Sustaining Faculty Collaboration: An Exploratory Process-Based Study of Research Collaboration Across Universities

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1. Introduction

Research collaborations between faculty members have become a typical practice in higher education. Faculty increasingly engage in collaborative work, individually or as part of a team, within their own institution or across institutions. Inter-institutional collaboration, as a form of partnership across domains, disciplines, institutions, and countries (Leachy, 2016), is also becoming more common and funding agencies encourage and in some cases require such practices (Cummings and Kiesler, 2005; Sonnenwald, 2007). Despite uncertainty about the influence on scientific productivity (Lee and Bozeman, 2005) and challenges of coordination and communication (Cummings and Kiesler, 2005), research collaboration between faculty across institutions has grown significantly over the past several decades (Jones et al. 2008). However, when it comes to collaboration across institutions with different identities and missions, the situation is less encouraging. Collaborations among elite schools and research-intensive universities appear to dominate multi-university partnerships and faculty tend to collaborate with individuals who are affiliated with institutions with similar status level as theirs, independent of geographic distance (Jones et al. 2008). Overall, inter-institutional collaborations among Predominantly White Institutions (PWIs) and research-intensive universities appear far more well supported and likely than between PWIs and Historically Black Colleges and Universities (HBCUs) or other minority-serving institutions (MSIs).

The Institute for Critical Technology and Applied Science (ICTAS) at Virginia Tech has deployed a unique seed funding program, the ICTAS Diversity and Inclusion Seed Investment (*ICTAS D&I Investment*), since 2016 to build direct faculty-to-faculty research partnerships between faculty at Virginia Tech, a PWI, and faculty at HBCUs/MSIs. Research centers and institutes typically provide some level of support for facilitating different research activities, in which collaboration is encouraged (Biancani et al. 2018; Boardman and Corley, 2008). A unique feature of the ICTAS D&I Investment though is its diversity-focused nature that promotes research collaboration across different types of institutions. ICTAS expects the partnerships to result in research proposals and the hope is that collaborative partners at Virginia Tech and HBCUs/MSIs maintain their working relationships beyond the duration of funded partnership.

During the last three years (2016-2019), 50 awards of $10k were made to help build and foster collaborative efforts between Virginia Tech faculty and HBCUs/MSIs partners. As a result, twenty-three different HBCUs/MSIs and at a minimum of 38 distinct collaborative pairs were involved in the program. Within Virginia Tech, six colleges and four centers/institutes were involved with the ICTAS D&I Investment, with most of the awards associated with the College of Engineering and the College of Science. This investment has helped faculty by providing resources for travel, joint publications, reciprocal visits to teach and offer guest lectures, and

provide access to Virginia Tech facilities to the HBCUs/MSIs faculty as well as exposing students to increased research and education opportunities at both institutions.

We initiated a study with the motivation of developing strategies to evaluate the outcomes of the research collaborations resulting from this seed funding program that focuses on the process-oriented illustration of inter-institutional collaboration and explores the nature/quality of the collaborations (Jalali et al. 2019). The study's focus was then shifted and narrowed to explore factors that may influence sustaining faculty research collaborations across universities using a qualitative multiple case study. In reviewing the literature along the way, it was realized that despite the growing collaboration within and across institutions, study of the process and the dynamics of collaboration has remained under explored, specifically in connection with institutions with different missions**.**

This paper aims to catalyze attention to the subject of process-based collaboration and shed light on theories, frameworks, and "thinking tools" that can resolve some of the complexities embedded in engaging in such studies. We first review the literature within engineering education and highlight the limitations. Second, we expand on the concept of the process of (research) collaboration and its importance informed by the literature. Next, we explore different views towards the role of theory in studying research collaboration. Finally, we briefly review the research design and address potential propositions that may provide an account and explain different factors that influence the sustainability of research collaboration.

2. Research in the context of engineering education literature

Within engineering education, there have been limited studies on the dynamics of research collaboration in general, and faculty collaboration across universities in particular; much literature was concerned with three major areas in connection with research collaboration: collaboration between engineers and non-engineers (Borrego, 2006; Borrego and Newswander, 2008; Borrego et al. 2009), bibliometric studies examining research outputs over time (Jesiek et al. 2011; Nowaz and Strobel, 2016), and studies on engineering education research trends and international research collaboration (Beddoes et al. 2011; Borrego et al. 2009; Jesiek et al. 2011).

