Conceptualizing Program Quality in Engineering Education Ph.D. Programs

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Dr. Le Shorn Benjamin has amassed over a decade of experience in the field of education. Her career spans local and international borders and have included roles in educational research, program administration, higher education accreditation and K-12 teaching. She is the recipient of the Robert Newby Award for Diversity Efforts, the Central Michigan University College of Graduate Studies 2019 Outstanding Dissertation Award, a Central Michigan University Department of Educational Leadership Faculty Endowed Award and is consistently motivated by the distinction of her University of the West Indies Most All-Round Social Policy Student award. Dr Benjamin is a previous New York City Teaching Fellow and an inaugural member of the American Society for Engineering Education Post-Doctoral E-Fellowship. Through her scholarship, she explores matters related to minoritized student experiences, doctoral education, and engineering education with an educational philosophy that equates quality with equity. Dr Benjamin is committed to transforming educational systems into more inclusive, equitable and just spaces that adequately support learners – particularly those who have been historically and intentionally positioned at the fringes of education – to succeed, excel, and thrive.

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He began his higher education pursuits at Morehouse College and North Carolina Agricultural & Technical State University where he earned degrees in both Chemistry and Chemical Engineering as a part of the Atlanta University Center’s Dual Degree in Engineering Program. While in college he was a Ronald E. McNair Scholar which afforded him the opportunity to intern at NASA Langley. He also earned distinction as a Phi Beta Kappa member and an American Chemical Society Scholar. Dr. Henderson completed his Ph.D. in Chemical & Biomolecular Engineering at the University of Illinois at Urbana-Champaign. During his time as a graduate student, he was a NASA Harriet G. Jenkins Graduate Fellow.

Dr. Henderson has dedicated his career to increasing the number of students who are on pathways to pursue STEM careers. He believes that exposing students to STEM early will have a lasting impact on their lives and academic pursuits. He is the co-founder of the St. Elmo Brady STEM Academy (SEBA). SEBA is an educational intervention aimed at exposing underrepresented fourth and fifth-grade students and their families to hands-on STEM experiences.

Henderson’s research interests are in engineering identity development among Black men. He was most recently recognized by INSIGHT Into Diversity Magazine as an Inspiring STEM Leader, the University of Illinois at Urbana-Champaign with the College of Liberal Arts & Sciences (LAS) Outstanding Young Alumni Award, and Career Communications Group with a Black Engineer of the Year Award for college-level promotion of engineering education.

Paper ID 39415

Contemplating Quality: Conceptions of Engineering Education PhD Program Quality [Work-in-Progress]

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This material is based upon work supported by the National Science Foundation under Grant # EEC-2127509 to the American Society for Engineering Education

Abstract

Doctor of Philosophy (PhD) degree programs occupy the apex of the academic hierarchy. This is mainly because graduates are required to extend the bounds of existing knowledge. In the recent doctoral discipline of engineering education, students are prepared to conduct effective educational research on engineering curriculum, pedagogy, assessment, and faculty development among other topics. With the recency of these programs, there is significant opportunity to learn more about what constitutes quality within this educational context. In this work-in-progress paper, authors explore conceptions of engineering education PhD program quality as understood from the lived experiences of the program directors who facilitate their delivery. Research into the quality of doctoral-level programs is at an all-time high due to increased attention by national agencies, disciplinary bodies, and higher education stakeholders. These calls result from several factors but are most amplified by the inextricable link between research doctoral programs and the national economy. In this study, researchers conducted an Interpretative Phenomenological Analysis (IPA) of interviews with four individuals holding leadership roles in engineering education PhD programs. Participants' leadership tenure ranged from 0.16 to 6 years in programs that have existed for between 3 to 15 years. Participants' interview responses suggested that the role of a program leader was multifaceted. Their duties encompassed a combination of administrative tasks involving institutional stakeholders as well as student-facing responsibilities related to admissions, recruitment, and student support across the program life cycle. Although each participant provided a unique interpretation of the social reality under investigation, we, the researchers, identified a telling consensus across their interviews. Participants illuminated unrelenting reflections about their programs and "what does it mean" to offer one that is of quality and how even answers to these questions may exist only "at that time" since they were likely to change. Finally, there were other key quotes that found participants examining how they used program goals and outcomes "to assess the[ir] program" and change them accordingly if they were not "working so well." After three stages of (descriptive, linguistic, and conceptual) analysis, authors present a singular superordinate theme *The Role of Assessment in Eng Ed PhD Program Quality*. Implications of this study are applicable to programs in the design phase as well as those currently being delivered.

