

The Rising Doctoral Institute: Preparing Minority Students for the Transition into the Engineering Ph.D.

Dr. Mayra S. Artiles Ph.D., Arizona State University

Mayra S. Artiles is an assistant professor in engineering at the Polytechnic School of the Ira A. Fulton Schools of Engineering at Arizona State University. Her research expertise includes engineering doctoral education structure, experiences of underrepresented minorities in doctoral engineering programs, and doctoral student motivation and persistence. Her research methods specialty is qualitative data analysis. Prior to transitioning into engineering education, Artiles worked at Ford Motor Company as an Electrified Vehicle Thermal Engineer. She holds a B.S. in Mechanical Engineering from the University of Puerto Rico at Mayaguez, an M.S. in Mechanical Engineering from Purdue University, and a Ph.D. in Engineering Education from Virginia Tech.

Dr. Juan M. Cruz, Rowan University

Juan M. Cruz is an assistant professor of the Experiential Engineering Education Department at Rowan University. He has a B.S. in Electronic Engineering and a Masters in Education from Universidad Javeriana in Colombia, and a Ph.D. in Engineering Education from Virginia Tech. His research interests include using system thinking to understand how instructional change occurs, faculty development process, and faculty and students' motivation.

Sarah Anne Blackowski, Virginia Polytechnic Institute and State University

Sarah is a PhD Candidate in the Department of Engineering Education at Virginia Tech. She has a bachelor's degree in Aerospace Engineering from Embry-Riddle Aeronautical University and, during that time, spent a summer at Franklin W. Olin College of Engineering for an REU in engineering education. Sarah's research interests include: motivation, student and faculty metacognition, and engineering faculty self-regulated learning.

Dr. Holly M. Matusovich, Virginia Polytechnic Institute and State University

Dr. Holly M. Matusovich is an Associate Professor in the Department of Engineering Education. She is current the Assistant Department Head for Undergraduate Programs and the former Assistant Department Head for Graduate Programs in Virginia Tech's Department of Engineering Education. Dr. Matusovich is recognized for her research and practice related to graduate student mentoring. She won the Hokie Supervisor Spotlight Award in 2014, was nominated for a Graduate Advising Award in 2015, and won the 2018 Graduate Student Mentor Award for the College of Engineering. Dr. Matusovich has graduated 10 doctoral students since starting her research program in Spring 2009. Dr. Matusovich co-hosts the Dissertation Institute, a one-week workshop each summer funded by NSF, to help underrepresented students develop the skills and writing habits to complete doctorate degrees in engineering. Across all of her research avenues, Dr. Matusovich has been a PI/Co-PI on 12 funded research projects including the NSF CAREER Award with her share of funding being nearly \$2.3 million. She has co-authored 2 book chapters, 21 journal publications and more than 70 conference papers. She has won several Virginia Tech awards including a Dean's Award for Outstanding New Faculty, an Outstanding Teacher Award and a Faculty Fellow Award. She holds a B.S. in Chemical Engineering from Cornell University, an M.S. in Materials Science from the University of Connecticut and a Ph.D. in Engineering Education from Purdue University.

Dr. Stephanie G. Adams, University of Texas at Dallas

Dr. Stephanie G. Adams is the Department Head and Professor of Engineering Education at Virginia Tech. She previously served as Associate Dean for Undergraduate Studies in the School of Engineering at Virginia Commonwealth University and was a faculty member and administrator at the University of Nebraska-Lincoln (UNL). Her research interests include: Teamwork, International Collaborations, Faculty Development, Quality Control/Management and Broadening Participation. She is an honor graduate

of North Carolina A&T State University, where she earned her BS in Mechanical Engineering, in 1988. In 1991 she was awarded the Master of Engineering degree in Systems Engineering from the University of Virginia. She received her Ph.D. in Interdisciplinary Engineering from Texas A&M University in 1998. She is the recipient of numerous awards and honors, including the National Science Foundation's most prestigious, Faculty Early Career Development (CAREER) award. She is a Fellow of the American Society of Engineering Education, holds membership in a number of organizations and presently serves on the National Advisory Board of the National Society of Black Engineers.

Dr. Gwen Lee-Thomas, Quality Measures LLC

Dr. Gwen Lee-Thomas is the CEO of Quality Measures, LLC, a Virginia-based consulting firm specializing in program and project evaluation, accreditation preparation, and capacity building. With over 22 years of experience in project evaluation and implementation of educational activities for over \$100M in federal and state funded projects, Gwen consistently works collaboratively with her clients to maximize evaluation outcomes.

As an external evaluator, Gwen has conducted over 70 evaluations in various areas with an emphasis in STEM-H related curriculum experiences at various colleges and universities across the U.S. Gwen's work with NSF, USDOE, DOE, DOD, HRSA, and DOJ helps in providing the evaluative needs and expectations of federally funded grants with regard to accountability and compliance. In addition, she has served as a panel reviewer for NSF proposals for S-STEM and other EHR programs, GAANN, SIP, and EOC with the USDOE, and is currently an AQIP Reviewer and Peer Reviewer for the NCA Higher Learning Commission.