The first category of the literature address the need for contribution from multiple disciplines for engineering education scholarship, and explore the factors that may contribute to successful engineering education research collaboration. Borrego and Newswander (2008) interviewed 24 pairs (engineers and social scientists) of cross disciplinary teams who published in the Journal of Engineering Education in the period of 4 years. The authors distinguished between a multidisciplinary approach that is based on individual expertise and separated tasks and workload, and an interdisciplinary approach in which truly collaborative efforts and learning will take place. The authors reported a high degree of interdisciplinarity, learning, and satisfaction based on interview data. In another study, Borrego (2006) focused on teams of researchers including traditional engineering, general engineering, and education faculty who had or were

planning to write engineering education proposals, in order to understand the characteristics of cross disciplinary engineering education collaboration. While there were some differences in terms of the ways that members of a collaborative teams viewed collaboration, the author reported overall respect and understanding for their collaborative pairs. Borrego (2006) argued that common interest in the purpose of the project will determine how closely the collaborators work.

Within the second category, Jesiek et al. (2011) argued that increase in funding, general growth of the field, and expanding the numbers of academic centers of engineering education research in different countries are among the major factors that contributed to the increase of collaborative efforts in engineering education within recent years, The authors analyzed 2,173 relevant conference and journal papers between 2005-2008. Co-authorship was considered as collaboration and it was reported that 2 to 3 researchers are often involved in engineering education publications. The authors argued that engineering education research cannot be considered as a solitary activity. In another study, Nowaz and Strobel (2016) reported that authorship patterns have moved towards collaboration. The authors analyzed all the articles published in IEEE Transactions on Education between 1963 and 2011 (2250 articles). While considering publication and citation as measure of productivity and co-authorship as measure of collaboration, the authors reported that articles with two and more authors had been cited more.

In the last category, there are studies aimed in examining current state and future trend of engineering education research around the world and also studies on fostering collaboration internationally. One significant work was a series of sessions that were held in different international engineering education conferences from July 2007 to December 2008 in which engineering education research and scholarship were discussed (Borrego et al. 2009; Jesiek et al. 2010). Borrego et al. (2009) reported that participants in the workshops agreed on the need of collaboration, knowledge, and skills from multiple disciplines to advance engineering education scholarship. They also reflected on the challenges of collaboration such as language barriers, exchanges between engineers and non-engineers, shared language, culture, and body of knowledge. In another effort, Beddoes et al. (2011) reported the details and the results from three international workshops in 2009 with the emphasis on fostering international engineering education research collaboration on three areas: e-learning, gender and diversity, and problem/project-based learning. The authors reported that a few long-term collaborations have resulted from the workshops and argued that workshops and conference sessions are not enough to get to a point that there is a shared understanding, trust, and respect for building collaborative efforts. They used the pattern of interaction as an illustration of collaboration in which both online tools and face-to-face (communications) interactions play an important role.

Apart from the categories described above, Mills et al (2009) in a unique study reflected on their collaboration around studying women in engineering that included four faculty from different disciplines, civil engineering, economics, education, and sociology. The authors addressed some

factors that contributed to the process of the research collaboration such as sharing knowledge, collective understanding, and facing with distant geographic locations.

Overall, although there have been some discussions on the process of research collaboration and some important aspects such as trust and power issues in engineering education literature, not only there is a gap of empirical studies in this area but also it appears that research collaboration as an important area of research has not gained enough attention. The studies concerned with research collaboration in engineering education literature often maintained the conventional product-oriented illustration of collaboration by focusing on co-authorship or publications. Katz and Martin (1997) questioned the implicit assumptions about research collaboration, such as assumptions about the meaning and measuring the collaboration. The authors argued that there is a difference between collaboration and co-authorship; co-authorship is no more than a partial indicator of collaboration. In addition, now after more than a decade of growing scholarship and appreciation of engineering education as a field, it is important to recognize research collaboration at both *institutional* and *individual-relational* levels as important research areas both within engineering education and across disciplines.

3. Collaboration process

Within the past few decades, scholars in the interorganizational domain, perhaps more than any other disciplines, influenced by the bodies of literature in sociology, organizational studies, and management science, have made attempts to illustrate and develop different frameworks that explain meanings and dimensions of collaboration. In a comprehensive work, Gray and Wood (1991) identified six theoretical perspectives that explain collaboration: resource dependence theory, corporate social performance theory/institutional economics theory, strategic management theory/social ecology theory, microeconomics theory, institutional theory/negotiated order theory, and political theory. The authors described different perspectives in relation with three major issues crucial to understanding collaboration: preconditions, process, and outcomes. They reviewed different publications in connection with each theory. Among six major theoretical perspectives, three theories pay attention to the process of collaboration: institutional economics, institutional and negotiated order, and political perspectives, Gray and Wood (1991) argued. The authors elaborated that institutional economics theory deals with institutionalization and policy implementation rather than interactions between different stakeholders. On the other hand, the other two theories, negotiated order theory and political theory, can explain the process as "microsociological perspective" of interactions. Gray (2000) in another useful classification offered five conceptual perspectives for assessing collaborative work based on particular orientation towards collaboration. Each perspective highlights different outcomes of collaboration: problem resolution/goal achievement, generation of social capital, creation of shared meaning, changes in network structure, and shifts in power distribution. From initial examination of different frameworks illustrated by Gray and Wood (1991) and Gray