Introduction

Doctoral degrees lead the hierarchy of higher education qualifications, and within the ranks of doctoral education, the Doctor of Philosophy (PhD) generally reigns supreme [1]. As a recent

addition to the compendium of research doctoral disciplines, Engineering Education (Eng Ed) programs aim to prepare students to independently conduct rigorous research on engineering curriculum, pedagogy, assessment, and faculty development" among other relevant topics [2], [3], [4]. It is expected that based on their doctoral education and training, graduates will not only serve as researchers but will also perform leadership functions within government bodies, disciplinary organizations, and industries [2], [3]. Due to "decreasing public investments in graduate education," however, there have been numerous calls to articulate the value of PhD programs [5]. While these stakeholder pressures have generally resulted in increased accountability measures and smaller coffers of financial support for PhD programs, engineering education programs seem anomalous. One of the main factors contributing to this disciplinary difference relates to the established funding mechanisms for Eng Ed research through the National Science Foundation [5]. Whereas in other disciplines, the drive to examine the quality of doctoral programs is tied to financial sustainability [5], conversations regarding program quality in Eng Ed PhD programs originate from a different position. For example, researchers, Murzi, Shekhar, and Mc Nair cited the increasing number of Eng Ed PhD programs, as a key motivator for their foundational scholarship on Eng Ed PhD program quality and as a reason for additional research in this area [2]. Their work, as well as that of Lopez and Garcia [4] and Benson et al. [3], provides a strong basis for our study, having presented a document-based, comparative analysis of the formation, aims, requirements, and outcomes of existing Eng Ed PhD programs. To expand the existing knowledge on the topic, we designed an overarching Interpretative Phenomenological Analysis project to examine *the conceptions of program quality that Eng Ed PhD program leaders possess based on their experiences in these programs.*

Background

Although a comprehensive research base on Eng Ed PhD programs has not yet been established, there is published literature on the purposes these programs serve, their learning outcomes, the extent of their effectiveness and anticipated future directions in program design [2], [3], [4]. This body of research shows that while some differences in program models exist, there are more commonalities between them. The greatest commonalities included a primary focus on research competence, mastery of research-based pedagogical strategies, requirement for teaching experience, and clear alignment to a specific engineering or STEM discipline [2], [3], [4]. Both Murzi et al. [2] and Benson et al. [3] highlighted this comparison, with Benson et al. asserting that "while these departments have similar visions that seek to prepare future faculty and build outcomes-based programs, each has a unique interpretation of that vision through its features, courses, and collaborations [3, p. 1044]".

Although these variations across programs exist, it is clear from the current body of research that Eng Ed doctoral programs synergize elements from the individual traditions of engineering and education PhD programs. [2], [4]. The disciplinary hybrid of educational outcomes, graduation requirements, and program structures has produced a complex research context, ripe with opportunity for scholarly exploration. Given the liminal development of Eng Ed as an academic discipline and how recent Eng Ed PhD programs are, there are several areas of research that are still to be undertaken [2], [3]. The review of literature conducted for this project revealed the need for greater attention to post-baccalaureate qualifications in Eng Ed research, generally, and more diverse data collection on Eng Ed PhD program quality, specifically. Most of the Eng Ed

literature focuses on improving undergraduate education and therefore provides limited insight into program quality at advanced degree levels [6]. Additionally, the substantive scope of literature underscoring our current study has employed document analysis as a key method of inquiry [2], [3], [4]. While document-based data such as course outlines, program descriptions and course syllabi provide valuable insight, particularly in the context of program evaluation [2], it offers limited opportunity for deep experiential investigation [7].

Theoretical Context

This in-progress study is informed by Nerad's [8] Input-Throughput-Output (ITO) framework of Fit-For-Purpose Research Doctoral Graduates and Benjamin's [9] conceptualization of doctoral research program quality, later inspired by Nerad. Figure 1 illustrates Benjamin's conceptualization of PhD program quality [9] across the I-T-O framework of doctoral programs [8] that underpins the design and development of this current study.

