National Academies, 2005). Significant changes in organizational policies and practices are needed to improve the climate for interdisciplinary activities within higher education institution (Dubrow et al., 2009; Lindvig, 2019). While most institutions value interdisciplinary work and would like to support these activities, university leadership continues to struggle with implementing the transformative reform needed. Often, administrative policies to support interdisciplinarity are developed haphazardly as challenges arise, and there are no efforts to develop comprehensive change strategies (Klein, 2010).

Faculty expressed frustration regarding the challenges in navigating the process of establishing new interdisciplinary graduate programs. Participants felt the approval process could benefit from greater clarity, consistency and transparency. In the absence of support and services for developing new programs, each group of faculty interested in developing a new interdisciplinary graduate program are at risk for "reinventing the wheel." Access to resources that clearly outline the steps in program development would significantly enhance the likelihood of developing successful programs. Therefore, it is recommended that a thorough review of the approval process and procedures be conducted. Efforts should be made to streamline the process and a procedure specific to interdisciplinary graduate programs should be established and disseminated.

The Graduate College bylaws have two sections related to the development of new programs: D. Operational Information for the Establishment of a New Interdisciplinary Graduate Program and E. Interdisciplinary Program Temporary Status

Approval (p. 10) (University of Delaware, 2019c). Unfortunately, it is unclear if either of these sections will provide any clarification or help to simplify the process. The section related to operational information merely states "to be provide as forms" and no further information is provided. The temporary status approval section outlines two approval pathways for interdisciplinary programs composed from existing programs and *de novo* interdisciplinary programs (Figure 5). However, the difference between these two types of programs is not apparent and no definition or description is given. While it is evident there was an attempt to assist interdisciplinary program development by including information in the Graduate College bylaws, the value of these sections remains uncertain. The Graduate College should expand their efforts and provide more detailed information in these sections.

Figure 5. Approval Pathways for Interdisciplinary Programs

Pathway A. Interdisciplinary Programs Composed from Existing Programs	**Pathway B. *De Novo* Interdisciplinary Programs**
Shared Department Curriculum Committees	**Interdisciplinary Curriculum Committee**
Shared Department Chairs	Interdisciplinary Program Director
Shared College Curriculum Committees	|
Shared College Deans	|
Graduate College Dean	Graduate College Dean
Faculty Senate Graduate Studies Committee	Faculty Senate Graduate Studies Committee
Faculty Senate Coordinating Committee on Education	Faculty Senate Coordinating Committee on Education
Faculty Senate Exec	Faculty Senate Exec
Faculty Senate	Faculty Senate

Another area where the Graduate College could provide more guidance for program development is clarifying options for administrative homes and structures. The structure and organization of interdisciplinary graduate programs varies on campus; however, there is no guidance on the advantages and disadvantages of each model. This leaves faculty to speculate on which model best supports their program needs and has created some misconceptions on how to achieve desired program outcomes. Moreover, program proposals do not require the inclusion of any information regarding operational and administrative approaches. Therefore, it is recommended that the Graduate College implement a more thorough and expansive investigation into the types of administration structures currently operating on campus. This inventory should then be used to inform best practices for the administrative structure, and these should be shared with the campus community. It is also recommended that programs be required to include information on the program governance and structure in the program approval documents.

Several faculty participants in this study commented on the need for administrative staff support to help navigate the approval process. Some were even hopeful that the newly formed Graduate College could provide this assistance moving forward. The Graduate College should consider providing faculty with administrative staff support to help with the new program approval process paperwork. This would provide faculty access to an 'expert' in the approval procedures and reduce the administrative burden that is currently placed on faculty. Additionally, staff oversight and support at the Graduate College level would help to ensure there is continuity between program applications from the very onset of developing program documents.

Recommendation 3: Develop funding schemes to support and sustain funding for interdisciplinary graduate programs.

Interdisciplinary programs are disadvantaged by the standard fiscal operating structure of higher education institutions which route funding to college and departmental units. At UD, there is no central office charged with the responsibility of allocating the needed resources to manage and sustain interdisciplinary graduate programs and program leaders are left to continually negotiate for resources. Additionally, it remains unclear how the new budget model will impact the flow of graduate tuition revenue for interdisciplinary programs. Faculty directors remain forced to cobble funding together by spending valuable time securing resources from multiple sources.

Developing funding mechanisms for interdisciplinary graduate programs is key to their sustained success, and there are a variety of solutions that institutions can implement to help address this problem. A few examples of sources for program funding include: 1) indirect cost returns from grants that are catalyzed by activities of the program; 2) training grants to support the development of new programs; 3) strategic partnerships with industry or corporations to support student stipends or to engage in fundraising efforts; 4) implement fundraising strategy with development office; or 5) internal programs (Klein, 2010; Welch-Devine et al., 2018). Internal funds are important for developing tangible rewards and incentives for participating in interdisciplinary activities. They can be used for release of salary monies to be awarded to departments in exchange for faculty time committed to interdisciplinary directoring or teaching, salary supplements for faculty providing administrative support to

interdisciplinary program who retain a substantial portion of their original academic commitments, or funds for administrative support staff (Dubrow & Harris, 2006).

Participants in this study expressed concern that the current funding model for interdisciplinary activities places programs in a vulnerable position and is not sustainable. Additionally, there is currently a great deal of confusion regarding the newly implemented budget model and how it impacts interdisciplinary programs. UD should evaluate the existing funding strategies for both the development and administration of interdisciplinary programs and decide which solutions would be best to put into practice at UD.

Recommendation 4: Reexamine and update academic policies and practices related to faculty appointments, tenure, and promotion to ensure faculty receive appropriate recognition and credit for interdisciplinary efforts.

Many institutions have relied on cluster hiring to achieve desired interdisciplinary faculty hiring goals, but most do not perform the preparation and planning that is needed to ensure a successful process (EAB, 2017). Most institutions were not prepared for the fundamental changes to existing policies and procedures that needed to occur; thus, they did not plan adequately for implementing successful cluster hiring. One critical issue is the development of an interdisciplinary tenure and promotion (T&P) process. Existing T&P policies are generally designed for traditional discipline focused research. Working across units or departments often means teaching, research, and service requirements are less clear and interdisciplinary faculty face a real risk of having interdisciplinary efforts go unrecognized by their "home" department. It is recommended that UD fully review existing T&P policies to ensure it adequately

supports interdisciplinary faculty. The key actions to support interdisciplinary tenure and promotion include rewriting guidelines, establishing committee structures, defining appropriate criteria, and support for dossier preparation (Klein, 2010; Martin & Pfirman, 2017).