(2000), it would appear that negotiated order theory and political theory both pay attention to the process of collaborative endeavor.

Thomson (cited in Thomson and Perry, 2006) extracted the essentials of collaboration processes into five key dimensions: governance, administration, organizational autonomy, mutuality, and norms of trust and reciprocity. Thomson and Perry (2006) argued that different factors including internal relationships, external factors such as antecedent conditions, uncertainty, ambiguity, shifting membership, and multiple accountability may influence the five key dimensions. Huxham (1996) in a practice driven research in developing theoretical framework of collaboration distinguished between purpose and advantage resulted from the collaboration that cannot be achieved by single organization, "collaborative advantage," and the output in the practice, the nature of the collaboration, "collaborative inertia." Huxham noted the lack of attention to collaborative inertia-- as a central aspect of collaboration--, and conceptualized the nature of collaboration based on several themes. Among five major themes, three were emerged from the concerns expressed by practitioners: common aims, power, and trust.

The literature on interorganizational domain can-- at the minimum-- be applied to the cases in which individuals from different organizations collaborate (Huxham, 1996). However, although the criteria emphasized in interorganizational domain provide valuable resources, their explicit application in studying faculty research collaboration will depend on the organizational factors and membership structure governs the collaboration. As the structures of collaborations and decision-making processes moves from an institutional level to an individual level, the type of relationships between collaborators becomes closer to interpersonal rather than inter-institutional. While the institutional factors have been relatively well represented in literature, there are few studies that have identified and carried out appropriate methodological strategies to study the individual level-- the level of interpersonal relationships among collaborators. In other words, available research gives us a picture of institutional policies and structures that benefit research collaborations, and yet paints almost no picture of the interpersonal interactions that comprise the life, the daily activity, of such collaborations. If this argument holds, the fact that collaborators come from different institutions adds another level of complexity to the studies of the collaboration process.

The importance of the process of collaboration, its dynamics and quality of relationships among collaborators have been contended in the literature directly concerned with the faculty research collaboration (Baldwin and Austin, 1995; Bozeman et al. 2013; Clark et al. 1996; Creamer, 2003; Creamer, 2004a; Creamer, 2004b; Kraut et al. 1987; John-Steiner et al. 1998; Sonnenwald, 2007). Creamer (2003), for example, emphasized the influence of studying collaboration process in practice and creating collaborative culture: "Understanding more about the collaborative process can impact practice by helping to identify ways to create a collaborative culture that embraces difference and by clarifying how collaboration is associated with productivity and innovation" (p. 448).

Among a few empirical studies involving pairs of research collaborators in which the collaboration process was treated as central, Creamer (2003) examined the link between inquiry paradigms--- positivism, post positivism, critical theory, and constructivism--- and the dynamics of the collaboration process for four cases, including three heterosexual partners (two of them married) and a pair of women collaborators, who have been collaborating for 10 or more years. The faculty members participated in a semi-structured telephone interview and were asked to describe different aspects of the collaboration relationships, such as division of labor and negotiation of differences of opinion. The collaborators displayed clear differences across four inquiry paradigms. However, there were noticeable differences among two pairs of collaborators within a shared paradigm. Creamer concluded that the inconsistency in the patterns of collaboration dynamics points to the existence of multiple models for effective collaboration. In a similar process-oriented study, Creamer (2004b) explored how collaborators deal with conflict and differences of opinion as an element of relational dynamics. In the study, participants were asked to describe how they negotiated substantive differences of opinion. In addition to one-on-one interviews with twelve collaborative pairs, Creamer analyzed their selected publications and curriculum vita, and conducted joint interviews and observation of four faculty pairs. The author identified three different groups:

1. Like-Minded who deny significant differences of opinion
2. Triangulators who acknowledge the possibility of differences of opinion--- often not from significant issues
3. Multiplisits who acknowledge expected and frequent differences of opinion

Creamer (2004b) interpreted that all collaborative pairs experience differences of opinion, however they make different meaning of such process. Nevertheless, the participants all reflected on different means and strategies to deal with conflicts and resolve them. Eventually, it appeared that as a result of prolonged engagement and a high level of interaction between collaborators, differences of opinion are interpreted in constructive ways to the collaboration process.

