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Is the "E" in Engineering for Entrepreneurship? An Emerging Concept of Entrepreneurial Engineering Identity

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Dr Le Shorn Benjamin has amassed over a decade of experience in the field of education. These experiences span local and international borders and have included roles in educational research, program administration, higher education accreditation and K-12 teaching. Dr Benjamin's research agenda explores issues related to minoritized student experiences, doctoral education, and engineering education.

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Session XXXX

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Abstract

The topic of engineering identity is neither new nor complete in its coverage within current literature. By applying both quantitative and qualitative lenses to this inquiry, researchers have concluded that, much like a STEM identity, an engineering identity describes how students see themselves, their competence and potential for success in the academic and career context of the field. To further examine students' potential for academic and career success, we attend to an emerging concept of an entrepreneurial engineering identity. This preliminary work unfolded organically; authors' primary goal involved a larger ongoing Interpretative Phenomenological Analysis (IPA) study that investigated persistence and advanced degree aspirations among 20 Black male engineering undergraduate students. We observed a latent phenomenon of interest among participants: these Black male engineering undergraduates recurrently articulated clear intentions for academic and career opportunities that integrated business components into their engineering realities. Based on these findings, authors were inspired to explore the conceptual development of an entrepreneurial engineering identity and its practical application to engineering degree (re)design, student academic advisory and career planning.

Introduction

The inextricable link between innovation and commercial enterprise has provided a suitable niche for entrepreneurship within engineering programs and industries[1,2,3,4,5,6]. Recent economic and societal trends have illuminated a need for future engineers to be equipped with business acumen and, in particular, entrepreneurial skills[1,2,3,4,5,6]. Researchers have suggested that these skills are not only beneficial in traditional entrepreneurial settings such as startup companies but also for established organizations as well[3]. These competencies are so crucial that researchers have explored opportunities for integrating entrepreneurial outcomes into ABET accreditation standards[3]. This sentiment, while popular, is often challenged by uncertainty due to the dense nature of engineering course sequences and other concerns regarding disciplinary dilution[7]. Understandably, this topic is widely discussed by stakeholders of the industry and academy alike[3]. Yet, very little research has been published through the meaning-making lens of engineering students[3]. We further opine that given the stark underrepresentation of Black males in undergraduate engineering programs, even less is heard from this minoritized group. This exploratory work-in-progress, aims to examine an emerging concept of entrepreneurial engineering identity presented through the meaning-making of

20 Black male engineering undergraduate students. It should be noted that while we did not intentionally seek to examine this emerging component of engineering identity, preliminary data analysis for a larger, ongoing study led us down this path.

Literature Review

At minimum, a literature review provides readers with an outline of existent research underpinning the current study and illuminates the gap which the author seeks to address[8]. Since we aimed to ensure that our study findings were situated within the meaning-making of the participants, we conducted a search of the literature that was rigorous enough to provide a "flavor" of the existing work [9] but not "explain away" the essence of participants' lived experience and meaning making too prematurely[10]. We approached the literature with the intent to understand: (i) constituents of an engineering identity and (ii) conceptualizations of entrepreneurship within engineering education literature. Notably, this approach would also accommodate evolving demands for published literature, known to arise in latter stages of meaning-making research projects[9, 11].

Constituents of an Engineering Identity

Research on engineering identity has grown increasingly prominent throughout engineering education scholarship[12, 13, 14]. Through their investigations, researchers have found *interest*, *competence* and *recognition* to be key components of engineering identity[13]. *Interest* refers to "a person's likes, preferences, favorites, affinity toward, or attraction to a subject, topic, or activity" [15]. An individuals' belief in their ability to perform well and understand concepts in the area is understood to be a measure of *competence*; while *recognition* refers to one's belief that they are perceived, by others, to be the type of person that performs well within the context of the field[13].

Although the interest-competence-recognition framing of engineering identity remains significantly prominent, it is not indicative of consensus within the literature. Other researchers have conceptualized engineering identity differently, having included additional constructs based on specific research populations[16, 17]. Another factor limiting the achievement of consensus is the frequency with which STEM and engineering identities are conflated [18]. Despite these challenges, Gee's contribution remains a viable lens, as it equates and relates identity to an understanding of what it means to be a "certain kind of person"[19]. In similar fashion, Kendall also distilled the essence of engineering identity, concluding that the concept connotes the extent to which one perceives oneself to be an engineer[20].