As an administrator, Gwen has served Director of Assessment for 6 years and Executive Assistant to the President for one year at Rose-Hulman Institute of Technology. She has also served as Assistant to the President and Provost for Special Projects at a Old Dominion University. Her experience as a Commissioner on the Indiana Commission for Higher Education has allowed her to embrace a broader perspective of the nuances of higher education and business & industry. In addition, Gwen has served as the board chair for the Indiana Minority Health Coalition—a grassroots legislated non-profit organization that promoted advocacy and education across the state with 19 local coalitions. As a full-time tenure track assistant professor and an adjunct faculty, Gwen has helped Master and PhD students understand and navigate the subtleties of organizational culture to negotiate their professional success.

Gwen received her bachelor's degree from Southeastern Louisiana University in 1984, her Master's Degree in Curriculum and Instruction in 1996, and a PhD in Education Administration in 1999 from Indiana State University.

The Rising Doctoral Institute: Preparing Minority Students for the Transition into the Engineering Ph.D.

Abstract

Studies on graduate education have shown that underrepresented minorities finish PhDs in engineering at lesser rates and longer timeframes than their majority counterparts. While multiple interventions have been designed for students considering their decision to apply for graduate school or students completing their doctoral journey, few focus on the transition into those doctoral programs. To prepare minoritized doctoral students for this transition to the Ph.D., we developed and researched the Rising Doctoral Institute (RDI). The RDI is a four-day summer workshop for incoming doctoral students who identify as underrepresented in engineering and intend to begin graduate school in the Fall semester. This paper aims to discuss the process through which we developed the RDI and our initial research findings. We conclude with our plan to disseminate these workshops across multiple US institutions using a change-theory informed dissemination model.

Introduction

According to the 2008 CGS Report, *Ph.D. Completion and Attrition: Analysis of Baseline Data*, underrepresented minorities (URM) (African American, Hispanics, and Native Americans) are more likely to depart from the doctorate in engineering than their majority counterparts (Council of Graduate Schools, 2007). More recent data has shown that for every seven White or Asian students that obtain a Ph.D., only one underrepresented minority student will obtain a doctorate in engineering (National Academies of Sciences, Engineering, and Medicine, 2018; *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019*, 2019).

Transitioning into the doctorate without having a proper understanding of what it entails can make the journey unnecessarily difficult (Lovitts, 2001; Weidman, Twale, & Stein, 2001). Students often enter the doctorate, assuming that what made them successful as an undergraduate will also make them successful as a doctoral student (Holbrook et al., 2014). This gap causes students to often lose focus of their primary responsibilities, such as research and maintaining a positive relationship with their advisor, instead of focusing their efforts less effectively on other activities such as coursework or extracurricular tasks that do not hold the same significance in the doctoral journey. It is not until later in the Ph.D. process that students face the reality that their efforts were misaligned with the best activities for degree progress (Artiles, 2019; Artiles et al., 2018). This far into the Ph.D. process, it often seems too late to refocus and make timely degree progress, causing students to lose motivation and, in some severe cases, depart from the doctoral pursuit (Lovitts, 2001).

This gap of knowing what they are facing and being prepared for the journey is often exacerbated for underrepresented minorities compared to their majority counterparts (Sowell et

al., 2015; Wood et al., 2016). Experiences related to race and ethnicity in earlier academic experiences often inform the perceptions of navigating the doctorate even before they begin their graduate education (Wood et al., 2016). Sowell et al. (2015) have found that minoritized students often rely on informal support to complete the doctorate, such as mentors, peers, and personal determination. However, they are often more affected by their program's climate. Thus, one could argue that learning how to manage the broader environment of the doctorate early in the process could lead to higher persistence and a smoother transition into graduate education.

We have found these conclusions to be particularly true through our Dissertation Institute (DI) project (Cruz et al., 2019, 2018). The Dissertation Institute is a week-long workshop for underrepresented minorities in the dissertation and proposal stages of pursuing a Ph.D. in engineering. During this week, participants engage in sessions where they both learn and practice strategies related to writing and other skills needed to complete their dissertations. A total of 113 students from underrepresented groups in engineering have participated since the start of the DI in 2016. Also, the DI has a strong research component, and we have gathered quantitative and qualitative data about the sessions and minoritized student's experiences pursuing a doctorate in engineering. A salient result of our findings is that the strategies learned in the DI would have helped the participants earlier in the doctoral process because it would have given them a clearer understanding of the process, thus allowing wiser decisions along the way. At the proposal or dissertation stage of the doctorate might be too late to refocus and make timely degree progress, causing students to lose motivation beyond repair.

To address this necessity, we developed the Rising Doctoral Institute (RDI). The RDI is a one-week intervention for minoritized graduate students entering doctoral engineering programs and aims to provide a timely and preparatory experience for rising doctoral students in engineering to address issues related to transitioning into the Ph.D. The purpose of this paper is to describe the RDI intervention hosted in 2019, the research findings obtained from this pilot, and outline the RDI Dissemination Model we have developed and will be executing over the next five years.