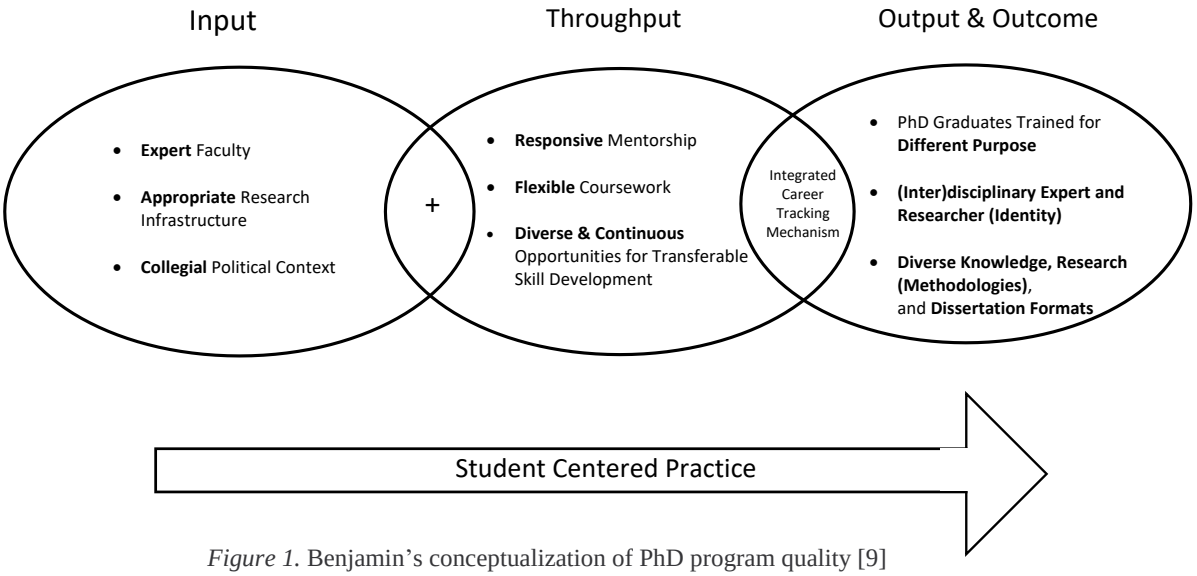

Figure 1. Benjamin's conceptualization of PhD program quality [9]

Theoretical application

The conceptual model underscored all design elements of the study. Its most evident influence can be noted in the data collection, analysis, and discussion components of the study. The conceptualization of PhD program quality illustrated in the model informed the development and administration of the interview protocol, specifically the subset of questions related to program milestones, and offered greater context for ad hoc probing during interviews. The model also provided a sensitizing perspective for the data analysis process: specifically, it delimited the scope of data included in this component of the project by helping us identify key meaning units and a schema for code and theme development.

Method of Inquiry

This study addresses the research gaps mentioned in the Background section: namely, the limited focus on advanced degrees in current engineering education research and a heavy reliance on document analysis in Eng Ed PhD program quality studies. Before commencing any research activity, The Research Integrity and Oversight (RIO) Office at the University of Houston granted Institutional Review Board (IRB) approval for the overarching project from which this study stemmed.

Sample

Given our aim to understand conceptions of Eng Ed PhD program quality from participants' lived experiences, an interpretative qualitative approach was found to be most beneficial [7]. The sample criteria solicited the participation of individuals 18 years of age and older who have served in program leadership roles, related to the design and/or delivery of an US Eng Ed PhD program. Program selection was restricted to Engineering Education PhD degree programs in the US and it excluded programs with any integration of other disciplines and focus areas in the title e.g., Science Technology Engineering Mathematics Education PhD programs. The focus on leaders, such as program directors and/or coordinators, resonates with perspectives of doctoral education leadership that Prewitt espoused [10]. Prewitt argued that unlike pre-doctoral qualifications, the design and delivery of PhD programs is shaped by a broad spectrum of institutional and national leaders who control entry into PhD programs, doctoral training, publication outlets, career development, and research funding [10]. Given the diverse span of these roles and the nascent stage of this study, a decision was made to delimit participant selection to individuals who provide direct or day-to-day programmatic oversight for US Eng Ed PhD programs. Four representatives of existing Eng Ed PhD programs (Pseudonyms: AK, Atlas Smith, Mary, and Twyla) responded affirmatively to the participant recruitment email distributed. Participants' leadership tenure in these programs ranged from 0.16 to 6 years and the affiliated programs have existed for between 3 to 15 years. Reports on any other participant demographics will be withheld due to the relatively small population they represent. Such measures are crucial in an easily identifiable study population such as program directors and coordinators of Eng Ed PhD programs which is a relatively small group.

Data collection

As part of the recruitment process, participants were asked to submit a recent copy of their curriculum vitae and complete a demographic survey in which they self-reported their social identities and details about their professional role and respective Eng Ed programs. After reviewing their survey responses and resume submissions, participants' eligibility for inclusion was confirmed and they were invited to participate in one-on-one virtual interviews. Interviews were transcribed and minor transcription errors corrected prior to data analysis.

We tailored methodological approaches reported in current Interpretative Phenomenological Analysis (IPA) literature to understand the conceptions about program quality that Eng Ed PhD program leaders have formed based on their professional experiences within these programs. IPA was selected because of its methodological suitability for exploring participants' experiences and understanding how individuals make sense of the personal meanings associated with them [7]. Consistent with IPA methodology, participants were interviewed with a specific focus on their

experiences and with an aim to develop vigorous experiential accounts [7], [11]. As a result, we constructed interview prompts that centered their professional experiences in Eng Ed PhD programs and probed about how these experiences informed their conceptualization about quality in Eng Ed PhD programs [7], [8], [9],[11].