Scholars have applied these framings of engineering identity to examine a variety of issues. Such studies have linked engineering identity to pedagogical styles, engagement, retention and persistence[14, 20, 21]. Others have highlighted the marginalizing impact of dominant engineering identity theories, noting that traditional theories rarely acknowledge the intersectional, gendered, and/or racialized experiences of minoritized members of the field[14, 22, 23, 24].

Conceptualizations of Entrepreneurship within Engineering Education Literature

The need for engineers to respond to economic, workforce, and social needs has given rise to the prevailing nexus between entrepreneurship and engineering[5, 16, 25]. Over the last decade, the concept

of entrepreneurship has shown to be a staple within engineering education literature and conferences; particularly, as stakeholders re/imagine ways to integrate entrepreneurial competencies into the curricular landscape[5, 25].

Benefits of entrepreneurship are so well situated within engineering that scholarship on the contemporary entrepreneurial engineer has increasingly been reported[2,6]. Insights emerging from this body of research acknowledges the experiences of many engineering graduates who, due to organizational downsizing and changes in employment taste and preferences, elect to pursue job opportunities in small companies and create start-ups of their own[25].

This body of research makes a valuable contribution to the larger field, as it outlines pertinent skills which entrepreneurial engineers should possess. While nomenclature for these competencies vary across the literature, Ohland and colleagues acknowledged that they generally involve skills such as designing to meet desired needs, multidisciplinary teamwork, communication, problem-solving, and the understanding of engineering practice and its place in society[26]. Further, the Kern Entrepreneurship Education Network [KEEN], a distinguished network of engineering faculty, have proffered that when these competencies are mastered, they combine to give rise to engineers who are not only technically savvy but also equipped to foster the "3C's" i.e. curiosity, connections, and creating value[27].

While there is some - though not complete - consensus around what constitutes entrepreneurial engineering skills[5, 28], there is still significant debate about effective models for integrating them into engineering programs[23, 25]. Inherent in the literature is varying levels of agreement for which of the following models prove to be most worthwhile: (a) coursework within engineering and across other fields, (b) experiential learning opportunities, (c) stand-alone programs for engineering students and/or multi-disciplinary stand-alone entrepreneurship programs[25, 29]. Although differences in views exist, Hagvall Svensson et al., have provided two general routes for enhancing entrepreneurial learning[30]. Irrespective of the instructional model, these researchers recommend making learning more personal and more professional as key strategies for strengthening entrepreneurial skill development among engineering students[30].

The nuances of an *entrepreneurial engineering identity* reflect yet another emergent topic in engineering education. A key component of this area of research discusses the various categories of entrepreneurial engineers and how they contribute to the current and future advancement of the field[31]. Based on an application of earlier work by Edwards & Pillapakkam[31], Har-el, Thomas, and Ochia contended that *founders*, *developers* and *inventors* are the three main types of entrepreneurial engineering identities[4]. These identities represent the kinds of entrepreneurial engineers that are required from the initial stage of conceptualizing needs to the final stage of solution development. These entrepreneurial engineering identities, as referenced by Edwards and Pillapakkam[31], and Har-el, Thomas, and Ochia[4], can be described as follows:

Founders are people who want to create firms/companies based on ideas or social motivations. Developers are people who want to take nascent firms/companies further than just initial stages… Inventors … want to identify and propose solutions to problems[4, 31].

It is understood that an individual is neither confined to a sole identity nor is there a clear path through which engineers transition through these identities[13, 20]. This work-in-progress study makes a novel contribution to the existent body of literature by reporting the meaning-making of a historically underrepresented engineering student group i.e., Black male undergraduates.

Theoretical Underpinning

Given the emergent nature of the study design, authors employed a retroactive theoretical underpinning. Prior research has promoted retroactive theoretical selections, advising that, at times, a theoretical perspective can only be selected after some time of data analysis and pondering "what does this [data] remind me of? " [32] Mutch argued that when the selection is undertaken like this, a scholar can capitalize on the chance to explore multiple theories before selecting which of them most closely aligns with the "key players" and direction of the project[32].