Program Description

The goals of the pilot RDI program were to 1) provide a timely orientation for rising doctoral students about preparing themselves to start graduate school, 2) create a mentoring network where minority graduate students at proposal and dissertation phases (DI participants) can mentor rising doctoral students. To accomplish the first goal, we held the RDI intervention in summer 2019 with 17 URM participants (8 African-American, 6 Hispanic or Latina(o), 1 Native American, and two of mixed ethnic-racial identities). To accomplish the second goal, we held The RDI intervention concurrent with the 3rd iteration of the Dissertation Institute (DI) with the participation of 33 URM doctoral engineering students in the proposal and doctoral stages. We used the same networks reported elsewhere in our execution of the DI, to advertise the RDI event and students applied to the RDI program after the April 15 signing deadline with their graduate schools.

The RDI had the following list of workshops and sessions offered. Table 1 organizes them by content to demonstrate an explicit connection to graduate education theory and critical constructs/concepts for success. Research has shown that addressing the topics in Table 1 can significantly impact student retention. These workshops provide students with tools for successful degree navigation as well as a network of support at their institutions, in the broader RDI cohort, and the larger online network.

Underlying every session is the understanding that students are aiming to persist in an environment that was not designed for them. Through our sessions, we provided validation that feelings of not belonging are real and valid (Gardner & Holley, 2011; Gildersleeve et al., 2011; Wood et al., 2016), but also that they can succeed with supportive tools. To that end, the RDI placed emphasis on providing participants with strategies and tools for forming enabling and supportive mentoring and coaching alliances with faculty, other graduate student peers, staff, and administrators. Such alliances offered an excellent opportunity for minoritized students to get early exposure to the knowledge content, language, vocabulary, and philosophy of the discipline, as well as become engaged in research laboratory meetings to acquire skills, protocols, and practices designed to move a beginning graduate student to an engaged researcher and scholar (Barker, 2011; Felder et al., 2014; Twale et al., 2016).

Table 1***Theoretical Support of the RDI Workshops***

Workshop	Content	Theoretical Support
Getting Off to a Good Start in Grad School	These sessions described doctoral program management and degree progress from a macro perspective. Among these, it was discussed how to seek and manage funding during graduate school, interactions with the department and the advisor, programmatic components of what it means to pursue a Ph.D. upon which students are assessed, and other administrative components of graduate school.	Students enter graduate school with misconceptions that can ultimately impact their persistence. Having a clear understanding early on can help them make critical decisions conscientiously. (Holbrook et al., 2014; Lovitts, 2001)
Finding and Managing Funding		Funding types and management has been shown to impact the doctoral experience and time to degree (Knight et al., 2018), (Ferrer de Valero, 2001). In the case of minoritized students specifically, the investments made to attend doctoral education often extend beyond the financial (Artiles et al., 2018).
Selecting an Advisor & Committee		The doctoral advisor is one of the most important decisions students make in the doctorate, and the process of selecting an advisor is often complex (Artiles, 2019).
When the Professor Says... They Mean...	These sessions discuss the political environment of the doctorate that is typically inaccessible for minoritized students due to a lack of social capital.	Maintaining a positive advising relationship is a key factor for student retention. Learning how to handle disagreements has been shown to increase persistence (Barker, 2011; Devos et al., 2016; Zhao et al., 2007).
Tips from the Top		Awareness of the broader departmental politics and environment can be key in the development of graduate students and their persistence (Berdanier et al., 2020; Golde, 2005; Sowell et al., 2015; Weidman et al., 2001; Zhou & Okahana, 2016). Minoritized students in engineering have been found to struggle with this awareness (Twale et al., 2016; Wood et al., 2016).
Managing Time and Procrastination	These sessions discussed constructs established in the literature to impact retention and persistence across all doctoral students. The key focus is on differences between the undergraduate pursuit of higher education and the expectations of the graduate level.	Shifting from a prescribed schedule and explicit assessment guidelines in the undergraduate to a hidden process at the doctoral level is often a barrier for students who lack self-management (Gardner, 2008; Gardner & Holley, 2011; Wood et al., 2016).
Writing During Graduate School		The writing process can often be a challenge for engineering doctoral students as they may not have developed these skills in the undergraduate (Berdanier, 2016; Berdanier & Zerbe, 2018).
Engaging with the Literature		
Career Options with a PhD	This session discusses potential careers in government, industry, and academia for STEM Ph.D. holders, as well as how to translate learning objectives in the doctoral pursuit beyond academia.	Over 70% of engineering and other STEM doctorate holders have been shown to pursue careers outside of academia, such as industry and government (Turk-Bicakci et al., 2014).
Navigating the Unwritten Rules	Topics in these sessions include, but are not limited to race in the doctorate, mentoring relationships, impostor syndrome, sustaining mental health, and navigating racism in the academy. We also include here mechanisms that students could use to communicate beyond the RDI throughout the first year to keep peer-to-peer connections across institutions.	Minoritized doctoral students often experience impostor syndrome and lack belongingness (Felder et al., 2014; Gildersleeve et al., 2011; Jaeger et al., 2017). The continuity of these feelings can develop mental health issues (Levecque et al., 2017) and impact doctoral progress (Artiles & Matusovich, 2020).
Mental Health in Grad School		
One on One Coaching Sessions		Managing such and creating support systems such as peer groups and mentoring relationships can help students manage to be visibly different from the norm in academia and persist in the doctorate (Ahn, 2016; Holloway-Friesen, 2019; Mondisa et al., 2015).

