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Exploring How Degree Apprentices Experience Their Engineering Identity Through Life Story Interviews and the Twenty Statement Test (TST)

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Abstract

Every year, around 35% of engineering graduates (mainly female and ethnic minority graduates) in the UK choose roles outside engineering. Given that engineering disciplines struggle to attract recruits, this represents a significant loss of qualified talent the profession can ill afford. A possible reason why engineers choose not to practise after qualifying may be that they have not developed a professional engineering identity during their engineering education. Research shows that engineering identity is an important indicator of persistence in both engineering education and the engineering profession. The purpose of this research is to gain a deeper understanding into the process of engineering identity formation in undergraduates studying for an engineering apprenticeship degree in England, with a view to proposing changes to engineering education that may better support the development of an engineering identity. A qualitative methodology is well-suited to the study of how engineering identity develops in engineering students, given that we are interested in the personal experiences of engineering students rather than in measuring standardised outcomes. This research is inspired by narrative inquiry through the use of life story interviews (LSI). This paper outlines the findings of a preliminary study with first and final year students. The findings presented are surprising in that they seem to indicate that the four years of a degree apprenticeship have little impact on students' identification with engineering. Going forward, engineering educators need to consider how the development of an engineering identity can be supported in engineering education.

Keywords

Engineering identity, engineering education, identity theory, degree apprenticeships

Introduction

Engineers are at the core of a country's economic success. They create the technologies that people want to buy, bringing wealth to their nations, and are well equipped to solve the problems facing the human race, from global warming to cyber security or water scarcity. The importance of engineering disciplines to the UK economy is well understood; in 2015, engineering generated 25% of the UK's GDP and employed 19% of the workforce (EngineeringUK, 2019). Although engineering graduates have excellent employment outcomes and earn 17% more than the average graduate six months after graduation, the profession struggles to attract recruits in sufficient numbers. This means that the UK has a shortage of engineers, threatening the country's ability to thrive in a globalized economy. However, the shortage of engineers is not just a problem in the UK; a 2019 report from the European Commission (McGrath, 2019) highlights the shortfall of skilled professionals in civil, mechanical,

electrical and software engineering in the EU, Norway, Iceland and Switzerland. The global competition for engineering talent exacerbates shortages at the national level. EngineeringUK, a not-for-profit organisation aiming to increase the talent pipeline into engineering, estimates that in the UK, there are 200,000 fewer graduates entering engineering than are needed, with 46% of engineering employers reporting difficulties to recruit engineers. To make matters worse, not all engineering graduates develop their careers in engineering roles; a report from EngineeringUK notes that in 2018, of all the engineering and technology graduates who found jobs within 6 months after graduation, 34.7% of women and 36.2 % of ethnic minority graduates "were in roles that were neither engineering-related nor within the engineering sector" (EngineeringUK, 2019). This represents an important loss of qualified talent to the profession. Pierrakos, Beam, Constantz, Johri and Anderson (2009) have suggested that those graduates who pursue careers outside engineering did not develop an engineering identity during their studies.

In England alone, there are more than 1,100 undergraduate engineering degrees, offered by 150 providers (UCAS website) and although they focus on diverse aspects of engineering and meet different student needs, their curricula are remarkably consistent and primarily focused on the acquisition of technical knowledge, engaging learners "in highly structured, recipe-like" learning activities (McGowan & Bell, 2020, p. 982). This positivist approach to course design is based on the tacit understanding that knowledge is "hard, objective and tangible" (Nicholl, 2009, p. 22) and disconnected from the learners' lived experiences (McGowan & Bell, 2020, p. 982). The prevalent positivist mindset in engineering education is reflected in the requirements of national and international accreditation bodies, who share a competency-based approach to engineering certification. This is not the case in other professions, where the development of a medical identity (Cruess, Cruess, Boudreau, Snell & Steinert, 2014; Jarvis-Selinger, Pratt & Regehr, 2012; Monrouxe, 2010) or a teacher identity (Beauchamp & Thomas, 2009; Gohier, Chevrier & Anadon, 2007) is an important part of the training for the profession. Could this be at the root of the problem in engineering? Is the lack of focus on developing an engineering identity damaging the profession?

Education in the UK is devolved to its four nations, so this paper will focus on engineering education in England, where there are two routes to qualifying as an engineer: an academic route via a university degree and a work-based route via an apprenticeship degree. Most European countries have apprenticeship schemes, such as Germany's highly respected Vocational Education and Training System, in which apprentices spend part of their time at a company and the rest at specialist vocational schools. In the Netherlands, apprentices spend typically four days per week in the company and one day per week in "off the job" training whilst in Belgium they generally spend two days per week in training and three days per week at the company. In other countries, such as Sweden, apprentices divide their time equally between the classroom and the workplace (Armitage, Bourne, Di Simone, Jones & Neave, 2020). The students in this preliminary study are Product Design and Development apprentices studying two days per week for a BEng in Engineering and working three days per week in engineering teams for a technology company. In order to investigate how students develop their engineering identity during the four years of their education, this research will explore how first and final year students experience their engineering identity and the impact of their engineering identity on how they envision their future – inside or outside engineering disciplines.