UD has launched several interdisciplinary faculty cluster-hires. The findings from this study suggest that progress has been made in developing guidelines for faculty participating in activities across multiple units, but more work needs to be done. Faculty with joint appointments still feel vulnerable and at risk for being evaluated primarily on departmental activities and contributions. Efforts must be made to ensure expectations of interdisciplinary faculty members are clearly outlined and communicated across all parties involved in evaluating the interdisciplinary faculty. While faculty appreciated the idea of developing an individualized memorandum of understanding (MOU) for interdisciplinary faculty, the current process was deemed inadequate to fully protect interdisciplinary faculty. Therefore, it is recommended that UD review current policies for joint appointments and evaluate existing MOU templates against best practices. There are available checklists and examples that contain best practices for developing MOUs for interdisciplinary faculty (Appendix E). UD should learn from solutions that have been implemented at peer institutions and summarized in the literature (Pfirman, 2011; EAB, 2017; Klein & Falk-Krzesinski, 2017).

Recommendation 5: Develop and implement a system for evaluation and review of interdisciplinary graduate programs.

Interdisciplinary (and disciplinary) graduate programs at UD are not engaged in regular assessment and are not required to report specific, measurable goals with any

consistency. Historically, assessment of interdisciplinary graduate programs has been limited to when the program is reviewed for permanent status (five years for MS programs and seven years for PhD programs). The bylaws for the Graduate College include new evaluation requirements that will increase the oversight of interdisciplinary programs during the provisional period. Interdisciplinary graduate programs are now required to submit an annual statement to the Graduate College Dean and it must include the number of matriculated students, the number of faculty advisors, summary of degree completion milestones achieved by students, and the numbers of presentations and publications made by students and faculty in the program. The Graduate College Dean will use this data to provide an annual appraisal, but it is not yet clear what purpose this report will serve. For example, the current bylaws state the permanent status approval process remains unchanged. This implies the results of the annual appraisal will not be taken into consideration when granting the program permanent status.

Participants in the study suggested an external evaluation of the program be required at some stage in the program life cycle to achieve a more objective review of the program. It is recommended that the guidelines for evaluation included in the Graduate College bylaws be expanded to include an external evaluation during the permanent status approval process. Additionally, it is also recommended that an evaluation system be developed for after interdisciplinary programs have been awarded permanent status. The Graduate College should be empowered to review and reward progress towards program benchmarks. Ideally, this should be coupled to the release of funds that can be strategically allocated to successful programs.

Recommendation 6: Enhance understanding and advocacy beyond immediate faculty and staff associated with interdisciplinary initiatives.

Advocacy at the highest levels of the institution is important for ensuring that interdisciplinary research and education remain a key component of strategic plans for the institution (Borrego, 2012). Additionally, support at top levels of the institution is important for tackling the administrative challenges faced by interdisciplinary programs and helping to create policies that nurture their success (Klein, 2010). Faculty participants of this study felt that interdisciplinary graduate education was a clear priority of upper administration, including the university president and provost. However, there is a perceived lack of support for interdisciplinary graduate programs from those same individuals. Participants felt that there was no alignment between the institutional priority of interdisciplinary activities and the necessary resources to ensure their success and sustainability. This has left some faculty feeling under-appreciated and that upper administration is not sensitive to the needs and demands of interdisciplinary programs.

University leadership needs to demonstrate its endorsement of interdisciplinary programs through tangible actions. Upper level administration, including chairs, deans, and provosts, will be critical for identifying and implementing changes to better facilitate and support interdisciplinary graduate education. To implement systemic change, interdisciplinary programs need advocates beyond their immediate faculty and staff. Leadership needs to listen to the voices of the interdisciplinary community and provide coordinated solutions. Existing infrastructure should be reexamined and policies and practices that more effectively support interdisciplinary activities should be implemented.

It is also important to expand the understanding about what is required to do this type of work by creating opportunities for shared learning about interdisciplinarity and best practices (Klein, 2010). Even if participants are not directly engaged in interdisciplinary work, their involvement will help to create a broad understanding of interdisciplinary efforts on campus (Welch-Devine, 2018). These types of opportunities can be provided by a central office that is charged with the oversight of interdisciplinary programs (Klein, 2010). Additionally, a central office can raise the profile of interdisciplinary graduate education on campus. The simple presence of a central monitoring unit demonstrates the value and importance of interdisciplinary education to the institution. Graduate schools or colleges are common locations for central offices and the newly formed Graduate College at UD is well poised to serve in this role (Council of Graduate Schools, 2004).

Recommendation 7: Conduct additional research to engage more stakeholders, including graduate students of interdisciplinary programs.

The scope of this work was limited to how the administrative structures and various academic policies specifically impact the development, administration, and evaluation of science-related graduate programs at UD. A more thorough inventory is recommended to develop a more comprehensive understanding of interdisciplinary activities at UD. Information should be collected beyond interdisciplinary science graduate program and efforts should be made to capture the barriers and facilitating mechanism within all four general themes identified as important focus areas for enhancing and promoting interdisciplinarity (as described in Chapter 2). Additionally, it is recommended that future studies be expanded to include student perspectives.

There is a great deal of literature to support that students participating in interdisciplinary graduate programs can also face challenges and struggles (Keck et al., 2017). Students can encounter difficulties navigating between disciplines and it is important to understand and address concerns from all stakeholders to effectively improve institutional support of interdisciplinary graduate programs.

The literature supports that this type of thorough inventory be conducted by a high-level administrative office (Klein, 2010). This report recommends that the Graduate College and the Office of Institutional Research and Effectiveness work collaboratively on this effort. Surveys should be developed and distributed to administrators, program and center directors, and students. The increased sampling size and data sources will allow for a more comprehensive understanding of how interdisciplinary graduate programs are performing on campus, how the same issues are handled across campus, and increase the understanding of possible solutions.

Recommendation 8: Empower the Graduate College to participate in the administration of interdisciplinary graduate programs, as well as provide leadership in this area.

Central leadership can provide the necessary advocacy for helping interdisciplinary graduate programs navigate administrative challenges and graduate colleges can fulfill this function. A graduate college dean can serve as important advocate for interdisciplinary programs, especially given he/she may be seen as a more neutral party than disciplinary colleges and their deans (Borrego, 2012). Therefore, graduate colleges can play an important role in establishing a structure of governance and institutionalizing policies that better support interdisciplinary graduate education. Additionally, a graduate college can serve as a communication hub and a place for

resource banking. It can compile and distribute findings of interdisciplinary task forces and committees across the campus community.