Methods

Alongside the programmatic goals of the RDI workshop, we aimed to conduct research examining the intersection of minority rising doctoral students' understanding of graduate education and their motivations to pursue a graduate degree. To do so, we conducted a series of qualitative data collection efforts throughout the week of the intervention. We used content analysis to extract emergent findings to illustrate whether and how an early intervention prepares incoming minoritized doctoral engineering students to transition into the engineering doctorate.

To accomplish this goal, we used Eccles' expectancy-value theory (EVT) (Eccles et al., 1983; Wigfield & Eccles, 2000) as a framework to conduct our research. EVT was appropriate for this study because it captures individual and social factors that support individual motivation to act. In this case, the action is pursuing a doctorate in engineering. At the fundamental level, EVT suggests that people engage in tasks or activities in which they believe that 1) they can succeed (expectancy of success) and 2) it is important to succeed (task values) (Eccles et al., 1983; Wigfield & Eccles, 2000). However, in complete form, expectancy of success and task values are part of a much larger system of personal and social factors "that include the experiences, processes, and interpretations that individuals use to make sense of themselves and their social environments" (Matusovich, Paretto, McNair, & Hixson, 2014). Essentially, EVT recognizes that people are acting within systems and that individual and social factors influence outcomes. We used EVT to develop the interviews and focus group protocols, as well as the a priori codes and categories for analysis. We were particularly interested in finding elements of the RDI that would have enhanced students' motivation to pursue their engineering doctorate.

During the RDI week, we invited students to participate in interviews and focus groups. The 1- hour interviews and focus groups were conducted during the open sessions. Out of the 19 participants, we conducted seven interviews and two focus groups of six students each. That is, almost all the students participated in the data collection process. Both instruments and protocols were approved under IRB guidelines. We present our findings in aggregate form to reduce identifiability of our participants. Detailed research analysis focusing on individual student traits and demographics are beyond the scope of this program overview.

Findings

Our results suggest that by participating in the RDI, students found a *network of peers* that looked like them and strengthened their sense of belonging. Also, they experienced an *increased clarity in their perception of the doctorate*, which may be particularly important for minority students. The following paragraphs describe such findings.

A network of peers. Participants described the RDI as being impactful because it helped them find a network of peers that looked like them and were also pursuing a Ph.D. Quotes from three RDI participants illustrate this point:

“It was nice to interact with everybody. I'm surprised how similar we all are. We're all unique but, [someone will say] ‘These are my experiences’ [and others can respond] ‘I relate’. It's the same type of nerd.”

“[in]My Master's program, I guess I took the wrong route. I was just more like, these people won't get me, I'm a Black person. So, I'm just going to put my head down, get through this, and then graduate. But I realize now from that, that I can't really do that in my PhD program because relationships are important.”

“It doesn't happen very often where I've been in that environment or where they already sectioned off into their own little social group [...] in this case, I've been floating around and everyone has not grouped up as is typical. It's been really nice.”

Our findings are consistent with current research that shows that minority students often struggle in the doctorate because the underrepresentation is starker than the undergraduate experience. Being the ‘only one like them’ often takes a social toll where they feel they do not belong in their program (Curtin et al., 2013; O’Meara et al., 2017). At the same time, research shows that finding a network of minority peers contributes to minority students’ sense of belonging in the doctorate and could impact the effects of impostor syndrome on these students (Mwenda, 2010). According to EVT, this sense of belonging would relate to finding others with similar success and value beliefs (Eccles, 2005). Hence, the RDI could be a model for helping minority students develop a network of peers that leads to a sense of belonging.

Increased Clarity in their Perception of the Doctorate. Participants also showed a difference regarding how they expressed their understanding of the doctorate. Before RDI, participants’ notions of the doctoral pursuit were vague, and their reasons for pursuing the degree were not always attached to the specific tasks they would execute during the doctorate. For example, the following participant described having a degree in their discipline would allow them to help others in underdeveloped countries, but such descriptions did not always connect to the doctoral degree:

“I chose [to pursue a PhD in] electrical engineering because I wanted to bring electricity to underdeveloped countries.”

Participants also shared that their decision to pursue a doctorate was often due to either a peer or a mentor they value encouraging them to do so:

“[a PhD] was something a lot of people in my corner told me I should pursue, and pretty much planted the idea in my head... My mentor’s like, hey, it’s been two years, so you’re ready to start grad school and I was like ‘Oh, yeah I guess I am’.”

“[My father] definitely really encouraged me to do as much education as possible upfront and really learn as much as I could.”