One primary limitation of these studies, and similar works is that only successful collaborative relationships, often with the narrow consideration of the notion of the success were included. The focus has often remained on the prolonged collaboration history and/or involving faculty with high records of publications. In addition, there is a shortcoming with regards to consideration of different individual attributes and different institutions. Overall, there is a gap in literature focusing on the process considering the dynamics of collaboration across institutions. Baldwin and Austin (1995) in their study of faculty research collaboration emphasized the lack of information in general about the process of collaboration. In a more recent study, Bozeman et al. (2013) critically reviewed the literature on research collaboration in university-- at individual-level-- and argued that there is underrepresentation of studies examining the dynamics of relationships between researchers. A few studies that their primary focus have been the process of collaboration have often either failed to include the perspectives of both collaborators

involved in professional relationships or focused on the successful instances of collaboration treating the products (e.g. publications) as central.

4. Use of theory

In one of the most comprehensive studies on faculty collaborations, Austin and Baldwin (1991) explored teaching- and research collaboration among faculty and examined organizational and group theories useful to studying academic collaboration. The authors argued that negotiated order theory is the most appropriate model for studying collaboration among faculty. Negotiated order theory initially appeared as a model to study hospitals (Day and Day, 1977). This model recognizes informal structure shaped in settings in which groups engage in developing agreements beyond formal rules and structures. In relation with this feature, another important feature of the negotiated theory is its strength in explaining the reasons for the absence of formal rules. The negotiated order theory also pays attention to the notion of power in collaboration in relation with ability of individuals/groups in controlling events or actions. Power in this view is circumstantial and subject to change. It implies emerging quality in which formal rules and agreements are negotiated and may be changed by active participations of individuals in an organization (Day and Day, 1977).

Within interorganizational domain, Gray (1989) has illustrated one of the widely recognized proposals on collaboration. In developing a theory of collaboration, Gray emphasized a dynamic, process-oriented picture for interorganizational relations. Gray (1989) argued that the process of collaboration causes changes in interaction among those who are involved. To develop a theory, the collaboration can be considered as negotiated orders created among stakeholders. The important characteristic of negotiated order perspective is "cognitive and expressive character" of relations rather than objective and instrumental (Gray, 1989). Gray and Wood (1991) clarified: "Negotiated order theory thus focuses on the symbolic and perceptual aspects of interorganizational relationships, particularly on the evolution of shared understandings among stakeholders of the domain's structures and processes, limits, and possibilities" (p.10).

The empirical studies directly concerned with the studying of faculty research collaborations discussed different, and in some cases opposing perspectives with regards to the use of theoretical approaches to collaboration, Clark et al. (1996) in a unique study of three different sites of collaborative research between K-12 teachers and university researchers, rejected imposing any theoretical framework. The authors reflected on their own collaborations and presented story based on their group meetings and written journals in the form of Readers Theater. The authors emphasized the importance of dialogue as the central element that can change the nature and outcome of collaborative endeavor; "what is gained is a level of understanding about the constraints of one another's practices and an opportunity that allows teachers and researchers to bring their varying expertise…" (p. 197). They concluded that successful collaborations involve increasing understanding of the partner's worlds and roles

through “shared dialogue.” Clark, et al. (1996) clearly rejected adopting a theoretical orientation to studying collaboration:

> “The prospect of situating our work in some single body of theory, and placing it into a single narrative form, is problematic in that it compels us toward a monologic construction of our work…connecting this work with that of others who situate themselves in the literature of postmodern theory and feminist epistemology …allows us, in some way, to both resist and acknowledge the need for an integrative theory” (p. 202).

John-Steiner et al. (1998) criticized the lack of commitment to theorizing in the study of Clark et al. (1996). The authors examined the article’s strengths and problems under four categories: definition of collaboration, theoretical approach, methods of analysis, and processes and outcomes of collaboration. In relation with theoretical approach, treating theory in a universalistic manner was criticized; John-Steiner et al. (1998) argued that unless there is a single model, the role of theory in generalizing and essentializing is under question. Theoretical development for collaboration should specify multiple models of collaborative practice; this can include identifying themes and comparison across cases such as situations and participants, etc. (John-Steiner et al. 1998). Among other studies that moved from the exclusive view on the use of theory in studying research collaboration, Baldwin and Austin (1995) interviewed faculty in higher education with considerable history of research collaborations, and reported four major themes as the elements of a grounded theory of collaboration: the process of initiating and terminating, the negotiation and trade-offs, the role of individual’s attributes, and the role of institutional and disciplinary contexts. They emphasized the uniqueness of each collaborative relationship and rejected the use of a single explanation or series of phases that define how collaborations form and develop. The authors argued that negotiated order theory can serve as one lens that helps to explain collaborators’ experiences over time (Baldwin and Austin, 1995).