In Spring 2018, the University of Delaware faculty senate approved the creation of a Graduate College contingent upon the Senate approving draft bylaws. In February 2019, the faculty senate approved a draft version of the bylaws and the Graduate College was launched in July 2019. The Graduate College will play an expanded role in interdisciplinary graduate education moving forward, as evident by the fact the mission and vision statement of the Graduate College includes "facilitate innovative, high-quality excellent interdisciplinary programs." Faculty were optimistic that the Graduate College was poised to play a positive role in interdisciplinary graduate education but were unsure how this would translate into practice. There is some confusion regarding what function and value the Graduate College will bring to interdisciplinary graduate programs, but this is not surprising given its infancy. Despite the lack of clarity on implementation, it is clear that the Graduate College is stepping into a more active leadership role in interdisciplinary education and it will be important to continue this trend. Many other institutions have already implemented Graduate Colleges or Schools with enhanced administrative roles, including University of Washington, University of California Davis, and Arizona State University (Borrego, 2012). The leadership at UD can look to these institutions as examples of expanded Graduate College leadership.

Due to the increased responsibility placed on the Graduate College for supporting interdisciplinary programs, it is recommended the university fund a position whose focus is to advise and assist with developing and maintaining interdisciplinary graduate programs. This person should have a comprehensive understanding of

interdisciplinary graduate activities and serve as a key resource for faculty. Moving forward, it will be imperative for the Graduate College to clarify and affirm its role in supporting and administering interdisciplinary graduate programs. If the Graduate College is committed to expanding its role in interdisciplinary education, this position would be a smart investment towards promoting the cultural changes needed to improve the facilitation and administration of interdisciplinary graduate programs.

4.1 Strategies for Implementation

Change does not come easily in higher education institutions. It tends to occur slowly and incrementally through subtle progress (Gardner, 2006). Institutions that have successfully nurtured interdisciplinary activities have done so over long periods of time with multiple self-assessments and a lengthy planning process (Sá, 2008). Change requires a robust portfolio with continuous intervention to create or adapt organizational structures (Klein, 2010). Therefore, it should be expected that implementing systematic change to better support interdisciplinary activities will take some time. However, the Graduate College is poised to play a key role in this process and should exert leadership in this area.

Graduate colleges (sometimes called schools) can play a central role in various academic policies and procedures. In addition to the standard array of policies related to admissions, academic progress and grievances, graduate colleges have the potential to influence a much broader range of processes across the institution (Council of Graduate Schools, 2019). Graduate colleges should partner with academic colleges and other campus units to achieve excellence in graduate education. The University of Delaware Graduate College is well positioned to facilitate many of the

recommendations outlined in this report. The governance structure of the Graduate College includes a graduate council who serves as the primary representative body of the Graduate College. Additionally, there are several standing committees: executive committee, interdisciplinary curriculum committee, and graduate student life committee. The Graduate College bylaws define the responsibilities of the interdisciplinary curriculum committee as the review and evaluation of:

i. graduate courses and curricula that originate within the Graduate College (e.g., Multi-College interdisciplinary programs);
ii. new or provisional University-wide academic policies and degree requirements;
iii. changes in the structure of academic programs that originate within the College;
iv. developments in graduate teaching and curricula that may affect the University; and
v. other matters related to graduate educational affairs. (p. 8)

The bylaws state that the graduate council has the authority to create *Ad hoc* committees to consider business outside the jurisdiction of the existing standing committees within the Graduate College.

In order to achieve the recommendations outlined in this report, the first proposed call to action is to challenge the Graduate Council with prioritizing the recommendations and developing a timeline for implementation. When formulating the timeline, it will be important to keep in mind that change in the academic world is slow and institutions who have been effective in interdisciplinary change have done so gradually and incrementally (Sá, 2005; Klein, 2010). It is not feasible to immediately tackle all recommendations provided here and UD should prepare for a multiyear implementation process. After priorities have been identified, the graduate council should identify who are the key facilitating stakeholders and assign tasks appropriately. While the literature is rich in identifying best practices important for supporting

interdisciplinary education, there is not much guidance provided on how to implement these best practices. Most likely this is a result of a need for each institution to identify a path forward that works best within their campus practices and culture. My experiences while working at UD have led me to believe that UD governs mostly through the formation of committees and the Graduate College bylaws support this assumption. The strategy of using committees and task forces to propel interdisciplinary change has been successfully executed by other academic institutions (Dubrow & Harris, 2006; Klein, 2010). Additionally, the recommendations assigned to committees will require a thorough review process and continuous intervention. Committees will play a key role in this process and will be a critical component to driving real change. Therefore, this implementation plan relies heavily on committees. It is important that these committees reside within the Graduate College so it can serve as the anchor to these conversations and help keep them moving forward.

This report has generated an initial draft of prioritization and key facilitating stakeholders that could be used as a starting point for the graduate council (Table 12). To develop the order of priority, both the importance and ease of implementation was considered. For example, empowering the Graduate College to take leadership in this area (recommendation eight) can be done relatively quickly and with minimal effort. Therefore, it was given the highest priority. The Graduate College will naturally emerge as a leader in this area by serving as the central office driving these conversations forward and the simple act of organizing these discussions is the first step in this evolution of leadership. The Graduate College will also need to host events to distribute findings and brainstorm future activities, such as workshops and forums. These types of events have demonstrated success in creating interdisciplinary institution

wide change (Klein, 2010). Not only will they facilitate progress towards change, these events will help to build the interdisciplinary community, as well as enhance the understanding and advocacy beyond the immediate faculty and staff associated with interdisciplinary initiatives (recommendation six). For those already directly involved in interdisciplinary activities, these gatherings provide an opportunity for exchanging ideas and building collaboration. Broader participation will serve to give the campus community a more comprehensive understanding of what is required to make interdisciplinary programs successful.

The first in this series should be an inaugural interdisciplinary graduate education forum that includes program administrators (both faculty and staff), faculty and senior leadership, such chairs, deans and provosts. Coordinating this event will also help to quickly establish the leadership role of the Graduate College and help to clarify the function and value the Graduate College brings to interdisciplinary graduate education. At this event, the working definition of interdisciplinary graduate education would be shared, as well as a preliminary draft of key priority areas for improving the facilitation of these programs. Meeting participants should have an opportunity to provide feedback and to volunteer for serving on *Ad hoc* committees. This would be an opportunity for the Graduate College leadership to engage various stakeholders in the efforts to better support and sustain interdisciplinary graduate education.