While this encouragement can be positive for recruiting students into the doctorate, motivation frameworks in educational psychology describe such as not being sufficient for continued persistence, as their idea of the degree may not be attached to specific career goals (Battle & Wigfield, 2003). After the RDI, these participants expressed having a clearer idea of why they wanted to pursue a doctorate and specific career goals they could use the degree for:

“I always thought that it was academia or industry. I guess today we kind of talked about, you can work in industry and still be able to go back into academia. So, you don't really have to commit all the way to one or the other.”

The RDI also cleared students' perception of the doctorate and the steps they have to take to complete the degree. Students expressed this newfound clarity to provide them with direction on how to succeed in the doctoral pursuit from day one:

“The structure of how grad school works is something that I didn't know before. No one tells you the things that are involved in going to the next level, [...] And so even just something as simple as understanding what a committee is and what they do, I think is extremely helpful, understanding the hierarchy, how things work, would be helpful in navigating that experience.”

“This really helped relieve a lot of stress of the unknown I was having. Now I have a game plan.”

Expectancy value theory suggests that having a clearer perception of the task one will be undertaking will increase one's value for the task and help one have a better-informed expectancy for succeeding in such a task (Eccles, 2005). In the case of our participants, understanding what the Ph.D. process entails will help them understand the actions that help them complete the Ph.D. and increase their belief that they can be successful in doing so.

Discussion

Another critical aspect of the DI and the pilot RDI success is in intentionally choosing workshop speakers who are also minoritized in engineering across multiple identities (Cruz et al., 2019, 2018). It was evidenced in our pilot RDI that this demographic resemblance allowed for two things. First, our participants were able to make personal, identity, or experience-based connections with the facilitators and see them as role models. The literature has shown that such visibility increases persistence and retention (Barker, 2011; Gildersleeve et al., 2011; Jaeger et al., 2017). Second, as our workshop speakers have lived and understood the participants'

experiences, the tools and strategies they brought to the table were based on the minoritized perspective of academia. This minoritized perspective acknowledges the ‘ways of knowing’ our participants bring into academia. Our workshops helped them identify ways to harness such assets towards persisting in the doctorate. It is important to note that the minoritized experience is not monolithic across all minoritized students. By bringing a set of speakers with diverse identities and backgrounds, we were able to help students draw connections to varied advice which they can choose upon. Our facilitator diversity also allowed for multiple informal conversations and mentoring opportunities that begin at our workshops through individual mentoring sessions and dialogue group meals but often persist beyond the intervention. We have received feedback such as *“It was good to hear how to handle racial discriminations,”* *“It always feels good to be heard and seen,”* and *“Talking about identity was very interesting and helpful.”* These quotes indicated to us that we had matched the specific content that students needed and gave them a space to express their identities.

In short, preliminary research and evaluation results show that participants believed they are better equipped to manage the graduate education process after attending the RDI. However, our results also show that we need to make some programmatic changes to better support mentoring specific to the context in which participants will be engaged while pursuing a Ph.D. That is, to increase the success of the RDI, we need to develop a better mechanism for mentoring students beyond the intervention once they return to campus and begin the doctorate. RDI participants particularly described their desire to ‘network’ or ‘interact with others like them’ as either a key reason for attending, an experience they found helpful at the RDI, and something they wish they could have more of as they move forward in their doctoral journey. We did not intend to provide direct support beyond the RDI week in the original execution, but we are hoping that the newly created networks maintain after the intervention.

Nevertheless, based on these findings, we have improved our design to meet such needs by incorporating intentional mentoring beyond the RDI intervention and into the academic year. Our preliminary results show the promise of the RDI and provide data we can use to improve future iterations of both the implementation and the research tools. As a result of the initial RDI, the changes in the RDI design, and the development of a dissemination model, the research team was recently awarded a grant by the National Science Foundation to train universities across the US on how to develop and model the RDI intervention at their own campuses. The following paragraphs describe briefly such future work starting in Summer 2021.

RDI Dissemination Model

The newly developed RDI is a 5-year project whose purpose is to examine the effect of early interventions for doctoral students on the transition into the engineering doctorate and to develop sustainable models for institutions to implement on their campus to help minoritized students transition into the doctorate.

The goal of the first year is to host an RDI intervention for a national sample of minoritized students pursuing engineering doctorates which will serve as a model for five

collaborating institutions. This intervention is similar to the one described in this paper with the adjustments suggested by our research. The intervention consists of a four-day workshop before the start of the doctorate and periodic virtual meetings throughout the first year of the doctorate. The four-day workshop will focus on helping students understand the nature of graduate school, expectations of graduate work, and correct misconceptions common to first-year doctoral students. This workshop will also serve as an initial meeting for students to develop a community of peers also pursuing the engineering doctorate.

One of the biggest changes we introduce in the RDI is that during the workshop students will be assigned into smaller groups called *success groups*. Each success group will have an expert facilitator who will host periodic virtual meetings with RDI participants throughout their first year of the doctorate. The goal of these virtual meetings is to support the community developed at the RDI but also help students process the transition into the doctorate as they experience it. During these meetings, students will be asked to share their experiences and they will be provided a space to ask questions and seek guidance to challenges common to the first year. By creating a space for students to share experiences, these meetings will help ease some of the difficulties that prior work has noted to be of particular prominence in minorities in predominantly white spaces such as impostor syndrome and a general lack of confidence towards completing the degree. Figure 1 outlines the RDI intervention for the first cohort.