Within the context of the ICTAS D&I Investment, there are many factors that can influence and explain persistence of relationships between pairs of researchers (ties) in connection with antecedents and outcomes of research collaboration as well as the process of collaboration. Homophily, communication strategies, and a broad area of diversity, equity, and inclusion can be considered as elements of analysis. Following, we will reflect on a potential explanation along with the research design.

5. Proposed research in the context of the ICTAS D&I Investment

A qualitative multiple case study has been proposed to study pairs of researchers--- cases--- to get to a better understanding/description of the phenomenon of interest in relation with the ICTAS D&I Investment. The case study is the exploration of a bounded system or systems (cases) in specific time and place (Creswell and Poth, 2018). Yin (2018) described the case study as a preferred method for in-depth investigation of a phenomenon within its real-world context.

The intent in this project is to look at individuals' experiences, compare and contrast across collaborative pairs, and explore factors that might explain connections between the dynamics of collaboration and sustainability of research collaborations. For the purpose of the selection of the cases, an initial survey will be distributed. The survey not only serves as a screening measure but also is used as a major source of data on demographic information, quality of relationships, communication patterns, and visions about research collaboration. The primary source of data collection is one-on-one interviews with collaborative pairs.

One potential body of research that can inform this study-- and similar studies focusing on relational aspects of collaborations across institutions-- is social network. Social network literature studies organizational topics with the central argument that actors within networks of organizations are defined in relations and that interconnected relationships can explain outcomes and behaviors such as satisfaction and performance (Brass et al. 2004). At the interpersonal level, when actors are individual people, there are major factors that can be explained as antecedents of interpersonal networks: similarity between individuals, personality, proximity and organizational structure, and environmental factors.

McPherson et al. (2001) in a comprehensive review of the studies on theoretical principles and empirical studies on homophily in social networks argued that patterns of tie dissolution mimic the influence of homophily in the creation of ties-- "tie formation" -- but in a weaker way. The major argument of McPherson et al. (2001) is that people with certain qualities such as age, gender, race, class and educational background tend to interact with people like themselves.

In the context of research collaboration, Dahlander and McFarland (2013) reviewed the detailed information on interorganizational collaboration using a longitudinal dataset of faculty collaborations at Stanford University between 2003 and 2007, and asserted that homophily, tie strength, and multiplexity influence repeated interaction and persistence. Granovetter (1973) defined the strength of interpersonal tie as: "…a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie." In the study of Dahlander and McFarland (2013), strength was measured by the number of shared published papers or applied grants in a given year. Multiplexity-- different numbers of relationships collaborators may share-- was operationalized based on the information on dissertation, grant, and publication network in a given year. Importantly, the authors acknowledged the limitation of their study as it lacks the methodology to investigate and provide insight into the interactions, relationships, and behaviors between collaborators and its influence on tie persistence (and formation). In another study, Cummings and Kiesler (2008) used the concept of tie strength, informed by theory in social networks, as the indicator of intensity of working relationships among collaborators. They developed a model incorporating three factors proximity, homophily, and familiarity to predict collaborative tie strength.

6. Conclusion

There is an inherent complexity in developing process-based studies of collaboration. On one hand, collaboration as an area of study has been discussed in different disciplines; management science, psychology, sociology, and research policy are among the different bodies of literature that discussed collaboration as research topic (Sonnenwald, 2007). On the other hand, there has been a lack of attention to the process and dynamics of the collaboration, in particular in relation with collaboration across different institutions. We have initiated an exploratory process-based study of research collaboration that aims to explore factors that influence sustainability of collaboration between faculty at Virginia Tech and faculty at HBCUs/MSIs. By further understanding of key dynamics involved in inter-institutional collaborations, we can diminish the probability of missed opportunities to enhance research, improve pathways for success among traditionally underrepresented groups, and streamline resource sharing across institutions. Considering the limitations in the literature, the main objective in this paper was to elaborate on fundamental and theoretical aspects of collaboration. We hope that this paper will encourage further discussions and studies on interpersonal and inter-institutional collaboration, in particular among engineering education scholars.

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