2023-10-10

First-Generation Engineering Students' Identity Development: Early Forays Into The Workplace

Renee SMIT
Centre for Research in Engineering Education (CREE), University of Cape Town, South Africa,
renee.smit@uct.ac.za

FIRST-GENERATION ENGINEERING STUDENTS' IDENTITY DEVELOPMENT: EARLY FORAYS INTO THE WORKPLACE

Reneé Smit [1]
Centre for Research in Engineering Education (CREE), University of Cape Town
Cape Town, South Africa
0000-0002-0249-3094

Conference Key Areas*: Equality Diversity and Inclusion in Engineering Education; Engineering Identity*
Keywords*: engineering identity; professional identity; first-generation engineering students; epistemic fluency*

ABSTRACT

In the context of global shortages of engineering professionals, research into factors that impact on training and retention of qualified engineers is important – this includes first-generation engineering students, a largely under-researched group of students. Research has shown that an elaborated, well-developed engineering identity is important for the retention of both engineering students at university, and for engineers in practice. Professional identities are fluid, emerging and develop over the lifetime of the professional. However, we still know little about the nature of a professional engineering identity, and how it develops.

Drawing on insights from the philosophy of science, I make an argument for a heuristic that allows for the analysis of data on engineering identity: professional identity is marked by epistemic fluency, a process of ontological becoming and axiological capacity. The paper reports on a set of interviews of new engineering professionals as they transition into their first few months in practice. The work is part a longitudinal study of first-generation engineers.

[1] *Reneé Smit*
R Smit
renee.smit@uct.ac.za

The study shows that the workplace environment expands the emerging identities the new engineers bring into their first jobs. The analytical framework allows the researcher to tease out aspects of the developing professional identity.

The study not only adds to conversations about the development of engineering identity in the transition into the workplace using the proposed analytical concepts, but also has implications for curriculum.

1 INTRODUCTION

In 2015 the United Nations adopted the 17 integrated Sustainable Development Goals in an effort to end global poverty and ensure that all people are able to live with dignity in peace and prosperity by 2030. There can be little doubt that engineering professionals have important roles to play as the global community strives towards these ambitious goals.

We also know that there is an acute shortage of engineering professionals in both developing and developed economies around the world. Understanding factors that impact on the recruitment, training and retention of qualified professionals in the engineering field is therefore an important objective.

Research has shown that the development of a professional identity is important for both the retention of engineering students in their field of study, and for the persistence of engineers in the profession.

In many countries first-generation students form an important part of the intake into higher education in general, and engineering studies in particular (in the longitudinal study at a prominent South African university that this paper draws on, around a third of the first-year students into the engineering programmes were the first in their immediate families enter university). These students face various challenges over and above the typical transition issues that all first-year students negotiate as they enter higher education: the absence of role models in immediate family, grappling to make sense of oft-tacit expectations of what is valued in higher education, and, in many cases, facing difficulties of multiple intersecting socio-economic issues and schooling that has left them under-prepared for engineering studies.

1.1 What is a professional identity?

In a wide-ranging review article looking at research on engineering identity, Morelock characterises engineering as an “ambiguous profession” (p.1240), obfuscating attempts to define an engineering identity and what it means for students or individual practitioners to identify with the profession. What is clear from the literature, is that any professional identity is complex and contested. It is also always provisional, fluid, temporal and evolves over the lifetime of the professional. Because of the difficulty to define what is meant by a professional identity, a pragmatic starting place is perhaps simply to describe it as the perception of the self in relation to the profession.

One of the most obvious aspects of what we call professionals (such as engineers, doctors, lawyers, teachers, etc), is the expert knowledge associated with practitioners in the professions. Here, in the context of engineering, it refers to expert technical knowledge and skills. In addition, there are also values and dispositions associated with professions.

The purpose of this paper is to explore the nature of an early professional engineering identity that engineers start to forge as they enter the workplace. In the next section I propose a conceptual framework as a heuristic analytical tool. The context of the study is a seven-year longitudinal study of first-generation engineering students journeys through their studies and into their early careers.

1.2 A conceptual argument for an analytical framework

Peter Deane (2018) argues for the inclusion of philosophical insights such as epistemology, ontology and axiology to extend understanding in interdisciplinary research (such as education research). In this paper I explore these ideas, attempting to find a productive analytical lens to think about professional identity.

