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Understanding Faculty Perspectives of Interdisciplinary Graduate Programs

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Understanding Faculty Perspectives of Interdisciplinary Graduate Programs

Abstract

The need for and value of scholars thinking across boundaries has resulted in a growing movement in interdisciplinary graduate programs. Such programs challenge students and faculty to think beyond their disciplinary expertise and work on complex problems that require perspectives from multiple disciplines. Despite the rise of these interdisciplinary programs, the disciplinary silos that persist in university settings create several structural barriers that hinder interdisciplinary programs from achieving their full potential; these include conflicts in policies, procedures, and budget models across disciplines [1]. While several of these conflicts have been explored by researchers in the early 2000s [2], [3], the persistence of the challenges coupled with the urgency of interdisciplinary work to address global challenges warrants renewed attention to these issues. In particular, despite the challenges, faculty continue to engage in interdisciplinary graduate education, but limited research has explored what accounts for this engagement. To that end, this paper explores the perspectives of faculty recently facilitating an interdisciplinary graduate certificate program at a large, public land-grant university to understand faculty decision-making related to interdisciplinary education.

To explore this issue, we use Lattuca and Pollard's model of faculty decision-making [4] to analyze semi-structured interviews with five faculty members of a current NSF-funded interdisciplinary graduate program. The framework describes the three influences of faculty decision-making: individual, such as values and beliefs; internal, such as departmental culture and supports; and external, such as job markets and national priorities. This framework provides a lens to understand how these influences positively and negatively affected their decisions to facilitate the program.

We find that with six participants, the data was saturated to indicate the limited university-level support given to faculty. Lack of time and recognition of efforts within individual disciplines or departments were consistently reported and revealed the need for incentive structures aligned with interdisciplinary values within academic institutions - a barrier that has remained constant for more than a decade. In contrast, what influenced the faculty to continue in the program was predominately the individual value for the area and the intrinsic motivation to support the success of interdisciplinary graduate students and their research. These dynamics place the onus of curricular change on faculty alone and risk their burnout. The results indicate that consistent with past findings, faculty need to be better supported through their respective departments and institutions for sustaining interdisciplinary graduate programs, and that additional work is needed to fully understand the role of more indirect factors of academic environments impact faculty decision-making.

Problem Statement

Interest in interdisciplinary research and graduate education dates back at least to the early 2000s when the U.S. National Science Foundation began funding interdisciplinary graduate education programs (first through the Integrative Graduate Education and Research Traineeship Program -

IGERT - and currently through the National Science Foundation Research Traineeship Program - NRT). The push for interdisciplinary programs and, consequently, for research on faculty participation in interdisciplinary teaching and research, has been going on for decades, and programs and funding opportunities have emerged in droves. That said, while interdisciplinary programs pose critical opportunities for interdisciplinary researchers, they also exist within both known academic structures and individual constraints that have consistently served to prevent cross-disciplinary collaborations [1], [5]–[7].

Previous scholars have highlighted the role that the siloed nature of universities, conflicting policies and expectations across disciplines, as well as resourcing challenges for interdisciplinary scholarship play in the facilitation of interdisciplinary education [2], [3]. A decade later, these challenges still persist, indicating that while universities are committed to interdisciplinary research, several structural barriers still need to be addressed, especially for faculty considering tenure and promotion [8]–[10]. However, current literature is limited in its discussions of the supports for interdisciplinary work, influences external to the universities, and faculty perspectives on what drives them to engage in curricular change necessary for interdisciplinary work despite the barriers. These gaps are important to address because faculty are critical players in the implementation of change in universities [4]; it is critical to better understand their perspectives on the impacts of not only university-level barriers but also individual and external supports (and barriers) on faculty decision-making about curricular change related to interdisciplinary graduate education. We are thus following scholars such as Graham [11] who have sought to explore what supports sustained change in engineering education as well as what limits it. In response, the research questions associated with this study are:

> RQ1: What are salient influences on faculty decisions to engage in an interdisciplinary graduate program?
> > a. What was the nature of these influences (e.g., individual, internal, or external)?
> > b. How do these influences act as supports or barriers to faculty decision-making about engaging in interdisciplinary graduate education?