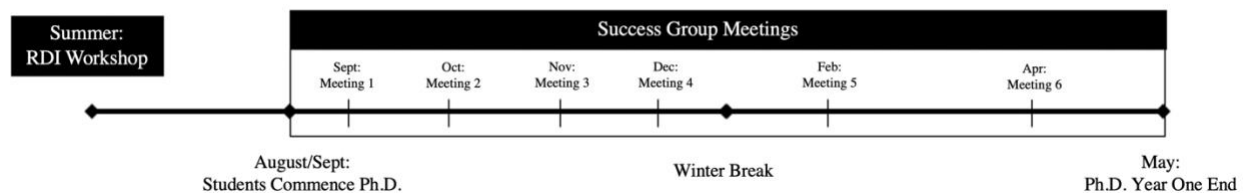


Figure 1. Cohort 1: RDI Timeline

During the RDI workshop, we will also host leaders from five collaborating institutions to participate in and observe how we run the RDI, later they will engage in their workshops to design an RDI intervention for their institutions. We called them *Local RDI*. The collaborating institutions are The University of Florida, Penn State University, North Carolina A&T State University, University of California Irvine, and Iowa State University. These collaborating institutions were predetermined based on their need for developing support for minoritized doctoral students, their geographical and institutional diversity, and their willingness to implement an RDI workshop on their campus. We purposefully contacted and selected leaders of the collaborating Institutions that have both agency and leadership roles (e.g., deans, assistant deans, supporting faculty), which will enable them to develop the RDI for their institution. Collaborating institution leaders will arrive a day before students for a pre-RDI workshop discussion activity to explain the intentionality behind the RDI design and to make suggestions

on what they should think about and observe during the RDI. In addition to observing the RDI, they will participate in facilitated discussions during and after the RDI to help them design a version of the RDI workshop that meets their specific institutional needs and constraints while maintaining the core elements critical to the RDI success. Leaders from collaborating institutions will not be invited to form part of the ongoing student success groups as we intend to keep those as a safe space for students to ask questions and share their experiences. However, we will share guidelines on how to facilitate these conversations on their campus as they are integral to fostering a student community.

In the second year, the collaborating institutions will each host an RDI-type intervention at their institution, and the RDI PIs will serve as on-site consultants helping the collaboration institutions address the needs of incoming minoritized graduate students at their institution. In the third year, we will expand our efforts to 20 additional institutions by conducting a showcase with the initial collaborating institutions to overview the different models of the RDI developed in the second year and help new institutions develop their versions of the interventions.

The 20 schools to receive invitations to the showcase in the third year (Georgia Tech, MIT, Purdue, Stanford, Texas A&M, Michigan, Cal-Berkeley, Puerto Rico-Mayaguez, Cornell, UC San Diego, UT Austin, Johns Hopkins, Florida International, UT El Paso, New Mexico, Howard, Tennessee State, Washington, Colorado- Boulder, and Tennessee) were selected based on the following criteria, using data from the ASEE Data Management System submitted in the Fall of 2018.

1. Top 10 engineering schools based on overall enrollment and doctoral degrees awarded. (7)
2. Top 10 engineering schools based on their enrollment and degrees awarded to URM doctoral students. (5)
3. A combination of HSIs/MSIs/HBCUs. (5)
4. The remaining schools were selected based on geography and a balance of public and private institutions. (3)

Figure 2 provides a geographical view of the Institutions targeted for participation in the Showcase. If any of these institutions 20 declines to participate, we will fill with a similar school that meets the same selection criteria.



Figure 2. Map of Institutions Targeted for RDI participation.

The diversity of partner institutions – large land-grant universities, major private institutions, minority-serving institutions, all located across the USA - provides a broad range of unique perspectives and experiences that can be shared and modeled.

In the fourth year, we will develop a network of institutions hosting RDI interventions and ‘train-the-trainer’ sessions with the initial collaborating institutions. Throughout the first four years of the project, our team will research doctoral students’ transition into graduate school based on the nationwide RDI participants’ experiences as well as the institutional factors that affect the adoption and design of the RDI interventions. In the fifth year, we will develop products based on the research findings such as evaluation tools for measuring the impact of RDI, guides to hosting support programs such as the RDI, and guides for mentoring doctoral students entering the Ph.D.

As part of the selection process, the collaborating institutions have manifested both a need to develop support for minoritized doctoral students and their willingness to participate and implement an RDI workshop on their campus. Each institution has committed two collaborators from each with the leadership and agency to advance their institution's change initiative. It is worth noting that collaborating institutions are willing to participate in the network because we offer them several benefits and products resultant of their participation. Through hosting their RDI and using our research and evaluation tools, institutions will be able to assess their current situation. Specifically, we will provide assessment tools, adaptable to their institutional language, that can help them understand the main issues affecting their incoming minoritized Ph.D. students and increasing the institutional sense of urgency to enact change. We will also provide hands-on strategizing with the collaborators on how they can customize the RDI model to suit their needs given the data, structures, and institutional culture.