One of the marks of the professional, is expert knowledge in a particular disciplinary area. In the case of engineering, professional mastery of disciplinary knowledge is a central part of the engineering identity. Scholars who look at professional knowledge, go further – they refer to a *fluency* in the use of expertise (see the work done by Winch (2014)), which includes the need to wield expertise in making judgements and decisions about action. Markauskaite & Goodyear (2016) use the phrase "epistemic fluency" that they link to taking action, which they call "knowledgeable action" and "actionable knowledge" in the context of the professions.

At its deepest level, identity is about a sense of being, of becoming. There are therefore profound ontological aspects to the development of a professional identity – Downey & Lucena (2004) call the identity politics of engineering "ontological work" (p. 400). When we think about professional (engineering) identity development, it can therefore be argued that being recognised as a certain kind of person, here, an engineer, is crucial to identity development. Ron Barnett has written about the link between ontology and epistemology: in a book on the purposes of higher education, Barnett (2009) talks about the transforming power of encounters with knowledge. He makes a distinction between 'knowledge' and 'knowing', which involves an internalising of knowledge, resonating with the notion of epistemic fluency.

Axiology is a rather neglected aspect of the philosophy of science & engineering that has bearing on a professional identity (see the argument by Patterson and Williams (1998) for axiology to be included in considerations around the nature of science in natural resource management). Axiology refers to what is called value theory in philosophy. Here it recognises that engineering is not a neutral activity, but that it is inherently normative. It refers to the necessity in engineering to make values-based calls about the fitness-for-purpose of a proposed solution to a problem, and the requirement to weigh competing, and possibly conflicting, demands and needs and make professional values-based decisions – what Loui (2005) calls, "a capacious sense… [of] stewardship for society" (p.383). Another example is the concept of sustainability, in its broadest sense, that addresses the complex tensions between human aspirations for a better life and the constraints of limited resources. It speaks to the potential difference between the well-being of future and present generations.

In this paper I therefore propose a three-part heuristic or cognitive tool for considering the nature of professional identity: epistemic fluency, ontological belonging, and axiological capacity.

In the rest of this paper, I look at small set of interviews with first-generation engineers, conducted in the first few months of their entry into the workplace, and draw on the philosophical heuristic to analyse responses.

2 METHODOLOGY

The results described in this paper are part of an ongoing longitudinal study of 16 first-generation engineering students at a prominent South African university. The study is in its fifth year, and results from various stages of the project have been reported on the over the past few years. Nine students who started their undergraduate studies five years ago, graduated at the end of 2022, two were academically excluded, and five have not yet completed their studies. Of the nine graduates, one declined further participation, one went on to post-graduate studies and seven are now entering the job market. They are at an early stage in their careers (the interviews took place four months into the start of their career paths). Using qualitative data collection, semi-structured interviews of wide-ranging scope were conducted, following the various threads of interest in the larger project (identity formation, social expectations, familial relations, networking, etc.). Interviews were transcribed and anonymised, and coded according to the heuristic, using qualitative software. The data analysis draws on the heuristic developed from the philosophy of science/engineering, interpreting responses to interview questions in terms of epistemic fluency, ontological belonging/becoming and axiological capacity. In the interest of exploring the rich qualitative data in some depth, in this paper I report on aspects of the development of an emerging professional (engineering) identity of just three of the participants, purposefully selected to present variety in the employment fields students entered: software development, mining and renewable energy consulting.

There are limitations on the study in terms of the small sample size, the specific context, and the early stage of career development. However, the purpose of qualitative studies is to provide ideographic knowledge rather than generalisations – here, an understanding of the specific context of early career first-generation students provides us with a baseline study against which more traditional pathways into the development of an engineering identity can fruitfully be explored.

3 RESULTS AND DISCUSSION

In this section I discuss the identity development of the new engineers in terms of the heuristic proposed earlier, with illustrative quotes from the interviews.

3.1 Epistemic fluency

As these early-career professionals talk about their experiences in their new workplaces, they attempt to link their technical knowledge to the needs of the workplace. They feel some confidence in their training, but transitioning to the workplace environment is often still bewildering. Jerome describes how he is “shadowing other engineers to see how stuff gets done in the field” and adjusting to working a fixed workday: “it's really different to what… I expected… the most challenging thing is just getting used to the structure of working a nine to five as opposed to the loose… structure of studying”.