Research Context: Disaster Resilience and Risk Management (DRRM) Program

This study explores faculty experiences in an interdisciplinary graduate program funded through the National Science Foundation Research Traineeship (NRT) program at a large land-grant university in the United States. Importantly, the NRT program grew out of an existing collaboration that created a university-funded interdisciplinary graduate program and will continue after the NRT concludes with the support of both the university's graduate school and a large interdisciplinary research center. Focused on disaster management, the graduate program brings students and faculty from various disciplines including engineering, business, and sciences. The program offers courses to graduate students across levels and disciplines and funding for doctoral students completing the program's graduate certificate. Courses offered to include *Principles of Disaster Risk Management*, wherein faculty have co-taught or invited subject matter experts to cover a wide variety of issues related to disaster resilience and risk management. In addition to the required program coursework, which provides students with an interdisciplinary foundation in topics related to disaster management, doctoral students pursuing

the certificate are expected to apply an interdisciplinary perspective in their research by collaborating with faculty outside of their department or including them in their doctoral committee. Faculty affiliated with this program is, thus, expected to put in time and effort in their teaching and research outside of their home department.

Theoretical Framework

In order to classify factors on interdisciplinary faculty decision-making around curricular change in graduate education, this study responds to social-cognitive scholars' recommendations for exploring the supports and barriers to specific aspects of graduate training [12], [13], by not just defining but also examining how aspects of faculty's sociocultural contexts impact their decisions. The language of supports and barriers is not commonly used in studies of faculty decision-making towards curricular change, but categorizing influences in terms of whether they enhance or impinge upon a university's ability to organize itself around organization change that facilitates interdisciplinary scholarship helps shed additional light on the impacts of individual, internal, and external influences on faculty decision-making.

In light of this goal, we take a social-cultural perspective and draw from Lattuca and Pollard's model of faculty decision-making [4]. Lattuca and Pollard define curricular change as a change in any aspect of the course or program development, including the purpose of education, content, sequence of courses or topics, instructional processes, instructional resources, assessment strategies, approaches to evaluation of courses or programs, and the feedback loop of changes. Their model identifies three contextual influences that affect faculty decisions regarding curricular choices: external, internal (institutional), and individual. External factors, such as national policies, disciplinary/professional practices, and workforce needs, can have a direct influence on internal/institutional and individual influences. Internal/institutional factors include an institution's culture, vision, and resources; it also includes culture and policies on a departmental level. Individual influences refer to the identity, experience, knowledge, and beliefs of faculty members. This component of the model recognizes that while these factors play a role in curricular change, individual faculty have the agency to act (or not to act) based on these influences.

Methods

Participants

This exploratory study draws on semi-structured interviews with six faculty members who collaborated to create the university-funded interdisciplinary program, the NRT, or both, and who currently manage and teach courses within the program. Though these faculty are affiliated with disciplinary departments, they are key leaders in this interdisciplinary program and, in some cases, more broadly in curricular change around convergence at their university. Their backgrounds span disciplines, including, but not limited to engineering, business, and sciences.

Data Collection

This qualitative study draws on hour-long, semi-structured interviews with faculty participants who are affiliated with the program. The interviews were conducted and recorded by a graduate research assistant who is also participating in an interdisciplinary graduate program and who is an educational researcher. While the interviews included a broad range of questions, this paper draws primarily from participants' responses to the following interview questions:

- What prompted your interest in disasters and led you to be involved with the program?
- What's helped or hindered you as a researcher since the program began?
- What are the rewards for and supports for interdisciplinary work - related to research, teaching, or overall?
- What are the biggest barriers? What have been the biggest successes of the program?

Note that the protocol was not originally designed using Lattuca and Pollard's framework; instead, the protocol was designed to broadly capture participants' perceptions and experiences with the program. Participant responses and reviews of the literature around faculty choices related to curriculum development led us to identify Lattuca and Pollard's work as a meaningful frame for data analysis.