Table 11. Summary and Prioritization of Recommendations

Recommendations		Priority	Facilitating Stakeholders
1	Adopt an administrative definition of an interdisciplinary graduate program and clearly communicate it to the campus community.	2	Graduate College Committee, Graduate College Dean
2	Develop policies and procedures for providing appropriate assistance to faculty seeking to develop new interdisciplinary graduate programs.	4	Graduate College Committee, Graduate College Dean, Directors of Interdisciplinary programs, staff who have previously assisted in program development
3	Develop funding schemes to support and sustain funding for interdisciplinary graduate programs.	6	Graduate College Committee, President, Provost, Vice President for Finance, Deans
4	Reexamine and update academic policies and practices related to faculty appointments, tenure, and promotion to ensure faculty receive appropriate recognition and credit for interdisciplinary efforts.	5	Graduate College Committee, Vice Provost for Faculty Affairs, Deans, Faculty with appointments in interdisciplinary programs
5	Develop and implement a system for evaluation and review of interdisciplinary graduate programs.	8	Graduate College Committee, Graduate College Dean, Directors of Interdisciplinary programs
6	Enhance understanding and advocacy beyond immediate faculty and staff associated with interdisciplinary initiatives.	3	Graduate College staff, Deans
7	Conduct additional research to engage more stakeholders, including graduate students of interdisciplinary programs.	7	Graduate College Committee, Graduate College Dean, Office of Institutional Research and Effectiveness
8	Empower the Graduate College to participate in the administration of interdisciplinary graduate programs, as well as provide leadership in this area.	1	University President, Provost, Deans

The recommendations provided in this report are intended to advance efforts to facilitate interdisciplinary graduate education. They are envisioned as a starting point to move past the rhetoric of endorsement and towards tangible results. Barriers and impediments need to be eased, resources need to be leveraged and best practices need to be incorporated into the university. It will require collaboration and cooperation between and among faculty, departments, colleges, central offices, and university leaders. It will be challenging and slow, but efforts will be rewarded. Universities who have made a commitment to interdisciplinary and have implemented structural and organizational changes have seen benefits to both scholarly research and grant activity (Leahey & Barringer, 2020). If interdisciplinary graduate education continues to be an important initiative for the University of Delaware, it is critical to move forward with real change that truly supports interdisciplinary graduate education.

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APPENDICES

Appendix A

GRADUATE COLLEGE BYLAWS

Bylaws of the Graduate College

I. Mission and Vision of the Graduate College of the University of Delaware

The Graduate College of the University of Delaware has been established in order to better lead and incentivize University-wide partnerships among administration, academic colleges, faculty, staff, and students. To that end, it will:

- Support curriculum innovation to enable both university-wide achievement of excellence in graduate and professional education and substantial enrollment growth,
- Facilitate innovative, high-quality excellent interdisciplinary programs,
- Coordinate professional skills-building opportunities and career planning resources and programming of high value to all graduate students,
- Prepare graduate students to be leaders throughout their careers in a broad spectrum of professions,
- Foster diversity and inclusion,
- Advocate for and support high-quality graduate student life services,
- Advocate for the importance of excellence in graduate education and research training, and its multifaceted relationships to faculty research, undergraduate education, and community engagement,
- Improve recruitment, retention, mentoring, community-building, and alumni engagement
- Providing centralized support for market research, public relations and communications, and data-rich, evidence-based decision-making related to both capacity planning and program intake/outcomes assessment,
- Enhancing funding activity

These Bylaws therefore have been drafted in order to provide definition to and instruction for the implementation of these goals.

II. Relationships between the College and other Units

The relationships between the College and other units are unique because 1) College faculty members hold primary appointments in other units and secondary appointments in this College and 2) the mission of the College is to foster and improve graduate education and programs dependent on faculty with their primary appointments in the other units. Thus, the College's relationship to other units often will be lateral or subordinate to them. See proposed organizational structure (Figure 1.)

III. College Faculty and Governance Structure

A. Graduate College Faculty

The faculty of the Graduate College shall consist of all full-time faculty members of the University who hold primary appointments in the other colleges, and appointment to the graduate college will be considered secondary. All these full-time faculty have voting rights in the college.

1

B. Vice Provost for Graduate and Professional Education and Dean of the Graduate College

The Vice Provost for Graduate and Professional Education/Dean of the College (hereinafter the Dean), as chief representative and administrative officer of the College, shall have general administrative authority over routine College affairs. The Dean shall exercise leadership in recommending policies to the Graduate College Council, in the introduction of educational ideas and proposals to the Council, and in the stimulation of discussions leading to improvement of the University's graduate programs. The Dean's responsibilities shall include strengthening graduate education and advocating for graduate programs to the University and to the community. The Dean, as chief executive officer of the College, shall have final authority to make budgetary and personnel recommendations to the Provost.

The Dean shall consult with the Deans of the other units on matters which affect the other colleges, and shall consult with the College community concerning budgetary matters which affect the College as a whole. The Dean shall have the opportunity to review and advise on the administrative and technical (e.g. accreditation standards) aspects of new graduate program proposals before they enter the Faculty Senate approval process. For the programs initiated and housed in the Graduate College, the Dean shall serve the same function as the academic college deans. For existing programs housed in the other colleges, the Dean's input shall be limited to making recommendations to the program or to the relevant Dean of the college that houses the program. The Dean can be asked, at the candidate's discretion, to write letters of support for the promotion and/or tenure process, which the candidate may choose to include in their portfolio.

The Dean will play a coordinating role of the of Academic Program Reviews (APRs) of interdisciplinary programs initiated and housed within the Graduate College, however the Dean's participation in the APR's of disciplinary specific programs will be at the department's request.

The Dean is encouraged to formulate, and have approved by vote of the Graduate College Council, administrative procedures, which, though not a part of the Bylaws, shall be archived on the Graduate College website for the information of the University faculty.

C. Graduate College Council

The Graduate College Council (hereafter the Council) shall be the primary deliberative and representative body of the College. It shall consist of thirty-five

(35) faculty members who are nominated and elected as the representatives of graduate programs within the academic colleges. Those who serve in an administrative position at or above the level of department chair or academic program director (as defined in the *Policy Guide for Department Chairs and Academic Program Directors*) may not serve as Council members.