Conclusion

Early doctoral interventions, such as the RDI, could provide substantial support elements to improve incoming minoritized doctoral engineering students' experience. Our findings showed that these interventions have promise in strengthening the students' sense of belonging and clarify their perception of the doctorate. Based on these findings, we developed programmatic changes that will further support students' needs and scaffold this support in the doctorate's first year. We also propose a dissemination model to facilitate the adoption of RDI contextualized to different institutions for sustainability. This dissemination model is grounded in change theory to develop and manage the RDI model adaptation at each collaborating institution so the RDI can become a lever to institutional change in broadening participation of minorities in doctoral engineering education.

References

- Ahn, B. (2016). Applying the Cognitive Apprenticeship Theory to Examine Graduate and Postdoctoral Researchers' Mentoring Practices in Undergraduate Research Settings. *International Journal of Engineering Education*, 32(4), 1691–1703.
- Artiles, M. S. (2019). *Advisor Selection Processes in Doctoral STEM Programs in the US* [Dissertation.]. Virginia Polytechnic Institute and State University.
- Artiles, M. S., & Matusovich, H. M. (2020). Examining Doctoral Degree Attrition Rates: Using Expectancy-Value Theory to Compare Student Values and Faculty Supports. *International Journal of Engineering Education*, 36(3), 1071–1081.
- Artiles, M. S., Matusovich, H. M., Bey, C. J., & Adams, S. G. (2018). *Understanding the Investment of Underrepresented minorities in Doctoral Engineering Programs*. American Society for Engineering Education, Salt Lake City, UT.
- Barker, M. J. (2011). Racial context, currency and connections: Black doctoral student and white advisor perspectives on cross-race advising. *Innovations in Education and Teaching International*, 48(4), 387–400. <https://doi.org/10.1080/14703297.2011.617092>

- Berdanier, C. G. (2016). *Learning the language of academic engineering: Sociocognitive writing in graduate students*. Purdue University.
- Berdanier, C. G., Whitehair, C., Kirn, A., & Satterfield, D. (2020). Analysis of social media forums to elicit narratives of graduate engineering student attrition. *Journal of Engineering Education*, 109(1), 125–147. <https://doi.org/10.1002/jee.20299>
- Berdanier, C. G., & Zerbe, E. (2018). Quantitative Investigation of Engineering Graduate Student Conceptions and Processes of Academic Writing. *2018 IEEE International Professional Communication Conference (ProComm)*, 138–145.
- Council of Graduate Schools. (2007). *Ph.D. Completion and Attrition: Analysis of Baseline Program Data from the Ph.D. Completion Project*.
- Cruz, J. M., Artiles, M. S., Lee-Tomas, G., Matusovich, H. M., & Adams, S. G. (2018). The Dissertation Institute: Evaluation of a Doctoral Student Writing Workshop. *2018 IEEE Frontiers in Education Conference (FIE)*, 1–7.
- Cruz, J. M., Artiles, M. S., Matusovich, H. M., Lee-Thomas, G., & Adams, S. G. (2019). *Revising the Dissertation Institute: Contextual Factors Relevant to Transfer-ability*. American Society for Engineering Education Annual Meeting, Tampa, Florida.
- Curtin, N., Stewart, A. J., & Ostrove, J. M. (2013). Fostering Academic Self-Concept: Advisor Support and Sense of Belonging Among International and Domestic Graduate Students. *American Educational Research Journal*, 50(1), 108–137. <https://doi.org/10.3102/0002831212446662>
- Devos, C., Boudrenghien, G., Van der Linden, N., Frenay, M., Azzi, A., Galand, B., & Klein, O. (2016). " Misfits between doctoral students and their supervisors:(How) are they regulated? *International Journal of Doctoral Studies*, 11.

- Eccles, J. (2005). Subjective task value and the Eccles et al. Model of Achievement-Related Choices. In *Handbook of competence and motivation*, eds. A.J. Elliot and C.S. Dweck (pp. 105–121). The Guilford Press.
- Felder, P. P., Stevenson, H. C., & Gasman, M. (2014). Understanding race in doctoral student socialization. *International Journal of Doctoral Studies*, 9(19), 21–42.
- Ferrer de Valero, Y. (2001). Departmental Factors Affecting Time-to-Degree and Completion Rates of Doctoral Students at One Land-Grant Research Institution. *The Journal of Higher Education*, 72(3), 341. <https://doi.org/10.2307/2649335>
- Gardner, S. K. (2008). “What’s Too Much and What’s Too Little?”: The Process of Becoming an Independent Researcher in Doctoral Education. *The Journal of Higher Education*, 79(3), 326–350. <https://doi.org/10.1353/jhe.0.0007>
- Gardner, S. K., & Holley, K. A. (2011). “Those invisible barriers are real”: The Progression of First-Generation Students Through Doctoral Education. *Equity & Excellence in Education*, 44(1), 77–92. <https://doi.org/10.1080/10665684.2011.529791>
- Gildersleeve, R. E., Croom, N. N., & Vasquez, P. L. (2011). “Am I going crazy?!”: A critical race analysis of doctoral education. *Equity & Excellence in Education*, 44(1), 93–114.
- Golde, C. M. (2005). The Role of the Department and Discipline in Doctoral Student Attrition: Lessons from Four Departments. *The Journal of Higher Education*, 76(6), 669–700. <https://doi.org/10.1080/00221546.2005.11772304>
- Holbrook, A., Shaw, K., Scevak, J., Bourke, S., Cantwell, R., & Budd, J. (2014). PhD candidate expectations: Exploring mismatch with experience. *International Journal of Doctoral Studies*, 9, 329–346.