Data Analysis

Once the audio-recorded interviews were transcribed by a professional transcription service, researchers analyze the data via content analysis [14] and a priori coding scheme based on the influences described in the Lattuca and Pollard model (i.e., individual, internal, external) to analyze the data. A secondary round of inductive coding was conducted afterward to identify sub-codes within the three influences. The goal of this approach was to achieve both an initial categorization of the supports and barriers to faculty decision-making about interdisciplinary curriculum change (RQ 1) as well as an in-depth interpretation of the impact of these individual, internal, and external factors (RQ 1a and 1b).

Findings

The analysis indicated two salient influences that resonated with all the participants. One was the individual faculty member's perception of the value of interdisciplinary work. While other individual influences, such as their prior experience, background, and identity, supported faculty participation in the program to varying degrees, all participants expressed their interest in interdisciplinary research and their beliefs, as educators, in giving their students the opportunity to engage in interdisciplinary work. This individual influence acted as a strong support for faculty to continue their engagement in the interdisciplinary graduate program despite ongoing barriers.

At the same time, all participants also unanimously voiced the barriers they experienced as a result of the lack of support within the institution. This internal influence, particularly related to the lack of reward structures and restricted time within the institution and departments, was consistent across all participants as a barrier they constantly experienced, and one that discouraged new faculty members from participating.

Individual influences act as a support, while internal influences act as a barrier in faculty decisions to engage in interdisciplinary programs

Internal factors include an institution's culture, vision, and resources; it also includes culture and policies on a departmental level. **Individual** influences refer to the identity, experience, knowledge, and beliefs of faculty members.

internal

individual

interdisciplinary research interests; intellectual rewards of interdisciplinary work

belief in the value of interdisciplinary work

experience and enjoyment in interdisciplinary collaboration and education

interdisciplinary identity and capacity

tenure

individual

internal

lack of time, burnout

lack of individual supports or interdisciplinary identity

disciplinary-based reward structures

Supports to faculty's decision to engage in interdisciplinary programs

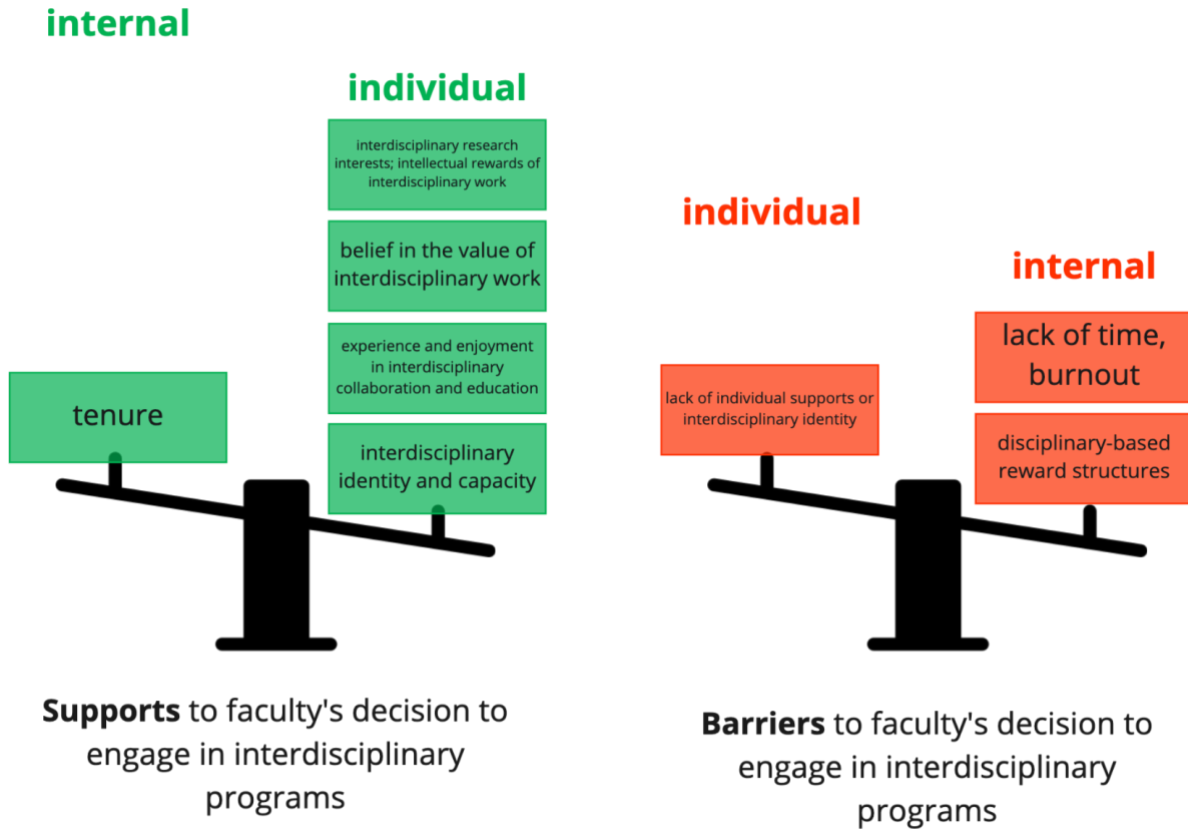**Barriers** to faculty's decision to engage in interdisciplinary programs