A semi-structured interview protocol was constructed for the overarching research project from which this study originated. Participant responses to the following excerpt of prompts were used as data sources for this study:

> A) Program Leadership
> Tell me a little about what you do as an engineering education program director and/or developer … what does a day or month look like?
>
> B) Engineering Education – As a field of study
> 1) So, changing gears a little here: tell me how you define the field of engineering education?
> b) Possible probe: Tell me a little about the relationship between engineering and engineering education
>
> C) Quality (in PhD Programs)
> 1) This study seeks to understand what a quality engineering education PhD program is. Dialing back this idea just a little:
> a) how would you define: i) quality? ii) A quality PhD program?
> b) I would like to learn more about how you generally define the stages and/or milestones associated with a quality PhD program. Tell me about how you see these stages/milestones sequentially and qualitatively.
>
> D) Engineering Education PhD Programs
> What are key learning and developmental outcomes students should achieve at each of these stages? What are best outcomes for students and the discipline when these outcomes are achieved.

Analytical procedure

Authors of current IPA literature have informed that their methodological guidance provides suggestions and not prescriptions for rote implementation [7], [11]. Instead of strict adherence to IPA tenets, methodological luminaries have guided users of the method to observe the unfolding narrative housed in data sources and commit to constructing compelling accounts [7], [11]. Our analytical process comprised descriptive, linguistic, and conceptual annotations of each individual transcription, a practice known as exploratory notetaking [7], [11]. After confirming that the research team was sufficiently familiar with the responses of each participant, specifically their language choices and conceptual meanings, experiential statements were then constructed to synthesize key sources of insight and possible gems within each transcript. After this stage had been completed for each transcript, the next step involved illuminating connections of convergence and divergence across participants' accounts [7], [11]. This process resulted in

the formation of multiple experiential subthemes – some more compelling than others – and the superordinate group experiential theme [7], [11] presented in this manuscript.

Based on the Interpretative Phenomenological Analysis process, three Experiential Themes were developed. For this work-in-progress paper, however, only one theme, i.e., *The Role of Assessment in Eng Ed PhD Program Quality*, is presented. Compared to others, this theme appeared most multidimensional, possessing both intrinsic and extrinsic intrigue. The elements that contributed to its internal intrigue included the theme's (i) *comprehensive representation*: each participant's account contributed to it's conceptual depth and did so from distinctly different viewpoints; (ii) *complexity:* it involved multiple approaches to theme development, including abstraction, polarization, and contextualization; and (iii) *originality*: it resulted from a process of induction, since the interview protocol had not included any reference to assessment [7].

The theme is reported in the next section. There, interpretative summaries are supported by representative quotes that prioritize participants' language, save and except for minor modifications to gerunds when needed to promote clarity.

Findings

In the theme, *Role of Assessment in Eng Ed PhD Program Quality*, assessment practice and experience are foregrounded as key elements of quality. Participants centered the notion of assessment within their conceptions of quality in Eng Ed PhD programs, articulating recursive use of words such as "measure," "equate," "evidence," "results," and "feedback," among other evaluative terms.

Role of Assessment in Eng Ed PhD Program Quality

Through the analytical process, the *Role of Assessment in Eng Ed PhD Program Quality* theme reveals the intersection between participants' assessment experiences and their conceptions of educational quality in Eng Ed PhD programs. The theme consists of two subthemes: (i) *Assessment Levels & Learning* and (ii) *Latent Assessment Tensions*. Descriptions of the sub-themes are illustrated in the table below.

Table 1

Description of Sub-themes

Superordinate Theme	Sub-Themes	Description
Role of Assessment in PhD Program Quality	Assessment Levels & Learning	Outlines levels of assessment and outcomes of the assessment processes
	Latent Assessment Tensions	Highlights challenges and conflicts embedded in the assessment process

Assessment Levels & Learning

Participants shared meaning-making accounts of their experiences in Engineering Education PhD programs which contributed to the conceptualization of program quality developed in the overarching study. As reflected in this subtheme, each participant's experience revealed insights into the impact of the assessment process on the quality of an Eng Ed PhD program. Participants' accounts referenced examples of program, course, and student levels of assessment and their implications for the input, throughput, and output/outcome components of the program quality framework illustrated in Figure 1.

Program Assessments

Regarding program-level assessments, Atlas Smith recalled how a prior engineering graduate program assessment project had informed his thinking about student support, which had primed his sensibilities for his leadership role in the Eng Ed PhD program. He shared:

> [the project] definitely gave me ideas regarding how to think about [student] support and which areas of a system can easily be missing and you're not realizing unless you start asking people questions. So, due to that, I started paying attention to … what people were incentivized to do, where they were kind of building mechanisms, what things were actually documented or not documented, how people were actually getting feedback. So, not necessarily the extent to which it was being done well or not well, but some of the things that made it likely for it to happen at all, and I think that spending the year looking for some of those things and figuring out where people had interests and where people didn't … kind of prime me to think about this role [of program director]

As Atlas Smith noted, the assessment project offered an opportunity to learn more "about [student] support and which areas of a system can easily be missing." This assertion has direct quality implications for the throughput stage of a PhD program (see Figure 1) since that is where the crux of student support takes place. As noted in Figure 1, the throughput stage characterizes quality through responsive mentorship, flexible coursework, and diverse opportunities for transferable skill development. Student support underscores each of these elements but especially the mentorship relationship between doctoral supervisor and supervisee. The mentorship experience for doctoral students is unique and interpersonal, and therefore to build mechanisms that structure this experience, it is important to attend to student needs and "areas of a system [that] can easily be missing" or which go "undocumented," as Atlas Smith aptly stated. When examined from this perspective, the outcomes of Atlas Smith's program assessment can provide significant value for the throughput stage of the Eng Ed PhD program he serves. This is important since, as AK, another participant, notes, the throughput stage prioritizes the "training and preparation" required for students to complete their program and transition into independent researchers.