With semi-structured interviews as the primary data source and the unexpected manifestation of the phenomenon of interest, authors aimed to gain a deep appreciation for how participants' made sense of their engineering learning experiences. As a result, Ignelzi's application of Kegan's work provided a useful blueprint for in-depth analysis of participant accounts[33, 34]. Ignelzi applied Kegan's earlier conceptualization, concluding that the design of college curricular environments should be informed by how students make meaning of their learning experiences, knowledge constructs, relationships, and sense of self. Ignelzi framed this sentiment within the general collegiate setting[33, 34]; however, the claim is easily applicable to the undergraduate context of engineering education. In fact, the assertion appears even more fitting given the noticeable congruence between the academic rigor of engineering programs and Ignelzi's observation that students often face educational challenges which exceed the academic support they receive. As it relates to engineering programs, Ignelzi's theorization makes appropriate use of Kegan's work which previously acknowledged students' dismay in constantly feeling "in over their heads."

Methodology

Unlike the structured IPA study from which this secondary project evolved, this work presents a generic exploratory style of qualitative inquiry[35]. Rather than adhering to strict methodological canons, this study allowed us to follow an undetermined path of inquiry which led us to understand participant's meaning-making[34, 36]. Authors deviated from a normative early-stage research question; instead, we remained responsive to the needs and direction of the inquiry, guided by our data analysis. After first stage descriptive noting[9] of transcripts for the primary study, we investigated, in greater depth, a latent phenomenon of interest which we unearthed. This phenomenon involved entrepreneurial intentions embedded in participants' meaning making of their engineering realities. Although there was no specific research question guiding the study, researchers aimed to examine an emerging concept of entrepreneurial engineering identity espoused through interview data.

Participants

This project is a smaller component of an ongoing study, aimed at investigating persistence and advanced degree aspirations among 20 Black male undergraduate engineering students. Table 1 provides a profile of the sample, outlining participants' selected pseudonyms, year classification, engineering discipline, and institutional type.

Table 1. Participant pseudonyms and demographic information

Pseudonym	Classification	Engineering Major(s)	Institution Type
Billy	Junior	Mechanical	PWI
Carl	Junior	Electrical	PWI
Christopher	Sophmore	Mechanical	HSI
Corbin	Senior	Electrical & Computer	HSI
Dave	Junior	Industrial	HSI
Ed	Junior	Chemical	PWI
Jack	Sophmore	Mechanical	HBCU
Jalen	Senior	Mechanical	PWI
Jay	Junior	Computer Science	PWI
Jefferson	Junior	Computer	PWI
Joe	Senior	Mechanical	PWI
John Edward	Senior	Civil	PWI
Jonail	Senior	Mechanical	PWI
Josh	Junior	Mechanical	PWI
Matthew	Senior	Civil	PWI
Oman	Senior	Chemical	PWI
Omarion	Junior	Civil	PWI
Peter	Senior	Chemical	PWI
Plato	Freshman	Chemical	HSI
Quinton	Senior	Mechanical	PWI

Data Collection

An IRB-approved recruitment email was distributed to National Society of Black Engineer (NSBE) secretaries and presidents from across the United States. These officials were asked to distribute the invite to their respective chapter members. In addition, the NSBE Headquarters communications team sent an email blast to all members. Snowball sampling was also found to be beneficial, given the known underrepresentation of the participant group of interest[11]. Before interviewing, participants completed an online demographic form which gathered information on their personal and academic backgrounds. Each participant was allowed to select a pseudonym of their choice. To maintain consistency and trustworthiness across interview sessions, two specific team members either individually or collaboratively conducted all semi-structured interviews. Consistent with established qualitative procedures, interviews were recorded and transcribed by an external transcription service, and minor transcription mistakes were corrected by project team members[9].

Data Analysis

Although this study unfolded as a type of generic exploratory qualitative inquiry[35], authors relied on data analytical techniques comparable to those of Interpretative Phenomenological Analysis[9, 11]. In so doing, authors employed Ignelzi and Kegan's theorization of meaning making to develop descriptive, linguistic and conceptual comments; these comments formed the basis of code and emergent theme development[11, 33, 34]. This approach proved practical and beneficial, as it allowed researchers to interpret participants' meaning making across concrete and abstract domains[33, 34]. Specifics of our data analysis techniques will subsequently be discussed.