Figure 1: Individual influences act as a support, while internal influences act as a barrier in faculty decisions to engage in interdisciplinary programs

Interestingly, other than noting the NSF funding for the current program, our data included few if any references to external influences on their engagement with the program; that is, the interviews captured only personal values and beliefs rather than national, institutional, disciplinary, or other cultural influences. Note that this gap may be the result of the interview protocol itself, which did not explicitly seek to draw out those influences; a larger forthcoming study focused on engineering education for sustainable development (EESD) more broadly that employed Lattuca and Pollard's model in the study design does indicate that, at least for faculty outside the U.S., such external influences are salient influences [hidden for review]. Thus, the sections below focus on the individual and internal influences.

Individual Influence: Value for Interdisciplinary Work

Individual influences, as noted earlier, refer to the identity, experience, knowledge, and beliefs of faculty members. All six participants had the background and experience for interdisciplinary work prior to joining the program. One of the individual influences that particularly stood out was their belief, both as researchers and as educators, in the value they placed on

interdisciplinary collaboration and scholarship. Especially given the focus of the program, all the participants recognized the need for experts from various fields to work together to address an issue of global importance. This value, to a large extent, stemmed from their own personal experiences, previous educational experiences or research collaborations, where they faced limitations in approaching the issue with a disciplinary approach rather than from external influences such as funding solicitations or government policies and priorities:

> I think it was really appealing this idea of interdisciplinary work where I could lend my technical kind of engineering background alongside with people who are more well versed in the social aspects of the disaster problem.

> I think when people talk about finding solutions for coping with climate change, sea level rise or disasters, obviously it's a very complex problem. And, we need engineers. I'm also advocate that we need a social science as well.

The value of this interdisciplinary work took several forms among the participants. For example, one explained the importance in terms of the nature of the questions and problems they sought to address:

> And so it kind of comes down to the answers, the kinds of questions that I want to answer to answer them - to look at the breadth of the problems and the solutions I think you can't just take one approach, you can't just take one viewpoint. You really have to acknowledge and embrace the different ways of doing things. And I don't do that fully - I think I acknowledge them as fully as I can. I don't embrace them myself in terms of what I actively do because you can't do everything, but you can collaborate with people and you can kind of dabble and you can bring that perspective in. And so it's really from that way of doing things.

Similarly, another participant identified the value of interdisciplinary work for its holistic approach and contribution to a problem:

> So, um, so I think it was really appealing this idea of interdisciplinary work where I could lend my technical kind of [disciplinary] background alongside with people who are more well versed in the social aspects of the disaster problem.

Participants also attributed their interest in engaging in interdisciplinary work to intellectual rewards. One participant associated it with a sense of accomplishment:

> Rewards I think it's - it's more like intellectual rewards. You feel accomplished if you do something nobody has ever done. You feel you're unique, right? You feel like you're making a difference.

Another framed similar values in terms of the opportunities to collaborate with faculty and students of other disciplines:

That's a really nice byproduct of this – the structure of this program is that in some ways, they bring that information to me and open my eyes to, like, colleagues and opportunities across the university that I wouldn't have thought about otherwise.