The proportion of representatives on the Council out of the thirty-five (35) will be based on a model weighted so that 50% of the representatives are based on the proportion of faculty in each college, and 50% from the proportion of full-time graduate students in each college (see Table 1). Every college must have a minimum of two (2) faculty, and there shall be one faculty member representing Professional and Continuing Studies who shall be appointed by the Provost. In addition, there will be members chosen by the duly formed Graduate Student Government, one from each of the other academic colleges (who may represent master's, doctoral, professional graduate programming, and/or post-doctoral students). Of these graduate student members, three (3) will be voting members and the others will be non-voting members. Additionally, the Vice President for Research, Scholarship and Innovation, and the Vice Provost for Graduate and Professional Education/Dean of the Graduate College will be *ex officio*, non-voting members of the council. The faculty serving as elected Council members may be, but are not required to be, the program directors of existing graduate programs, but must be active in some aspect of graduate education recognized as such in their college. Council members of the academic colleges must be elected by secret ballot among eligible faculty members of a college in a manner that is consistent with their college bylaws. Such elections shall be held annually by June 1 and the newly elected faculty Council member shall begin their term of office September 1. Colleges shall be notified by the Council Secretary by February 1 if they are required to hold an election that semester. Council members are eligible for reelection every two years with a term limit of two (2) terms. Colleges should stagger elections so that approximately half the Committee members are elected to office each year. The following requirements also will apply:

Any Council member who has more than two unexcused absences from Council meetings in any one semester shall automatically forfeit their position as Council member.

When a vacancy occurs in the position of an elected Council member, the college in need of the Council member shall be notified by the Graduate Council Secretary, and that college shall elect a new representative no later than thirty days after notification.

Faculty holding administrative appointments at the level of department chair or higher are ineligible for election as Council members.

D. College Council Meetings

1. Purpose of meetings
The purposes of Council meetings are to 1) discuss issues relevant to all aspects of graduate education, 2) develop and propose university-wide policies, which support and improve common aspects of graduate programs, for submission to the Faculty Senate, and 3) approve proposed interdisciplinary and multidisciplinary graduate programs for submission to the University Faculty Senate Graduate Studies Committee. These meetings will be open to all faculty with secondary appointments in the Graduate College.

2. Scheduling of meetings
The Council shall meet at least monthly during the regular fall and spring semesters and more often, if needed. More frequent meetings can be called by a majority vote of the Graduate College Executive Committee (Section IV A) or by petition of at least twenty percent of the Council members. Council meetings shall be open to all members of the College Faculty and invited guests. The Dean shall assign an administrative assistant to aid the Council when needed as determined by the Executive Committee in consultation with the Dean.

3. Agendas and minutes
Agendas for Council meetings shall be prepared by the Executive Committee and distributed to the Council Secretary.

Agendas for Council meetings shall be distributed electronically to Council members at least one week in advance of the meetings and also posted on the College website. Agendas also shall be distributed to all units (e.g., departments, schools, etc.) that are represented on the Council for distribution to all faculty members within those units.

Minutes shall be taken by the Secretary and shall include a summary record of discussions, voting, and newly introduced business. They shall be distributed by the Secretary, as are agendas no later than two weeks after a Committee meeting.

4. Procedures for Council meetings

a. A quorum in Council meetings shall consist of a majority of the members. A quorum is necessary to conduct business. If a quorum is not present, then discussions of agenda items may be conducted, but no voting or decisions shall be made concerning any items.

b. Only elected Council members, or in their absence formally designated graduate program alternates, may act as official members of the Council and have voting privileges. Alternates must be elected by the relevant graduate program faculty as are the primary members. To designate an alternate for a specific meeting, the primary elected member must provide the Secretary of the Council the name of the designated alternate before the relevant Council meeting takes place.

c. The Council shall establish or amend its rules of procedure in these Bylaws as described in Section VI. Ratification and Amendments of Bylaws.

d. In cases not addressed by the rules of procedure set out in these Bylaws, Robert's Rules of Order Newly Revised shall be the parliamentary authority.

e. The Chair of the Council shall appoint a parliamentarian, subject to confirmation by the Executive Committee, whose responsibilities will be to advise the Chair in procedural matters during meetings. If the parliamentarian is not already an elected Council member, then they do not have the right to vote.

f. The Council approves motions with majority vote of those present and voting either yes or no, except for amendments to these bylaws, which requires a two-thirds majority vote.

g. Matters may be brought before the Council by the Dean, Council members, the Executive Committee, or College faculty members. Items may be introduced either at the end of a Council meeting under Introduction of New Business or by contacting a Council member and submitting it directly to them. If the former method is used, then the item shall be routed to the applicable sub-committee, if applicable, and/or placed on the agenda of the next Council meeting with time permitting. If the latter method is used, then the Council member shall forward the matter to the Council officers for sub-committee referral and/or consideration at a future meeting.

h. Attendance at meetings of the Council is open to all members of the College.

IV. College Committees and Their Functions

In addition to the standing Graduate College committees listed below, the Graduate College Council has the authority to create additional standing committees by amending this section of the Bylaws to specify the title, responsibilities, committee composition, and terms of appointment of committee members. Decommission of standing committees shall be accomplished by amending these Bylaws to remove them from this section.

The following conditions apply to all College committees:

- Recruiting and appointing members of standing committees is the responsibility of the Council or a subcommittee delegated by the Council, excepting the Executive Committee members who shall be elected only by the full Council as stipulated in section IV.A, below. Standing committee appointments must be confirmed by vote of the Council.
- Faculty members who serve on standing College committees and/or *ad hoc* College committees are not required to be Council members, but they must be members of the College faculty and must be active in some aspect of graduate education, as recognized by the Council.
- Chairs of standing committees shall be elected by the Council.
- A standing committee chair may form subcommittees as necessary.
- Standing committees may initiate matters within the scope of their committee responsibilities.
- *Ad hoc* committees have responsibilities that are limited in both scope and time, and may be created only to consider business outside the jurisdiction of the standing committees. *Ad hoc* committees may be created by either the Council or the Dean without amending the Bylaws. Chairs of such committees shall be appointed by the Council or Dean, respectively.
- The activities of all standing and *ad hoc* committees shall be supervised by the Council, and all committees shall make their reports and/or recommendations to the Council, who shall have final authority for approving any proposed actions at the Graduate College level.
- Those who serve in an administrative position at or above the level of department chair or academic program director (as defined in the *Policy Guide for Department Chairs and Academic Program Directors*) may not serve as chairs of standing or *ad hoc* committees, but may serve on them when their expertise is deemed desirable.