Twyla, another participant, also made reference to the results of program-level feedback. In her response, she gave the example of eliminating a master's level engineering degree from their program admission requirements. Twyla shared that faculty members agreed that students admitted to the PhD program needed to demonstrate disciplinary grounding in the field of engineering but not necessarily at the advanced level of a master's degree. She stated:

> We just recently changed our requirement. We used to require that all of our students have a master's degree in engineering and a bachelor's. We've recently relaxed that to say we encourage a master's in engineering, but they have to have a bachelor's in engineering, so yes, they have to have a bachelor's in engineering and maybe a master's, but that's no longer requirement.

Though not a focal point of the program quality model shown in Figure 1, admission criteria are referenced as an input within the doctoral program framework Nerad [8] developed. Twyla's comment therefore highlights varying views on levels of academic preparation necessary for applicants of engineering education doctoral programs.

Course Assessments

Participants also highlighted the impact of course-level assessments on Eng Ed program quality. Mary, for instance, offered a layered example which showed a relationship between course and program-level assessments. In doing so she commented:

> Really, we're very conscious about what goals [we] wanted for the students after the program is over, and how they were going to hit those goals. So, we use that. We used our goals in the outcomes all the time to assess the program and we've changed them. We've amended them because maybe that wasn't working so well in this one class or in this one situation. We've changed some of the language in the objectives itself.

In this response, Mary references coursework objectives and student outcomes, which illustrate quality elements of the throughput and outcome components of the PhD program model respectively. Her conceptualization of this relationship has significant quality implications. She acknowledges that based on the results of course-level assessments, changes had to be made to ensure that the program was achieving the "goals they wanted for the students after the program" requirements had been completed. Mary's response is theoretically aligned to the Backward Design approach she and her colleagues used to develop their program. She identified the benefit of this strategy in the following comment:

> I think, first, having an understanding of the discipline that you are trying to make better. Having an understanding, knowing who you want to recruit to help you make it better… So, when we look for faculty and we look for students … I think that our values and our mission is in the back or our minds the whole time. I'm going to say I think our program is very high quality because our faculty very deliberately designed the PhD program using backward design theory, which is an educational theoretical perspective.

Throughout her interviews, Mary emphasizes the importance of conducting assessment on a continuous basis and highlights the role of assessment in sustaining program quality. Since Mary points to the frequency of their assessments, noting that they occur "all-the-time," it can suggest that these exercises are integrated throughout all components of the program. This claim is validated at another stage in the interview when Mary itemizes multiple areas of the program where she and her colleagues "reassess," "continually check," and "ask for feedback."

Mary's account revealed an interesting paradox embedded in her experiences. During her interviews, she identified features of her program that aligned with the input, throughput, and output components of the program quality framework used in this study. One such

example is illustrated in the following excerpt:

> So, I think being really deliberate in the choices you make, who you're hiring **(input)**, who you're recruiting **(input)**, the outcomes for your students **(outcome)**, the language you use when you write an exam **(throughput)**, all these even really small things, and continually checking, asking for feedback, reassessing and all that.

Though she alluded to characteristics, which notably aligned to each dimension of the program quality framework, she also posed the question, "we try to make a quality program, but what does that mean?" This interaction signaled some dissonance in her meaning-making. Notwithstanding the probable uncertainty, Mary's assessment experiences appear to inform her conception of Eng Ed program quality. It is likely that her assessment experiences, which include both the design and delivery phases of an Eng Ed PhD program, have provided her with a basis to hone her reflexivity on the topic. Though it is not covered in this component of the project, another theme from the overarching study addresses the role of reflection in conceptualizing Eng Ed PhD program quality.

Student Assessment

It comes as no surprise that even though the earlier subthemes addressed program and course-level assessments, the insights bore direct implications for students and their education. The student assessment subtheme, however, specifically attends to how various evaluations of student and student progress exist in participants' conception of Engineering Education program quality. One such example includes Twyla explaining how, with the guidance of their faculty advisors, students are required to assess their individual aspirations and chart an academic course through the curriculum. She described the process, stating:

> We work closely with the students and the students' faculty advisors to help the students sort of chart out a path, which probably looks very different for every student through the curriculum; that really helps them pick and choose courses that could benefit them in their career.