Finally, participants also saw explicit value not only in interdisciplinary research, but in the ability to train their students in interdisciplinary work:

I think the real reward is that you have a uniquely trained student who has a very different perspective than a more traditionally trained student.

This training was particularly important to faculty relative to the limits of their own knowledge and experience. For example, of the six faculty that were interviewed, five identified as interdisciplinary researchers; the one who did not still stress the importance of interdisciplinarity and believed that this program enables students to engage in interdisciplinary perspectives when faculty members do not have the breadth of knowledge beyond their home discipline. While the participant expressed their limited interdisciplinary capacity, their value for interdisciplinarity reflected in their decision to engage in this program:

I'm essentially relying on the DRRM program on the faculty who teach the classes and the students that participate in the classes and the, uh, the cohort idea that is, underlying all this to, to help them to develop the necessary in interdisciplinary capacity to, you know, to be able to integrate scientific paradigms, for example, with each other in order to ask more comprehensive research question that I'm simply unable to, to ask.

Thus, while not all participants identified their research as interdisciplinary, all emphasized the value of interdisciplinary research, and this value served as a salient individual influence that supported faculty participation in the program.

Internal Influence: Lack of Time and Reward Structures

While individual influences related to values supported participants' choices to build and help maintain an interdisciplinary graduate program, all participants also recognized the challenges related to the lack of rewards within their home disciplines for the work they do. For example, faculty are expected to teach a certain number of courses within their discipline. However, engaging in an interdisciplinary graduate program entailed teaching courses outside of their department, often with a faculty member from another department. Such initiatives were rarely recognized within participants' home departments. As one explained,

The departmental structure that the university has - there's a disconnection between that and [program name] program. So that makes the faculty's devotion to the [program name] program very challenging - because - because of time allocation teaching responsibility.

Other participants explicitly noted the time challenges associated with teaching in an interdisciplinary program:

I think it's the rest of it, like there's no buyout for if you're involved in the interdisciplinary class. And I think this is a problem, and I think this is perhaps why some of the other faculty really have not been engaged, because there's not a tangible benefit.

In other words, at this institution, teaching in interdisciplinary programs typically constitutes an overload. As several explained:

Our teaching effort is not recognized at all by our whole department - by the university.

We basically have been volunteering our time for the last X number of years. And that's great. Everyone is still doing that.

So, there's just these weird things – with time and credit that are not really acknowledged at the university, and I think is because of stove-piping and the way that the university is focused on their budget model and how they've – and I think by what they don't do shows how much they do value certain things – so, for example, there's a lot of lip service on interdisciplinary, but there's nothing behind it.

The frequency with which such comments arose indicates the pervasive nature of such "volunteer labor," at least at the institution where the program is housed.

Faculty also noted that variations in degree requirements also made interdisciplinary education challenging for some students:

What is frustrating at times is, not at times, pretty much always is the silos that we see at the university that are built around the colleges and the academic units that exist within the colleges even. And the, and the uneven distribution of degree requirements in departments.

The same participant noted similar variations for faculty in the tenure process, a point that recurred across participants:

"I think, I think there are, in some departments, there are – so each department has to develop an expectations document for tenure promotion. And some departments choose to, to put in some language on, uh, interdisciplinary work, whatever they mean by that, you know? Um, but some do not. And as long as this is not an institutionalized sort of requirement to allow for that to take place, then I don't see how this is gonna, how [interdisciplinary work] is gonna happen."

Similarly, a participant clearly linked the lack of alignment between getting tenured and doing interdisciplinary work to the lack of structural supports:

To get tenure you have to be able to show your peers a high level of rigor and success in publishing the kind of research that's recognized as being good research. And if you're a civil engineer and you're doing surveys and you're doing interviews it's going to be really hard to convince your colleagues, we're all doing finite element models, that you should

have tenure, and you should become a full professor, et cetera. And so it's this sort of - it's not - it's not even so much that it is siloed. It's that the focus and then to enter individual areas is - is very specific and people have very - if you want to do is interdisciplinary research you almost have to get tenure first or you have to be in a department that values interdisciplinary research or an area that values it and has figured out how to evaluate it. And that's a hard, hard thing to do.