The first and second author reviewed the transcripts independently, which included reading transcripts several times and making descriptive and linguistic notes[9, 11]. After significant words, phrases, or concepts were identified, authors reconvened to compare notes and interpretations of participant perspectives (Authors, in press). During these *calibration meetings*, we posed conceptual questions and conducted a long-table exercise which involved cutting quotes into strips of paper and physically arranging them to develop an engaging and compelling conversation between participants' accounts[9, 11]. Finally, all research team members came to a consensus of the final themes and then proceeded to develop this work-in-progress manuscript.

Researcher's Positionalities

Each researcher identified as Black. The first author is a higher education researcher of Afro-Caribbean immigrant identity who explores minoritized learner experiences in a variety of contexts. This author led all aspects of project development. The other authors are both male professors (assistant professor in engineering and associate professor in school counseling) who have both earned advanced degrees and are interested in broadening participation in engineering.

Methodological Limitations

Although researchers aimed to conduct a generic yet rigorous qualitative study, there were methodological limitations which were inescapable. The most significant of which is attributed to the unexpected origin of the study. The phenomenon of interest was not specifically identified in the apriori stages of study design; therefore, the topic of entrepreneurship was neither explicitly referenced within the interview protocol nor was the body of literature on entrepreneurial engineering used to inform the design of the interview protocol. Furthermore, given the in-progress nature of the study, analysis at the institutional-type level has not yet occurred. It is anticipated that these limitations will be addressed as the study undergoes further development.

Findings

"I mean the end goal, I always want to be an entrepreneur. I've had many different business ideas I want to get involved in but with engineering though, People look at engineering and think it's just a whole bunch of technical stuff but there's more to it than that - especially when I went in my internship. There's more to it than that. You have to learn more entrepreneur skills than you may believe you have to" ***Participant Jefferson (Junior, Computer Major)***

Findings for this study were derived from participants' responses to a subset of the protocol items from the original study. These items solicited participants' meaning making around their experiences prior to and during their engineering undergraduate education, their aspirations for after, and inquired about participants' views on support rendered by different K-16 educational stakeholders (e.g., teachers/faculty members, advisors, and support staff), peers, organizations, and parent/guardians and, correspondingly, sought participants' advice to these same stakeholder groups.

Participants meaning making around entrepreneurship were multifaceted and extended further than discourses solely rooted in the financial benefits of entrepreneurship. Insight into their meaning-making illuminated conceptions of business activities and entrepreneurship which varied across temporal, disciplinary, and functional divides. In this section, we present two findings developed through our data analysis: *Learning for Earning | Learning for Leading* and *Let's Talk Business..Business Economics that is!*

Learning for Earning | Learning for Leading

By analyzing participants' accounts of their experiences and aspirations for entrepreneurial and business related learning, we developed a trio of subthemes. We first noticed that participants' responses varied across current and future timescapes, which resulted in our development of the subtheme, "*Business Education: Now or Later*." In discussing business and entrepreneurship related

education, some participants referenced learning experiences which, at the time of their interview, were currently underway. Example, one participant stated, "I am currently studying to get my industrial engineering degree with a minor in economics" while another highlighted that, in the current pursuit of his engineering degree, he had already completed a "couple of economic classes". Conversely, however, most participants acknowledged the importance of business and entrepreneurial learning within the context of future aspirations, e.g. "I know I could be able to get an MBA…then I can use that to help advance me in my engineering career or business career." Another participant demonstrated similar meaning-making stating, "after I get my undergraduates…this semester, I plan to get an MBA…With my MBA, I'm making sure to have concentration on entrepreneurship." The variation in temporality clearly demonstrates possibilities for entrepreneurial and business learning across varying time periods.