Twyla outlines the outcomes of these individual assessments, using the example of an immersive learning experience course that is a requirement of the Eng Ed PhD Program she serves. The immersive experiences could entail any of the following:

> an internship, if they think they want to go into policy, maybe … at National Science Foundation [NSF]. If they think they want to take a faculty career, then maybe they do a mentored teaching experience with somebody at our university or maybe somebody somewhere else. We've had students do an internship at the national labs, really serving in the role as a like a diversity, equity and inclusion coordinator. We're still trying to figure out what this immersive learning experience might look like across the spectrum, but our students have been really wise about identifying experiences that work for them and the role that they'd like to take down the line.

Exemplified in Twyla's excerpt are throughput and output elements of quality. In selecting an appropriate immersive experience, the student must align their prospective career path (output) with an opportunity for transferable skill development (throughput). Since Twyla avers that students have "been really wise about" which experience they choose, it suggests that the selection of an immersive experience is an intentional decision that has required students to evaluate the goodness of fit of their experience. By

describing students' perceptions as an "evaluation" – rather than assessment – we forebode the role of their value judgements in the future development and quality of the immersive learning course. Based on Twyla's response, it can be inferred that these students' insights play a major role in helping Twyla and her colleagues "to figure out what th[e] immersive learning experience might look like across the spectrum."

As expected, other student assessments were referenced. Qualifier and candidacy exams were of particular interest, and while all participants addressed the topic, Atlas Smith and Mary specifically provided clear outlines of the assessment purpose these exams served. From their accounts, it can be concluded that the assessment mechanisms embedded in these milestones provide a scaffold for students to persist through their doctoral program. Both participants described how these assessments ensure that students understand the basics of the discipline and that students are gradually able to progress and "take on leadership roles" through "teaching … through research, through administration or in a way that …. brings in the insight from some of the other fields to … go about improving engineering." Yet again, it is seen how assessments in engineering education PhD programs are linked to aspects of program quality. Atlas Smith's response illustrates how qualifier and candidacy exams, which are associated with the throughput PhD stage, provide the scaffold for students to become leaders in a variety of ways. Though his response does not confirm at what stage students will assume these leadership roles, it can easily be linked to their post-graduation career pathways. It may also be assumed that the outcomes of this leadership development may extend further than students' profession and even encapsulate the intrinsic elements of *purpose* and *identity* referenced in the PhD program quality framework.

<u>Latent Assessment Tension</u>

The topic of student-level assessments revealed latent tensions underlying assessment processes in Engineering Education PhD programs. Two specific issues arose, both of which were highlighted by AK. In her responses, AK presented issues related to academic tradition and disciplinary gatekeeping that may in/advertently impact the quality of Eng Ed PhD programs. In addressing the topic of purposeless adherence to academic tradition, AK stated:

> all too often, I just hear it get[ting] mixed up with rigor and … this whole negative connotation of "I had to take a three-hour qualifier and answer 150 questions in those three hours so everybody should have to do that and that's the only way we can measure quality and THAT's the only way we can tell if students are doing the right stuff, is if they did all of the same stuff that I did."

She was also quoted as saying:

> [Laughter] so I'm not trying *to not* answer your question but that's the thing; when people say that, the first visceral reaction I have is that – we know what quality is but it's not what people tend to do. It's not what people tend to focus on. They tend to focus on some of these other things. Where is the bar you have to jump over? Is it as high as the bar that I had to jump over because if it's not, we need to do it. We need to make sure it is, because I had to do it, you have to do it too.

With a similar critique, AK also questioned the relevance of some student-level assessments and to what extent they served a beneficial purpose. In justifying her reasoning, AK explained the dangers of using assessment criteria to conceal unreasonable

gatekeeping mechanisms. She noted that while assessment was a "part of th[e] process," it was quite likely that some of these requirements existed merely to serve "gatekeeping" purposes. Although AK made this declaration jokingly, as noted by her laughter captured in the transcript, she elucidated her point with a pertinent example. She highlighted how publication requirements for graduation should be reconsidered, given that the process "is reviewer reliant and a lot of it is just the whims and fancies of that." She furthered that it was problematic for programs to present journal publications as the sole format for research dissemination. Instead, she argued for "students … to be exposed to dissemination and the different types." She opined that this process should occur "as early as possible and as often as possible" in Eng Ed programs and should also prepare students to "create dissemination artifacts" that "can vary by the type of work" conducted and locations for where "[the research] goes - and how it goes out."

She used an engineering-allied field, where conference publications tended to be the priority, to demonstrate the dangers of myopic dissemination perspectives.

> Acceptance rates are often lower than 30% for any conference. So, yes, you can get accepted but a lot of it is reviewer reliant and a lot of it is just the whims and fancies of that. This idea that the acceptance is the ticket - I mean, yes, we want our work accepted, we need to publish all of those things, but for a student in particular, there's a timeframe here that they're under and [they] don't have anything … ready to publish till almost the end. So, then that decreases [their] time.