At the same time, participants recognized that tenure itself gave them the freedom to engage in this program, even while the path to tenure perhaps limited engagement by early-career faculty:

> So I'm - I'm not gonna stop doing this, but I can afford to not stop doing it because I'm a full professor and I've been here forever. And so, I can choose to do it and nobody's gonna stop me.

In this case, the participant explicitly identifies the balance between individual and institutional influences: for a faculty member with tenure who values interdisciplinary work, the internal influence is outweighed by the individual influence.

Discussion

Research on faculty participation in interdisciplinary work has been going on for decades, and while faculty buy into the interdisciplinary initiatives, the disciplinary silos within institutions continue to act as a barrier to faculty engagement. In some ways, our findings suggest that although the National Science Foundation has revised its funding mechanism for interdisciplinary graduate education from IGERT (Integrative Graduate Education Research and Training) to NRT (National Science Foundation Research Traineeship), little has changed for faculty since Borrego and colleagues began studying IGERT programs more than a decade ago [2], [3]. The findings of the study highlight that the weight of supports lies at the individual level and the weight of the barriers is internal level. This aligns with the more recent research which also indicates that while universities are committed to interdisciplinary research, partly because it "may be most conducive to NSF grant activity" [8], this effort is often still not supported structurally. As Leahey and Barringer point out, structural commitment is not positively associated with NSF grant activity, perhaps, due to the disciplinary silos within the NSF programs. [8]

Not surprisingly, then, while there is a push for interdisciplinary programs by universities and external structures, the lack of institutional support to sustain that effort remains. External funding from NSF provides one driver for interdisciplinary research that has some institutional value, but for our participants, the funding mechanism was not the primary drive. Rather, the value of interdisciplinary research is evident as the faculty discuss their interest in participating in this interdisciplinary graduate program. They participate because they consider it important. However, consistent with research from past decades, findings from this study indicate that tenure and promotion is a critical factor that influences faculty decisions to engage in interdisciplinary programs. With the challenges of time restrictions and departmental requirements, the number of barriers seems to outweigh the supports. And yet, these faculty

continue to participate in such programs due to their teaching beliefs and their value for interdisciplinary research.

Conclusion and Future Work

This study explored the influences behind faculty decisions to engage in interdisciplinary graduate programs. We found that the NSF grant activity was an external influence that supported such programs, but, even though faculty were interested and motivated to engage in these programs, the lack of institutional and departmental support acted as a barrier. In this way, the faculty's individual motivations were not enough to produce systemic change around interdisciplinary scholarship in their universities. Issues of burnout suggest that only faculty with power and capacity can engage in interdisciplinary work, highlighting equity issues are also relevant to the need for incentive structures that better prioritize interdisciplinary thinking. The pressing nature of global challenges and the need for sustained interdisciplinary scholars and educators suggest that universities cannot continue to rely solely on the "goodwill" of faculty with the privilege and/or the commitment to engage in such work.

The key takeaway from this study is that interdisciplinary graduate programs need to be better supported by providing faculty with the rewards, tools, and resources for sustainable faculty engagement. A short-term recommendation would be to help faculty build interdisciplinary communities and provide faculty with the tools and resources to navigate around the disciplinary silos of an institution. As Cutler et al. point out [15], taking a holistic view of faculty and enabling faculty to engage in a way that closely aligns with individual faculty would be essential. However, as this study highlights a decade-long persistent problem, long-term solutions are much needed. Faculty developers who have the capacity to influence institutional structures might collaborate in efforts to change the existing system and advocate for better incentives for interdisciplinary work.

While this study indicated the possibility that this lack of support may be a negative influence on new faculty members, this would need to be further explored to understand the correlation between tenured faculty and the engagement in these programs as well as the way these dynamics change over time. This study focuses on a cross-sectional set of faculty data but it is likely that factors on faculty decision-making for interdisciplinary curricular change develop over time, particularly upon tenureship. Therefore the importance of incentive structures that prioritize interdisciplinary work for faculty and avoid their burnout is especially crucial for the participation of faculty members who are not tenured yet, and future work should explore more external factors on faculty decision-making about interdisciplinary curriculum change, the way these factors are impacted by time and context, and how the lack of interdisciplinary support structures for faculty create equity issues for non-tenured faculty.