- Holloway-Friesen, H. (2019). The Role of Mentoring on Hispanic Graduate Students' Sense of Belonging and Academic Self-Efficacy. *Journal of Hispanic Higher Education*, 153819271882371. <https://doi.org/10.1177/1538192718823716>
- Jaeger, A. J., Mitchall, A., O'Meara, K. A., Grantham, A., Zhang, J., Eliason, J., & Cowdery, K. (2017). Push and pull: The influence of race/ethnicity on agency in doctoral student career advancement. *Journal of Diversity in Higher Education*, 10(3), 232–252. <https://doi.org/10.1037/dhe0000018>
- Knight, D., Kinoshita, T. J., Choe, N., & Borrego, M. (2018). Doctoral student funding portfolios across and within engineering, life sciences and physical sciences. *Studies in Graduate and Postdoctoral Education*, 9(1), 75–90. <https://doi.org/10.1108/SGPE-D-17-00044>
- Levecque, K., Anseel, F., De Beuckelaer, A., Van der Heyden, J., & Gisle, L. (2017). Work organization and mental health problems in PhD students. *Research Policy*, 46(4), 868–879. <https://doi.org/10.1016/j.respol.2017.02.008>
- Lovitts, B. (2001). Leaving the Ivory Tower: The Causes and Consequences of Departure from Doctoral Study. *American Journal of Sociology*, 108(3), 679–681. <https://doi.org/10.1086/378426>
- Mondisa, J.-L., Brown, C., & Adams, R. (2015). *Mentoring African-American Science, Technology, Engineering, and Mathematics (STEM) Undergraduates: An African-American STEM Mentor's Perspective*. 26.1146.1-26.1146.11. <https://doi.org/10.18260/p.24483>
- Mwenda, M. N. (2010). *Underrepresented minority students in STEM doctoral programs: The role of financial support and relationships with faculty and peers*. <http://ir.uiowa.edu/etd/560/>

- National Academies of Sciences, Engineering, and Medicine. (2018). *Graduate STEM Education for the 21st Century*. National Academies Press. <https://doi.org/10.17226/25038>
- O'Meara, K. A., Griffin, K. A., Kuvaeva, A., Nyunt, G., & Robinson, T. (2017). Sense of Belonging and Its Contributing Factors in Graduate Education. *International Journal of Doctoral Studies*, 12, 251–279. <https://doi.org/10.28945/3903>
- Sowell, R., Allum, J., & Okahana, H. (2015). Doctoral initiative on minority attrition and completion. *Washington, DC: Council of Graduate Schools*.
- Turk-Bicakci, L., Berger, A., & Haxton, C. (2014). *The nonacademic careers of STEM PhD holders*.
- Twale, D. J., Weidman, J. C., & Bethea, K. (2016). Conceptualizing Socialization of Graduate Students of Color: Revisiting the Weidman-Twale-Stein Framework. *Western Journal of Black Studies*, 40(2).
- Weidman, J. C., Twale, D. J., & Stein, E. L. (2001). *Socialization of graduate and professional students in higher education: A perilous passage?* Prepared and published by Jossey-Bass in cooperation with ERIC Clearinghouse on Higher Education, Association for the Study of Higher Education, Graduate School of Education and Human Development, the George Washington University.
- Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019* (Special Report NSF 19-304). (2019). National Science Foundation. National Center for Science and Engineering Statistics. <https://www.nsf.gov/statistics/wmpd>.
- Wood, C. V., Campbell, P. B., & McGee, R. (2016). “An Incredibly Steep Hill”: How Gender, Race, and Class Shape Perspectives On Academic Careers Among Beginning Biomedical PhD Students. *Journal of Women and Minorities in Science and Engineering*, 22(2).

<http://www.dl.begellhouse.com/journals/00551c876cc2f027,42bf45761aa16485,3569f89030434b39.html>

Zhao, C.-M., Golde, C. M., & McCormick, A. C. (2007). More than a signature: How advisor choice and advisor behaviour affect doctoral student satisfaction. *Journal of Further and Higher Education*, 31(3), 263–281.

Zhou, E., & Okahana, H. (2016). The Role of Department Supports on Doctoral Completion and Time-to-Degree. *Journal of College Student Retention: Research, Theory & Practice*, 152102511668203. <https://doi.org/10.1177/1521025116682036>