AK rationalized that although dissemination might be a requirement for degree completion and scholarly life, the "idea that it has to be just this certain way," appeared "really constrictive" and did not "equate to quality" for her. Further, her responses showcased genuine concern for the relationship between assessment and quality, especially as it pertained to elements of quality that were difficult to assess. She held that some aspects of program quality were "harder to measure" than others, possibly because of their abstract nature. She used the following example of doctoral student advisory to illustrate her point:

> We all just have this assumption that the students are getting what they need out of their advisors, and I don't know. A lot of that, unfortunately, is coming down to the prestige of the place, not necessarily even an understanding of what's going on behind the scenes or under the hood.

She concluded that it was those "pieces" of program quality that she would "love to figure out" and "learn more about." AK further contextualized her point by highlighting the danger of conflating quantitative measures with accuracy or reliability. She noted how several of these "sort of notions we have, in academia, of how good someone is, [are] based on some number that Google computes." This assertion was particularly illuminative, given AK's expertise in this area. While AK highlighted that academic metrics are established and recognized assessment tools within the higher education community, she confirmed that they could easily "be gamed."

AK's criticism of assessments in Eng Ed PhD programs captured an unsettling reality that extends beyond the PhD program to the broader ecosystem of the academy. Her interpretations of purposeless tradition and ulterior gatekeeping motives reveal clear and present dangers which can diminish student success, program quality, and educational equity. Her perspective is coincidental, since the latent nature of these issues often goes unnoticed and unaddressed in a community of PhD practice, a viewpoint attributed to Atlas Smith earlier in the report.

Discussion

Notwithstanding the inherent differences in leadership tenure and experiences, each participant contributed to the complex conceptualization of the role of assessment in Eng Ed PhD program quality presented in this study [7], [11]. These data allowed for the development of an idiographic work-in-progress study that highlighted convergences and divergences within and across four individual accounts [7], [11] and which is reflected in the culminating conceptual model shown in Figure 2.