- Committees shall have thirty (30) business days (during regular fall and spring semesters) to act upon business items forwarded to them. If the committee cannot address an item within that time frame, the committee chair shall formally communicate to the originator of that business item the reason for the delay and the time frame by when the committee's action will occur.

Standing Committees:

A. Executive Committee

There shall be an Executive Committee made up of one representative from each academic college and one voting graduate student representative. Executive Committee members shall be elected yearly from the thirty-five (35) elected faculty members of the Council and one of the three voting graduate students. The Committee members shall elect a Secretary from the Committee membership who shall serve both the Executive Committee and the Council.

Executive Committee members shall be elected annually by the Council members by June 1 in the spring semester to begin a one-year term starting on September 1 of the following academic year. The Executive Committee chair shall be elected by the Council and shall preside over the Executive Committee and Council meetings. The Secretary shall keep a record of official actions of the Committee and the Council and shall post minutes on the College website. The Dean or their designee may attend Executive Committee meetings but shall only vote in the case of a tie.

The Executive Committee shall have the following authorities and responsibilities:

i. to establish the agenda for Council meetings;
ii. to refer appropriate matters to a standing or *ad hoc* committee of the College;
iii. to call special meetings of the Council;
iv. to make recommendations to the Council for action on any matter related to the College;
v. to investigate any condition that could affect the College's academic freedom or that of any of its members. The committee shall report its findings to the College Council and faculty;
vi. to discharge any other responsibility or authority that the Council assigns to the Executive Committee.

B. Interdisciplinary Curriculum Committee

This committee shall be composed of one faculty member from each of the other colleges, who shall serve renewable two-year terms, one graduate student, and one representative chosen by the Dean. This committee shall review and evaluate:

i. graduate courses and curricula that originate within the Graduate College (e.g., Multi-College interdisciplinary programs);
ii. new or provisional University-wide academic policies and degree requirements;
iii. changes in the structure of academic programs that originate within the College;
iv. developments in graduate teaching and curricula that may affect the University; and
v. other matters related to graduate educational affairs.

C. Graduate Student Life Committee

This committee shall consist of three faculty members, one of whom shall be chair, three graduate students chosen by the Graduate Student Government, one representative chosen by the Dean, and the Vice President (or designee) for Student Life. The Chair shall be selected and approved by a vote of the Committee at the beginning of each term. Committee members shall serve two-year renewable terms, which should be staggered insofar as possible.

This committee shall make recommendations bearing upon the care and support of graduate, professional, and post-doctoral students. It shall advise the College Dean on the implementation of rules and regulations enacted by the Graduate Council or the Faculty Senate. The committee shall advise upon graduate student financial aid, graduate student housing, graduate student counseling and placement, and graduate student health and mental health. It may meet with the directors of administrative units responsible for these matters at the request of the directors or at the discretion of the chairperson of the committee. Recommendations, which may be in the form of resolutions, may be routed from this committee either through the Council or directly to the Faculty Senate Committee on Student Life for consideration for approval.

V. Cross-College Interdisciplinary Graduate Programs

A Cross-College Interdisciplinary Graduate Program is a course of graduate study composed of two (2) or more departments across different colleges. The following bylaws are for the development, administration, approval, and assessment of Cross-College Interdisciplinary Graduate Programs (herein after Interdisciplinary). These programs should balance their coursework across multiple departments within the program.

A. Mechanism of Program Development

Interdisciplinary graduate programs should be faculty-initiated and developed by those faculty directly involved in the areas to be included in terms of scholarship, education, and research, etc. It is recognized that program development is best conducted by those most intimately associated with the program areas, and by those tasked with actually carrying out the research, teaching, and mentorship missions of the University. Each new program will endeavor to address a major fundamental problem or complex societal issue requiring an interdisciplinary team of scholars. Their focus will be on using innovative and integrative approaches to produce the next generation of global leaders in science, education, social sciences, business, literature and the arts. MOU's or other agreement mechanisms should be developed by the Graduate Council and sent to the relevant deans for consideration.

B. Justification for Program Development

Each new program must provide clear support for programming from participating departments and justification for its inception, approval, and adoption. Justifications for new Cross-College Interdisciplinary Programs may include:

1. Established education, research history, or trends observed or anticipated in a proposed interdisciplinary area (e.g., communicated national funding priorities, observed opportunities, etc.).
2. The existing talent, desire, and resources available to support the proposed area.
3. Current and/or anticipated collaboration in complementary scholarship fields or disciplines.
4. University investment priorities designed to increase the impact of education or research in a particular area.
5. Letters of support from the departments of the faculty that are participating in the new program.

C. Cross-College Interdisciplinary Program Organizational Structure

Cross-College Interdisciplinary Graduate Programs will be initiated and overseen by a Program Director and an Associate or Assistant Program Director. These will serve in a leadership capacity for the program and are charged with drafting the operational program information (see below), soliciting and securing faculty participation from the various departments and colleges participating in the program, and will be included as signatories on all graduate theses and dissertations conferred by the program.

The hierarchy for these programs will be as follows:

Provost
Graduate College Dean
Program Director/Assoc. Director
Participating Faculty

D. Operational Information for the Establishment of a New Interdisciplinary Graduate Program: (to be provided as forms)

E. Interdisciplinary Program Temporary Status Approval Process
Adoption of proposed Interdisciplinary Graduate Programs (including certificate, non-thesis Masters, M.A./M.S., and Ph.D.), upon completion of the appropriate submission form through Curriculog, will require the generation of a resolution for approval by a vote of the Faculty Senate. The process for submitting an Interdisciplinary Graduate Program will require approval on Curriculog using either of the following flow charts (depending on the initiating entity):

Pathway A. **Interdisciplinary Programs** **Composed from Existing Programs**	**Pathway B.** ***De Novo* Interdisciplinary Programs**
Shared Department Curriculum Committees	**Interdisciplinary Curriculum Committee**
Shared Department Chairs	Interdisciplinary Program Director
Shared College Curriculum Committees	|
Shared College Deans	|
Graduate College Dean	Graduate College Dean
Faculty Senate Graduate Studies Committee	Faculty Senate Graduate Studies Committee
Faculty Senate Coordinating Committee on Education	Faculty Senate Coordinating Committee on Education
Faculty Senate Exec	Faculty Senate Exec
Faculty Senate	Faculty Senate

F. Interdisciplinary Program Assessment
In the establishment of new interdisciplinary programs, the proposed director(s) must outline their outcome goals for the program, in terms of target numbers of graduate students trained, the level of this training (e.g., non-thesis, Master's or Doctorate), the level of faculty involvement (numbers, departments, positions). For example, what would their successful program look like in 5 (M.A./M.S.) or 7 (Ph.D.) years? This outline would be completed in consultation with the Dean of the Graduate College and would set mutually-agreed upon annual goals for recruitment, retention, and degree progress/completion.