Skill and Wealth Building, the second sub-theme, represented participants' meaning making around the functionality of business and entrepreneurial learning. Participants understood that business and entrepreneurship education - whether future or current - would facilitate both skill and wealth building. One participant extolled this value, stating:

"the reason why I've chosen [my industrial engineering degree with a minor in economics] is because I believe I would get the best from engineering, from knowing the basic engineering concepts... Also, with a minor in economics, it would help me with numbers and how the basic business works, like opportunity cost and all that." Participant Dave (Junior, Industrial Major)

Another participant acknowledged that through his future MBA education, the focus of which will be entrepreneurship, he would gain the skills needed for patenting and selling ideas. Similarly, another participant with future interest in an MBA degree, described "opportunities for promotions and better job positions and salary" as his "driving force" for earning the MBA degree. Another viewed his aspiration for an advanced degree in business as an opportunity to become more acquainted with business concepts that would allow him to build managerial skills and be able "to lead from the front of the pack [and] reach the very, very top" of the organization. This sentiment was also shared by another participant who likened his undergraduate degree to "management engineering." He proffered that the industrial focus of his program endowed him with the skills needed to make a "positive impact" on future engineers and the profession as a whole. He was adamant that the management focus of his coursework diametrically opposed "other engineering [disciplines], like chemical engineering and civil engineering" which, he opined, monotonously did "the same thing over and over".

The final sub-component of the learning theme, while not as provocative as the first two, was still telling. In attending to participants' linguistics, authors formed a sub-theme called *"MBA: the name of the business game"*. The formation of this theme originated from participants' frequent and explicit indication of the MBA qualification as a route for entrepreneurial and business training. There were some participants who highlighted alternatives such as undergraduate coursework in economics, or professional certifications but participants meaning making around business and entrepreneurial training mostly focused on the MBA degree. The popularity of the MBA inherent in participants' meaning making could easily be attributed to the common association of MBA degrees with professional seniority and advancement in engineering settings (e.g., plants and firms).

One participant alluded to this sentiment, recalling that "a lot of people" had advised him to "wait [to pursue] an MBA because people who are getting their MBA already worked for a couple of years. They have a little bit more experience." With the exception of the participants who likened his degree to "managerial engineering", and the other whose degree plan consisted of an economics course, there were no other instances where participants highlighted, aspired to, or acknowledged any learning experiences which merged business with engineering.

Let's Talk Business...Business Economics that is!

Given the constantly evolving nexus between engineering, innovation, and economy, contemporary engineers are charged with harnessing skills which exceed technical know-how. Correspondingly, participants' meaning making demonstrated a collective understanding of economic constructs and sectoral mechanisms existent within the context of the engineering business enterprise.

Participants articulated these constructs across varying degrees of abstraction i.e., while some made explicit references to economic terminology, others implicitly alluded to their economic understandings. Examples of the former, included one participant who commented,

I'm actually Nigerian. In that part of the world and those third world countries, we, most times, import things from foreign countries. We don't make things locally, so I feel like … I want to be a person who makes things and not get things from other countries. I want to start up my own manufacturing company back at home, so it will help the economy Dave (Junior, Industrial Major)

and another declaring:

I have an interest in oil and gas but I also have a fear of that because I feel like with oil and gas, it's unstable because it's really dependent on the price of oil, which does tend to fluctuate, and that's my fear. I don't know if that's a reasonable fear because I just don't feel like – I'm afraid of putting my job, like tying my job to the price of a commodity. Participant Plato (1st Year, Chemical)

Others shared aspirations such as, "Hopefully, I can patent that idea, I can sell it off and sell out." While another participant acknowledged that his economics degree minor would aid in his understanding of "how the basic business works, like opportunity cost and all that." These references to *import economies*, *price instability, patents* and *opportunity cost* explicitly demonstrate participants' development of economic knowledge constructs which they have appropriately applied within the context of their engineering realities. Conversely, other participants alluded to economic constructs but articulated them indirectly. Examples of such allusions can be observed in the following quotes from multiple participants:

going to graduate school has to do with how much money I'm getting since I'm going to graduate; that has to do with how much the school's going to give me. Do I possibly have a fellowship … or something? Whereas for a job, it depends on how close to home it is and how much they're paying me Participant Oman (Senior, Chemical)

and

If I want to get a master's, I'd work for a year to get my company to pay for it and graduate in like two years, continue working for that company for maybe a year or more, or two years more, because they want you to stay after spending so much money on you. Participant Jonail (Senior, Mechanical)