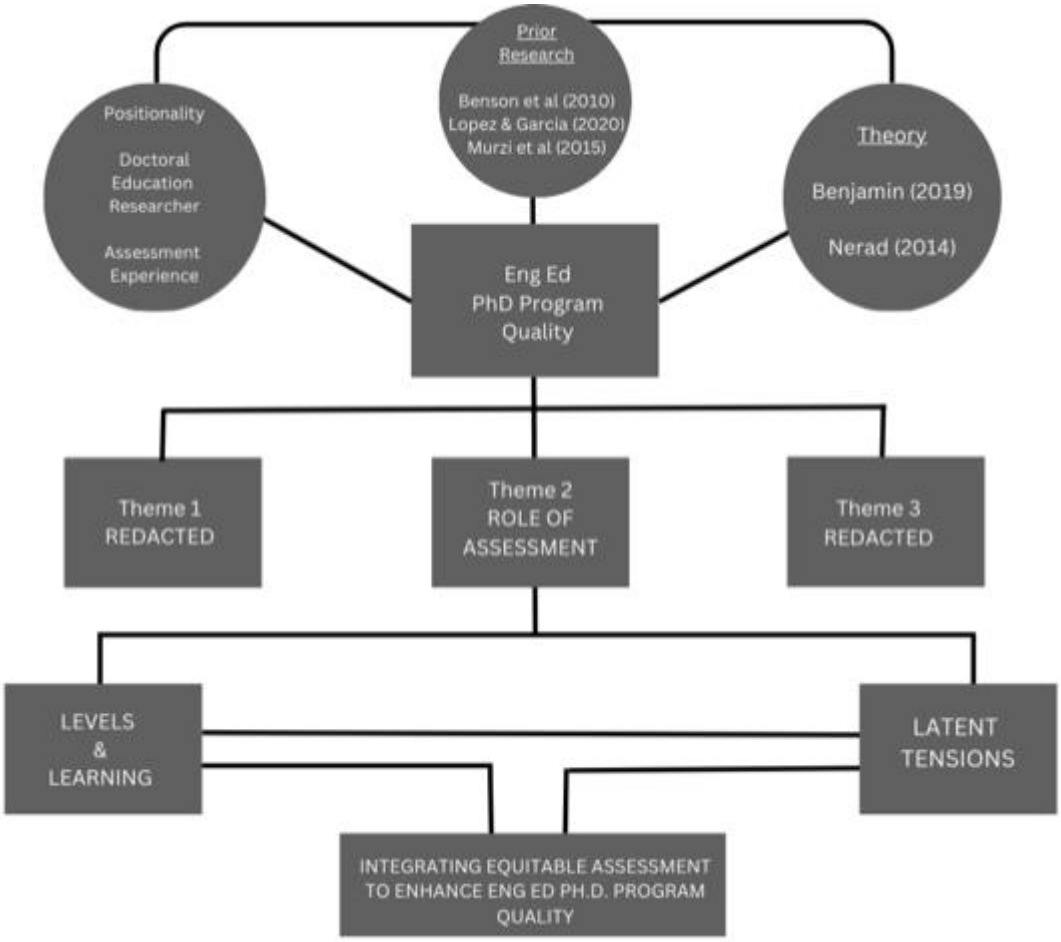

Figure 2 *Culminating Conceptual Model*

Findings from this study are uniquely beneficial to the existent body of research highlighted in earlier sections of this paper. The contribution made is dynamic as it builds on and extends several areas of current literature. At the most overarching level, this study situates the concept of assessment within ongoing discussions about Eng Ed PhD programs [2], [3], [4]. These findings provide a basis for responding to Murzi and colleagues, who welcomed further interview-based research with key stakeholders of engineering education [2]. Having attended to the experiences of program leaders, this study not only implements Murzi et al. [2]

recommendation but it also acknowledges Prewitt's view about the diverse group of stakeholders responsible for the design and delivery of doctoral programs [10]. The focus on program leaders demonstrates that whereas various professions contribute to the quality of an Eng Ed PhD program, program leaders have a first-hand view since, as AK phrased it, they are responsible for "the day-to-day dealings" of these programs. Much like Atlas Smith, AK's experiences confirmed that program leaders are charged with addressing and supporting "students and issues around students… from pre-admission discussions to admissions to … how they progress through the program, how they achieve their milestones, [and] the types of challenges that students face along the way." With such an influential mandate, it was evident that participants' leadership experience would be suitable to provide the type of "vigorous experiential account[s]" required for "high quality" Interpretative Phenomenological Analysis [11, p. 10].

Having attended to the role of assessment, findings from this study emphasize the need for unified, transparent, and, probably most pressingly, equitable assessment within and across Eng Ed PhD programs. This point is telling since engineering education is currently characterized by a focus on broadening participation. Integrating more equity-based assessments might contribute to this goal within the context of Eng Ed PhD programs, given the points about unnecessary gatekeeping expressed by AK. Additionally, the minor "discrepancies regarding the purpose, the focus of the goals, and the learning outcomes of the[se] PhD program[s]" suggest that further assessments may provide the evidence needed for characterizing a unified understanding of quality in Eng Ed doctoral programs and prevent the current conceptions that result in key stakeholders, such as Atlas Smith, "going back and forth on what [programs] are trying to do sometimes". Defining quality in Eng Ed PhD programs might become less of a "tricky question" as he put it, if "intentions" behind different programmatic elements were transparent, consistent, and equitable [2, p. 9]. Lopez et al. are advocates of a similar perspective, arguing that further evaluations into the Eng Ed PhD are needed given the continued emergence of new programs [4].

An interesting paradox about the role of assessment in Eng Ed PhD programs was noted as a final outcome of this study. Though numerous researchers of the Eng Ed PhD have identified mastery of assessment techniques as a staple learning outcome [2], [3], [4], the current Eng Ed PhD program landscape appears well positioned to benefit from an overarching assessment project. It is envisioned that doing so can provide evidence-based insight into what constitutes programmatic quality in Eng Ed PhD programs. Of major concern to this claim, however, is the need to re/consider "who does what?" - a question Prewitt posed about doctoral programs [10] and on which both Atlas Smith and AK provided analytic insight. It is understood from Atlas Smith's description of the field that academic stakeholders of Eng Ed PhD programs are situated at various positions on the Social Science - Engineering Science continuum of Eng Education research. These positionalities and resulting subjectivities can undoubtedly influence any such assessment activities and their outcome. AK's account of philosophical differences among faculty members regarding programmatic change may be acutely related and might also be a point for deeper investigation. Though often associated with the best practice of closing the assessment loop, the process and outcome of change might be a difficult sell for which to gain buy-in. Finally, the time needed to complete such an endeavor should also be considered. As highlighted in Atlas Smith's introductory account, sufficient time – in his case, a year – and flexibility are needed to even identify "gaps" and promote "transparency" based on assessment

findings. This should be a point of deep consideration since rushed approaches may not provide the quality of evidence needed to support sustained change and the type of improvement envisaged.

Conclusions

Having centered assessment in this work-in-progress study, it has illustrated how programmatic gaps, improvements, and tensions affect the delivery of a quality Eng Ed PhD program. Together, these conceptions provide a comprehensive basis for characterizing Eng Ed PhD program quality not as a static condition but as the result of critical, continual, and contemplative assessment practices. Given what has been learnt about how different levels of assessment improve and transform facets of Eng Ed doctoral program quality, this in-progress project encourages further and more deliberate assessment of these programs. Future research might focus on specific levels of assessments in Eng Ed PhD programs since this study broached the concept from a general perspective. By engaging in a more nuanced study, researchers might reveal unique differences, tensions, and opportunities inherent across student, course and program level assessments.

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