Preliminary Assessment (during provisional 5 year approval)
Director(s) of a program must provide to the Graduate College Dean an annual statement of number of students matriculating into the program, the number of faculty advisers within the program, the progress of students in the program (in terms of degree completion milestones), and the numbers of presentations and publications made by students and faculty specific to this program. These data will be collected by the office of the Dean of the Graduate College and will be followed by a verbal and written appraisal each year to assess progress of the program.

G. Program Permanent Status Approval
The existing permanent program approval process already contained in the faculty handbook will be used to grant permanent status to programs.

H. Governance of such programs
Each interdisciplinary program should write their own bylaws (similar to standing departments) to assure internal governance is successful.

VI. Ratification and Amendment of Bylaws
These Bylaws were considered and passed by the University Faculty Senate to provide an initial framework for the College as seen fit by the Senate. However, it was recognized that once the College was formed, the College Council defined herein subsequently should ratify these Bylaws and have the ability to amend them. Therefore, these Bylaws should be considered in a duly scheduled meeting of the Council, ratified without amendment, or initially amended and then ratified as outlined below no later than three (3) calendar years after being passed by the University Faculty Senate. Failure to do so shall constitute automatic adoption of these Bylaws as passed by the Faculty Senate, although this will not preclude future amendment by the Council.

These Bylaws may be amended by a vote of the Graduate College Council at a duly scheduled Council meeting, provided 1) previous notice of intent to amend has been given to all Faculty with secondary appointments in the College, in the call for the meeting in which proposed amendments are to be considered, 2) notice is given at least one month in advance of the scheduled meeting, and 3) the proposed amendments are provided in the notice. At such a meeting, for the votes cast yes or no by Council members, two-thirds in approval is required to amend the Bylaws.

Because the proposed Graduate College affects all University of Delaware Colleges, the University Faculty Senate shall review and vote on any revised version of these bylaws at the end of a five (5) year provisional period beginning after their initial approval by the Senate. If the Faculty Senate does not approve the revised bylaws after the five (5) year provisional period, a joint *ad hoc* committee of the Faculty Senate and the Graduate Council will be established to coordinate and reconcile any concerns or discrepancies. Any coordinated and reconciled bylaws then shall be submitted to the Faculty Senate for consideration and voting, and this process shall continue until passage by the Senate. During the five (5) year provisional period, the Dean of the Graduate College shall provide an annual report to the Senate to be presented as an agenda item of the Faculty Senate during either the April or May Faculty Senate meeting.

At anytime during or after the provisional period (this means forever) any changes in bylaws related to the Graduate College's mission and its relationship to graduate programs in other colleges, or any changes to the organizational structure of the Graduate College within the University hierarchy (Figure 1), must be considered and approved by a two-thirds vote of the UD Faculty Senate after a two-thirds vote of the Graduate College Council's members.

Appendix B

INTERVIEW PROTOCOL

INTRODUCTION
I'd like to thank you once again for being willing to participate in the interview aspect of my study. As I have mentioned to you before, the purpose of this study is to gain a better understanding of interdisciplinary graduate program administration and organization within the University of Delaware – with a specific focus on STEM ID programs.
Our interview today will last approximately one hour during which I will be asking you questions related to the creation, administration, evaluation, and sustainability of interdisciplinary graduate programs at UD.

PREAMBLE/CONSENT FORM INSTRUCTIONS
Before we get started, please take a few minutes to read and sign this consent form. (Hand participant consent form)

If it is okay with you, I will start the tape recorder now. The purpose of this is so that I can get all the details while allowing me to stay focused on our conversation here today. I assure you all of your comments will remain confidential.

QUESTIONS
Establish Meaning

1. People sometimes apply different meanings to the word "interdisciplinary". How do you define interdisciplinary graduate education? Specifically, I am interested what it means to be an interdisciplinary graduate program (not necessarily what it means to participate in interdisciplinary research).

2. How is interdisciplinary graduate education defined here at UD?
    a. Is this well-communicated, clear, and understood?

3. How many ID STEM graduate programs do you think currently exist on campus?

Creation of Programs

Let's talk a bit about how interdisciplinary programs are created. Specifically, I would like to discuss how programs are initiated and developed.

4. Who is responsible for identifying which ID programs should be pursued?
    a. Are efforts made to ensure ID programs align with strategic themes of institution?

5. Are there policies in place that clearly allocate resources to support the development and creation of ID programs?

6. Who is responsible for doing the actual work to get the program up and running? This would include curriculum development and completion of program application for faculty senate approval.
    a. What offices or departments on campus provide support for this process?
    b. What policies are in place to help guide this process (i.e. creation and development) of ID programs?

Program Administration

So once programs are in place, let's talk about how they work.

7. What policies are in place to guide the administration of an ID graduate program?

8. Who is primarily responsible for program administration once program has been developed?

9. Can you tell me about course offerings? Do ID programs typically have their own core courses or do they rely on mix of existing courses?

I would like to take a moment to talk about staffing in particular.

10. What guidance exists for ID faculty hiring, tenure and promotion, and salary?
    a. If guidance exists, can these policies be found in any formal institutional documents?
    b. Are individual MOU's ever negotiated at time of hire?
11. Can you tell me how most faculty participate in ID programs? Are there core faculty with full-time appointments or do they usually have joint appointments between multiple units?
    a. If faculty are not full-time with the ID program, what are the expectations for faculty engaging with the ID unit?

Now I would like to learn more about the oversight of ID programs.

12. What is the extent of central administration oversight of ID programs?

13. Who provides oversight at central level?

14. What central office is charged with the responsibility and resources needed to proactively manage ID programs?
    a. If no central office is helping, who is managing resources for ID programs?