Inherent in the first quote is the participant's understanding of economic concepts such as opportunity cost and cost and benefit analysis. In similar fashion, the second quote reflects the participant's application of return-on-investment analysis. Authors were keen to include "business economics" in the title of the theme, as this economic subspeciality involves the application of economic theory to business management and, in particular, organizational structures, global markets and human capital development. Participants observably integrated their personal experiences of human capital development throughout their meaning-making. Such examples were noted as participants explained their intentions for career advancement. For example, "I can see myself growing in the power industry. That's a great industry" and "like I was saying, industrial engineering is more long-term in the sense that, I feel like after I gained the required skills, I needed to elevate myself or to satisfy my knowledge - ten years down the line, 15-20 years down the line, I'll be able to manage the younger set of engineers." Comparable meaning-making was also observed when another participant recognized that by getting a job, earning a master's degree and having "worked for 10 years," he would increase his value "to the working world, to industry, to companies, to the government, and stuff like that." These accounts clearly demonstrate knowledge of business economics constructs which participants situated within the context of the engineering industry and wider economy.

Discussions

Based on our findings, authors contemplated if participants' meaning making culminated in the development of an inductive conceptualization of entrepreneurial engineering identity. Our considerations occurred within the context of the scholarship presented in the literature review as well as additional sources which refined authors' thinking after data analysis. In light of the entrepreneurial engineering identities previously discussed, participants' meaning making illustrated characteristics of founder and inventor identities[4, 31]. Notably, however, characteristics of the developer identity were neither directly nor indirectly present in participants' meaning making.

We offer these claims given participants' articulation of ideas and social motivations for business ownership, startup development, and idea patenting i.e. attributes of the founder identity[4, 31]. Omitted from their accounts were any aims to advance these articulations past nascent idea formulation and early-stage business development i.e attributes of developer identity[4, 31]. While representations of developer identity appeared sparse, possibly even non-existent, participants' identification and proposition of viable solutions to socio-economic problems coincided with our understanding of the inventor identity. Participants' emphasis on social impact is well-aligned with the perspective of contemporary engineering espoused by El-Zein and Hedemann, who likened engineering in the 21st century to a public good[37]. El-Zein et al. charged engineers to employ their technical knowledge and shrewd problem-solving skills to effect positive social and environmental change, much in the same way that participants envisioned their future realities in engineering.

With limited reference to attributes of developer identity embedded in participants' meaning-making,

authors are confident that a worthwhile application of these findings would be the design of learning experiences that allow engineering students to gain the cognitive and practical skills necessary for "tak[ing] nascent firms/companies further than just initial stage" i.e. attributes of the developer identity[4, 31]. In line with Ignelzi and Kegans theorization of meaning-making outlined in our theoretical underpinning, we recommend that faculty integrate such competencies into engineering coursework in a manner that does not contribute to students' feeling "in over their heads[4, 31]". In scaffolding this developmental transition, as Ignelzi phrased it, students must be provided with levels of support and challenge that are analogous[33]. Such equilibrium is crucial for advancing students' competency and their ability to metacognitively make-meaning of their development. By encouraging incremental, albeit strategic, introductions of entrepreneurship concepts into undergraduate engineering curriculum, it is likely to mitigate concerns about coursework extensions and/or disciplinary dilution. We find this curricular update to be overdue considering Saleh's prediction that non-traditional engineering concepts such as entrepreneurism and corporative managerialism will increasingly become definitive features of the engineering work environment[7]. With the anticipation of these transformations, future research in this area may examine impediments to and models for promoting students' formation of developer attributes.

Summary and Conclusions

In summary, authors pursued an unexpected path of inquiry which originated during primary stages of analysis for a larger IPA study. In this in-progress work, authors aimed to understand entrepreneurial engineering identity through the collective meaning-making of Black male engineering students. Participants articulated accounts that were consistent with attributes of founder and inventor entrepreneurial engineering identities while also emphasizing the social impact of engineering. Since there was no reference to the developer-type entrepreneurial engineering identity, authors recommend that educational stakeholders - faculty in particular - facilitate students' development and meaning-making associated with this developmental transition.

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