Acknowledgments

References

[1] M. Welch-Devine, A. Shaw, J. Coffield, and N. Heynen, "Facilitating Interdisciplinary Graduate Education: Barriers, Solutions, and Needed Innovations," *Change: The Magazine of Higher Learning*, vol. 50, no. 5, pp. 53–59, Sep. 2018, doi: 10.1080/00091383.2018.1510268.

[2] D. Boden and M. Borrego, "Academic Departments and Related Organizational Barriers to Interdisciplinary Research," *Higher Education in Review*, no. 8, pp. 41–64, 2011.

[3] M. Borrego, D. Boden, and L. K. Newswander, "Sustained Change: Institutionalizing Interdisciplinary Graduate Education," *The Journal of Higher Education*, vol. 85, no. 6, pp. 858–885, Nov. 2014, doi: 10.1080/00221546.2014.11777350.

[4] L. Lattuca and J. Pollard, "Towards a Conceptualization of Faculty Decision-Making About Curricular and Instructional Change," p. 20, 2016.

[5] M. Paretti, J. Deters, and M. Menon, "Building a Sustainable University-Wide Interdisciplinary Graduate Program to Address Disasters," in *ASEE Annual Conference & Exposition*, 2022. [Online]. Available: https://strategy.asee.org/41956

[6] J. R. Deters, M. Menon, M. C. Paretti, and M. Webb, "Exploring Interdisciplinary Identity Development Using Possible Selves: An Exploratory Study," *REES AAEE 2021 conference: Engineering Education Research Capability Development*, pp. 653–661, 2021, doi: 10.3316/informit.354300280910991.

[7] K. O'Meara and C. M. Campbell, "Faculty Sense of Agency in Decisions about Work and Family," *Review of Higher Education: Journal of the Association for the Study of Higher Education*, vol. 34, pp. 447–476, 2011, doi: 10.1353/rhe.2011.0000.

[8] E. Leahey and S. N. Barringer, "Universities' commitment to interdisciplinary research: To what end?," *Research Policy*, vol. 49, no. 2, p. 103910, Mar. 2020, doi: 10.1016/j.respol.2019.103910.

[9] I. Schoon, "Let's Work Together: Towards Interdisciplinary Collaboration," *Research in Human Development*, vol. 12, no. 3–4, pp. 350–355, Oct. 2015, doi: 10.1080/15427609.2015.1068050.

[10] S. N. Barringer, E. Leahey, and K. Salazar, "What Catalyzes Research Universities to Commit to Interdisciplinary Research?," *Res High Educ*, vol. 61, no. 6, pp. 679–705, Sep. 2020, doi: 10.1007/s11162-020-09603-x.

[11] R. Graham, *Achieving excellence in engineering education: the ingredients of successful change*. London: Royal Academy of Engineering, 2012.

[12] L. M. Gonzalez, K. L. Wester, and L. D. Borders, "Supports and barriers to new faculty researcher development," *Studies in Graduate and Postdoctoral Education*, vol. 10, no. 1, pp. 21–34, Jan. 2019, doi: 10.1108/SGPE-D-18-00020.

[13] C. J. Gelso and R. W. Lent, "Scientific training and scholarly productivity: The person, the training environment, and their interaction," in *Handbook of counseling psychology, 3rd ed*, Hoboken, NJ, US: John Wiley & Sons, Inc., 2000, pp. 109–139.

[14] S. Stemler, "An Overview of Content Analysis," 2001, Practical Assessment, Research, and Evaluation: Vol. 7, Article 17, doi: https://doi.org/10.7275/z6fm-2e34

[15] S. Cutler, A. Kottmeyer, R. Heinen, Y. Xia, S. Zappe, and T. Litzinger, "A holistic assessment of the responsibilities and areas of support of engineering faculty," *International Journal for Academic Development*, pp. 1–14, Dec. 2020, doi: 10.1080/1360144X.2020.1855592.