What is quite striking about the comments made, is that the new engineers often feel most unsure about what engineering educators might call the “soft” (social) skills and knowledge. Technical report-writing looms large for Kholo, and he acknowledges that it is an area where he needs to grow: “I'm not really strong on that side because my English side also is not that strong. It's not my first language…” In addition, he

finds that his tendency to “doing things on my own” (which stood him in good stead during his studies), must be tempered with working as a team member. Jerome talks about the heavy responsibility he feels for doing work that his teammates depend on: “… some people are relying on you to get your work done by the end of the day so they can use it tomorrow… I feel like it presses you to really think about what you're doing and to really like make sure that you're doing your job well”. Jerome feels pressure to succeed: “At the end of the day… especially since I'm… trying to build myself up, if I make mistakes… I can… limit my opportunities in the future”. Jerome also sees the need for project management skills, and he invests time in the online space to learn more about what he perceives to be a gap in his training.

Even so, Matteo warns that it is not possible for university engineering training to completely prepare students for the demands of the workplace: a “company infrastructure thing... it's … not something that someone at the university could prepare for, because every company… [is] different”. What is needed, is a flexibility which he confidently claims on the basis of his university engineering education: “I feel like the engineering degree like has helped me… pick up things faster so you know… you don't need to ask… what the process is because you already identified [where to start]”. Matteo, perhaps most clearly, displays the inception of a budding epistemic fluency as he describes his interaction with stakeholders which is part of a skill he has to develop to deliver on developing software solutions to identified problems. The different kinds of epistemic demands require him to translate vague user requirements into technical requirements: “someone says… we want things to run faster… or if you want this process to be different, it's like, well, how do you want it to be different? … you need to quantify it a bit, you know … the requesting team has to break it down more. And then we… break down their requirement into… more understandable requirements for our back end and front end”. What he describes comes close to what Markauskaite and Goodyear call “actionable knowledge”. Furthermore, Matteo recognises that while there may be short-cuts, and off-the-shelf work-arounds, the deep disciplinary knowledge from his technical engineering science training provides a framing for his approach to problems: “… if you want to improve something, you need to understand how it actually works“.

3.2 Ontological becoming

A professional identity is fundamentally about a perception of the self in relation to the profession. In the entry-level engineering roles in which our study participants find themselves, some struggle to find a sense of belonging. Jerome finds it hard to relate to his (older) work colleagues who fit a more traditional role: “I'm not sure of what an engineer looks like, and to be honest… I look at people at my work and… I can't really relate to them… I don't know if it's the generational differences… how they… specifically, how they dress and how they act”. However, his feeling of disconnectedness is linked to the specific job, not to his identity as an engineer. He holds on to quite a clear picture of himself in a different working environment – this represents intrinsic motivation for future change: “I really want to work somewhere in the design space where I can feel like I have more space or freedom, to… express my creativity and where I … [can] just push the boundary of … electronics or robotics a bit”. Jerome struggles with the routine aspects of his current position: “[there are] specific recipes… already in place, and if you follow them, you'll get the work done… It's very boring”. He expresses a need for “something where… I can sit down for two to three hours and then just think about it and try and solve this problem… I find that

really rewarding where you come up with this idea, you grapple with it for a bit, and then here you see the thing – it works."

Kholo is also uncertain about a long-term commitment to the company where he is starting out. While he appreciates their support in starting the process of gaining status as a professional engineer, he is ambivalent about his opportunities at the company and the potential for him to meet extrinsic personal goals that focus on material needs: "My responsibilities might change… maybe I want to get married… I'm trying to support my family and build a house for my mother… I need something that can make things happen quicker… like pay me more".
.
Matteo, on the other hand, has a strong sense of belonging in his place of work. He speaks about doing "what I enjoy and… what keeps me… interested and entertained at in this role". Matteo's sense of belonging stems from his supportive line manager: "…if I come up with an idea, she's like... Let's set up a meeting with these people and get it going". He has a confident sense of his place in the organisation: "Look, it's still… very early in my career and… I would… like to stay in the industry because there is a lot of opportunity… I want to be in technology, I want to… push for new ideas to bring into… the banking world". His motivation for staying in his role is intrinsic: "I've spoken to my manager about the path that I want… if I'm not given the opportunity for that, then I would probably move. But… if I'm afforded with the opportunity of growing within the company, then I don't need to go anywhere else."