Evaluation

Related to oversight is evaluation. Now I am going to ask you a few questions related to how ID programs are evaluated.

15. What mechanisms are in place to evaluate the value of a newly proposed ID graduate program?

16. What data is collected and tracked for ID graduate programs?

17. How often are ID programs reviewed?
    a. What policies are in place to guide this process?
    b. What actions are taken if a program does not improve?

Sustainability

The final issue that I would like to discuss with you is sustainability.

18. What do you feel is needed to keep ID programs going?

19. What policies are in place for when key faculty depart, retire, or take on other responsibilities?

20. What challenges have you experienced in developing and sustaining ID graduate programs?

21. What types of supports would like to see at the department, college, or university level?

22. Do you feel progress has been made to address any issues/challenges related to developing and sustaining ID graduate programs?

Appendix C

IRB EXEMPT STATUS

UNIVERSITY OF DELAWARE
RESEARCH OFFICE
210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE:	March 18, 2019
TO:	Katherine Lakofsky
FROM:	University of Delaware IRB
STUDY TITLE:	[1231509-1] UNDERSTANDING INTERDISCPLINARY SCIENCE GRADUATE EDUCATION PROGRAMS AT THE UNIVERSITY OF DELAWARE
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	March 18, 2019
REVIEW CATEGORY:	Exemption category # *(2)*

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.

Appendix D

PROGRAM POLICY TEMPLATE

Program Policy Statement Template for Graduate Programs

Part I. Program History

A. Statement of purpose and expectation of graduate study in the program.
B. Date of Permanent Status (or current status).
C. Degrees offered (include brief description of concentrations, fields, etc.).

Part II. Admission

A. Admission Requirements (be specific about GRE, GMAT, and TOEFL Scores, G.P.A and others).
B. Prior degree requirements.
C. Application deadlines.
D. Special competencies needed (i.e., specific courses or experience).
E. Admission categories (explain other than regular such as provisional).
F. Other documents required (i.e., letters of recommendation, essays, portfolios, interviews, writing assessments, etc.).
G. **Must include** University statement: Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

Part III. Academic (present all information separately for each degree)

A. Degree Requirements
    1. List course requirements according to categories such as core requirements, concentration options, electives, research credits and dissertation credit requirements. List number of credits in each category and include total credits required for degree.
    2. Give non-registered requirements in detail; includes residency requirements, qualifying examinations (number and format), portfolios, seminars, English proficiency, language requirements, teaching experience, internships, etc.
    3. Give procedure for petitions for variance in degree requirements (e.g., course substitution policies, completion deadlines, etc.).
    4. Define any grade minimums in courses that are different from University policy.
    5. Identify any courses, which may not be used towards the degree (i.e., independent study, pre-candidacy study).
    6. Identify expectations of facility of expression in English (oral and written) as part of the degree requirement.
B. Committees for exams, thesis, or dissertations
    1. Identify initial procedure for advisor and advisement procedures.
    2. Identify each student committee needed and procedures for selecting committee members.
    3. Give deadlines for establishing and preparation requirements for comprehensive examinations.
    4. Give policies for dates of examinations, grading of committee examinations and retake options.

5. Give guidelines for approving research proposals involving human or animal subjects.
6. Define procedures for thesis/dissertation approval in the department (e.g., role of department chair, dean, etc.).
7. Define departmental and student obligations for finding committee members.
8. Define departmental and student obligations and procedures for changes in committee members.

C. Timetable and definition of satisfactory progress towards the degree
   1. Academic load (full & part-time) expectations. Define normal progress. Define departmental review procedures for evaluating normal progress and evaluation of performance.
   2. Grade requirements (general and specific). Include any special departmental expectations such as minimum grades in specific courses, limits on special problem courses, etc.
   3. Thesis/dissertation progress timetable guidelines.
   4. Thesis/dissertation defense guidelines.
   5. Forms required.
   6. Identify consequence for failure to make satisfactory progress.
   7. Protocol for grievance procedure if student has been recommended for termination for failure to make satisfactory progress.

Part IV. Assessment Plan Indicate how the program will be evaluated and assessed. Every learning outcome needs to be assessed in at least two ways. One measure must be a direct measurement (where you can see the student demonstrate their learning). Other measures can be direct or indirect (such as a survey). Success should be measured against the criteria listed including the stated learning outcomes and against whatever objectives have been set forth in the first section of the proposal. Academic units are encouraged to consult with the Center for Educational Effectiveness to develop appropriate learning outcomes, assessment criteria, and benchmarks for success.

Part V. Financial aid

A. Financial Awards
   1. Types of awards, policy for granting financial awards, summer appointments, and number of years of support.
   2. Responsibilities of students on contract.
   3. Evaluation of students on contract.

Part VI. Departmental Operations

A. General student responsibilities
   1. Up-to-date addresses, etc.
   2. Laboratories and research equipment.
   3. Hazardous Chemical Information Act.
   4. Vehicles.
   5. Keys, offices, mail, telephone, copy machine, computer terminals, etc.

B. Student government and organizations (both student and professional).

c. Travel for professional meetings or presentations

Appendix E

MOU CHECKLIST

Appendix II: CEDD Interdisciplinary MOU Checklist

Strategic issues

a. Managing expectations
b. Maintaining flexibility and contingencies

Home

a. Department(s)/program(s)/center(s)
b. Space
c. Budget (amount and split)
    i. Salary
    ii. Start up
d. Promotion/tenure committee
e. Research/teaching/community balance
f. Disciplinary/interdisciplinary balance

Mentoring and Advising

a. Departmental/External
b. Formal/Informal

Research

a. Basic/applied/theoretical/descriptive
b. Publications
    i. Approximate Number
    ii. Journals
    iii. Citations
    iv. Approach: synthesis, analysis
c. Presentations
    i. Annual meetings of professional societies
    ii. Workshops
    iii. Invited vs. contributed
    iv. On campus
d. Support
    i. Funding sources
    ii. Amounts
e. Committees
    i. National
    ii. International
    iii. Leadership

Public scholarship

a. Outreach
b. Engagement
c. Stakeholder involvement

Teaching

a. Departments
    i. Classes
b. Team teaching
c. Advising
    i. Undergraduate
        1. Academic
        2. Research
    ii. Graduate

Campus participation

a. Departmental/program meetings
b. Committees
c. Campus programming

Approvals:

Department(s) _____
Program/Center(s) _____
Dean/Provost _____

Source: Pfirman et al., 2011.