It is interesting to see how the different kinds of knowledge and skills implicated in epistemic fluency also speaks deeply to issues of belonging and becoming (ontological concerns)—some experience these as constraints, while other participants find epistemic fluency enables a stronger sense of belonging. For Kholo his perceived struggle with report-writing in his new job reminds him of how his lower mark on his Final Year Project report at university cost him a first-class honours pass in his undergraduate degree "… it was so close to getting there and I feel if I … [had done] well in my… report, [I would have received] a distinction in my average." At this stage of his career the report-writing presents a shortcoming and forms part of the way in which he sees himself in relation to his work. Jerome faces similar ontological concerns in his need to work more collaboratively in a team – he speaks of his "personality… limiting" him, and how he has had to learn to approach colleagues with questions. He can see change in himself, necessitated by the demands of working with others. Matteo's ability to fluently negotiate his role to translate user demands into technical requirements that his team can respond to, gives him confidence to "kind of feel like you [are] always… contributing".

3.3 Axiological capacity

In this paper I argue that the development of an axiological capacity is an integral aspect of the development of a professional identity. Participants in the study voice this in different ways. Matteo sees links between the notion of sustainability (typically "associated with climate and the environment") in more encompassing ways to include the question, "is what you're investing in, … whether it's yourself, … or whatever, is it going to improve processes in future that will lead to a more productive, healthier, more efficient... kind of reward at the end?" For him this includes ideas around equity: "… in the sense where it's rewarding for everyone, not just for select few, for example". He argues that improving efficiency cannot be

considered in isolation and has to be held in tension with potential undesirable consequences: there are constantly questions about, “can we make it more efficient… what are the impacts and how can we reduce… if there happens to be, you know, some sort of … negative impact”.

Kholo describes sustainability as “using resources we have now so that future generations can also benefit from them. I feel like engineers are very focused that way”. Kholo sees his company making value decisions based on the intersection between ethics, environmental concerns, societal responsiveness, and economic constraints: “engineering, ethics and all that... overlapping engineering and the environment, overlapping engineering and society, overlapping engineering and economics”.

For Jerome his engineering studies sensitised him: “our control and automation course... they spoke… about the processes that goes on there and how whenever you design, a process plant… you need to take into account that… there's going to be limited amount of [resources].” Jerome finds it interesting to see how these value-based notions manifest in the practices of the mining company he works for: “… they are really trying to minimize their environmental footprint and so they do a lot of rehabilitation work.” Jerome explains that he has become more aware of making value decisions in his new role: “I've really seen it over the past 2-3 months… in my work, where I'm kind of forced to really think about how my work is affecting not only the immediate surrounding area or resources that's available, but then also how? How long can this specific sensor last… how often does it need to be replaced and where does the waste go once it's taken off? All that because… on site we have a very limited amount of space where we can [dispose of] waste and we're trying to minimize that… over the lifespan of the mine…”

3.4 First-generation students – early engineering identity

First-generation students start their university training in many ways with less information on what engineering entails because of the absence of role models, and less exposure to networks that can inform and support. To qualify for acceptance into competitive programmes in top universities, these students develop coping mechanisms to compensate for the absence of support structures --- their journeys into higher education are often marked by lonely independence and having to forge their own way. Kholo describes what it is like “coming from a… school where resources are limited. We literally [only] had one teacher teaching [all] the physics and chemistry [in the school]”. His teacher was not coping with the content and “I needed to go through the textbook on my own and … trying to correct [the teaching] in class at times”. This ability to work by themselves served them during their years of study, but in the workplace they now need to learn skills of working with others. Jerome explains, “It's very much team-based and you have to… draw from the expertise of other people to get the job done.” New engineers need to recognize and grow in their ability to contribute meaningfully a common objective.

While acknowledging that ontology, epistemology and axiology do not exist as separate concepts in a study such as the one undertaken here, the distinctions become useful for analytical purposes as a heuristic.

4 CONCLUSION

In this paper I explored the nature of the engineering identities being developed by some first-generation engineers as they enter the workplace after graduation. The workplace environment serves to elaborate the nascent identities that engineering students bring from university. The study shows that the transition makes new demands on the young professionals who must resolve the way in which the skills and knowledge they bring with them, translate into the workplace.

This qualitative study involved first-generation engineers. Study participants had less they could rely on in the transition into and through engineering studies (Hunt et al, 2018). They developed resilience and determination as coping skills to make their independent way. However, at the same time, the very independence and self-reliance that stood them in good stead in their studies, now must be moderated to accommodate the workplace priority of working in teams to solve problems.

The analytical framework of epistemic fluency, ontological becoming and axiological capacity provides a useful way to conceptualise professional identity in general, and engineering identity in particular. The new engineers start their first careers with technical knowledge and skills, but the workplace demands a flexibility and fluency that integrates different kinds of knowledge and action. For some their first job is not an ideal fit and they have to use the experience to clarify own priorities and the way they see themselves. For others, their first job fits hand-in-glove, and the interviews revealed a strong sense of becoming and belonging. New engineers grapple with axiological considerations in their new jobs: relating competing demands that require value judgements, juggling regulatory requirements, personal values and company ethos take them beyond superficial definitions of efficiency and sustainability.

The study contributes to the literature on the development of an engineering identity (Morelock, 2017), and the longitudinal nature of the project potentially allows for a more coherent view of the process. The insights arrived at can fruitfully translate into a framework for larger more comprehensive study of thinking about identity development. There are several avenues that could fruitfully be explored in the near future. Similar to the disruption all new technologies bring, the proliferation of artificial intelligence and use in the workplace push boundaries and raise new questions around identity: what does “knowing” and “knowledge” look like in this age? What does epistemic fluency become? What does “belonging” include in this age of chat bots? What changes will be introduced in the axiological space? Where do we take our questions about what should be valued, what matters, of what it means to have an engineering identity? All these questions have implications for what it means to be and thrive as an engineer.

The findings potentially have implications for engineering education: new engineers report less confidence in their ability to negotiate the more social aspects of the engineering workplace: making meaningful contributions to work teams, writing the technical reports that are needed, and managing real-life projects. Planners of engineering curricula would do well to keep in mind that these sometimes-neglected parts of the curriculum become crucial as new engineers negotiate entry into the workplace and formulate new ways to relate to their profession.

REFERENCES

Barnett, R. 2009. "Knowing and Becoming in the Higher Education Curriculum." *Studies in higher education* 34, no. 4: 429-40. http://dx.doi.org/10.1080/03075070902771978

Gee, J. P. 2000. "Identity as an Analytic Lens for Research in Education." *Review of Research in Education* 25, no. 1: 99-125. https://doi.org/https://doi.org/10.2307/1167322.

Hoyer, Patrizia. 2020. "An Ongoing Narrative Accomplishment." In *The Oxford Handbook of Identities in Organizations,* edited by A.D. Brown, 101-116. Oxford: Oxford University Press. ISBN: 9780198827115.

Hughes, B. E., W. J Schell, E. Annand, R. Beigel, M. B. Kwapisz, and B. Tallman. 2019. "Do I Think I'm an Engineer? Understanding the Impact of Engineering Identity on Retention." Paper presented at *2019 ASEE Annual Conference & Exposition, Tampa, Florida, June 16-19, 2019*. https://doi.org/10.18260/1-2--32674.

Hunt, C., B. Collins, A. Wardrop, M. Hutchings, V.Heaslip & C. Pritchard. 2018. "First- and second-generation design and engineering students: experience, attainment and factors influencing them to attend university." *Higher Education Research & Development* 37, no.1, 30-43, https://doi.org/10.1080/07294360.2017.1342607.

Kuhlman, T., and J. Farrington. 2010. "What Is Sustainability?". *Sustainability* 2, no. 11: 3436-3448. doi:10.3390/su2113436.

Markauskaite, L., and P. Goodyear. 2016. *Epistemic Fluency and Professional Education: Innovation, Knowledgeable Action and Actionable Knowledge.* Dordrecht*:* Springer Netherlands. ISBN 978-94-007-4369-4.

Meyers, K. L., M. W. Ohland, A. L. Pawley, S. E. Silliman, and K. A. Smith. 2012. "Factors Relating to Engineering Identity." *Global Journal of Engineering Education* 14, no. 1: 119-31.

Morelock, J. R. 2017. "A Systematic Literature Review of Engineering Identity: Definitions, Factors, and Interventions Affecting Development, and Means of Measurement." *European journal of engineering education* 42, no. 6: 1240-62. https://doi.org/10.1080/03043797.2017.1287664.

Patterson, M. E., and D. R. Williams. 1998. "Paradigms and Problems: The Practice of Social Science in Natural Resource Management." *Society & Natural Resources* 11, no. 3: 279-295. https://doi.org/10.1080/08941929809381080.

Radder, H. 2009. "Why Technologies Are Inherently Normative." In *Philosophy of Technology and Engineering Sciences*, edited by A. Meijers, 887-921. Amsterdam, The Netherlands: Elsevier.