Identity theory provides a useful lens for the study of professional engineering identity. If we believe that "Identities are the meanings that individuals hold for themselves – what it means to be who they are" (Burke, 2003, p. 196) then a methodology that uses the tools of social science to study personal meaning, such as narrative enquiry, seems well suited to the study of identity (Goodson & Sikes, 2001). This methodology is rarely used in engineering education, that tends to favour a quantitative paradigm, with few engineering educators trained in qualitative methodologies (McGowan & Bell, 2020, p. 1001). This paper proposes the use of narrative enquiry as a research method for engineering education and presents findings from an initial study using this method. The findings draw together new insights about how engineering students experience their engineering identity, thereby also confirming narrative enquiry as a valuable research method to develop understanding of this topic.

Identity in Engineering Education

Admissions processes for engineering programs tend to focus on finding candidates who are good at sciences, mathematics and physics in particular. However, the persistence of those candidates in the engineering profession is closely linked to their identities (Pierrakos et al. 2009). It is this link between engineering identity and persistence in the profession that we aim to test with our first hypothesis: students with a strong engineering identity are more likely to be committed to a future in engineering. Whilst formally all a student needs to become a professional is to graduate from the appropriate institution, as Costello's research shows, "a certified professional school graduate who cannot "walk the walk and talk the talk" will not seem like a true professional to others and will not be successful" (Costello, 2005, p. 23). Acquiring engineering knowledge and skills is clearly an important part of becoming an engineer but it is not enough; to become engineers, students must develop an engineering identity (Brickhouse, Lowery & Schultz, 2000). Many authors have looked at engineering identity, however, identity theory as a conceptual model has been largely overlooked when considering engineering student identity. This article seeks to address that gap. Identity theory is rooted in the work of the American sociologist George Herbert Mead (1934), who theorized that:

The self is something which has a development; it is not initially there, at birth, but arises in the process of social experience and activity, that is, develops in the given individual as a result of his relations to that process as a whole and to other individuals within that process. (p. 135).

This is to say that the self arises from social interaction. Blumer (1962) coined the term "symbolic interaction" to highlight that behaviours are symbols that carry meaning; what is important is not so much how we behave but how we and others interpret our behaviour. We operate within the structures in our society and our behaviour is shaped by those structures; this is what Stryker (1980) means when he refers to "structural symbolic interactionism" (SSI). Those structures include class, gender, ethnicity, profession, etc. Identity theory also draws on the work of William James (1890). Although James never actually used the word "identity", he talked about "multiple selves" in a way we would now understand as referring to multiple identities. He suggests that people have "as many different selves as there are different others that can recognize the individual" (James, 1890, p. 294). One can be a mother, a daughter, a wife, an engineer, a Christian, a volunteer, etc. depending on the different roles one plays in society.

Stryker and Burke (2000, p. 284) define identity as "the meanings that persons attach to the multiple roles they typically play in highly differentiated contemporary societies". The basic premise of SSI is that identity emerges through interpersonal interaction and that these interactions are shaped by social structure; the social structure defines what behaviours are appropriate for each role. As we internalize those expectations, we are setting up the basis for our identity in that particular role. Stryker emphasized the role played by social structures in shaping human behaviour, recognizing the reciprocal nature of these relationships: "society shapes self, which shapes social interaction" (Stryker & Burke, 2000, p. 231). He defines identity as the "internalized positional designation" linked to each role a person has in society (Stryker, [1980] 2002, p. 60). He understands those positions to be relatively stable and built into the structure of a given society. Individuals within a society label each other and themselves, according to the positions they occupy, i.e., teacher, student, engineer. As individuals internalise those identities, they also internalise the meanings and behaviours that are expected of those identities, as well as the symbols and shared perceptions associated with an identity, in this case engineering identity. For engineering students, this means embracing the personal characteristics associated with the engineering profession, such as a logical approach to problem solving, attention to detail and tough-mindedness (Williamson, Lounsbury & Han, 2013). They must also be perceived as an engineer by their peers (Costello, 2009). This led us to construct our second hypothesis: students with a strong engineering identity are more likely to have person identities that support their role identity as an engineer.

A central premise in identity theory is that "people seek ways to establish and maintain those social situations and relationships in which their identities are verified" (Burke & Stets, 1999, p. 351). As engineering educators, we probably have a sense that this is the case in relation to our students and indeed, research shows that difficulties in verifying an engineering identity can cause students to abandon their studies (Pierrakos et al. 2009; Patrick, Borrego & Prybutok, 2018). Burke and Stets (2009) propose that identities operate as a continuous feedback loop, managing the meanings perceived in a given situation, with the objective of maintaining self-meaning within a comfortable range. When the perceived meaning (our interpretation of how others see us) matches our own self-meaning, our identities are verified. Identity verification leads to increased trust, commitment, and emotional attachment towards those who are verifying our identity and in turn, those feelings increase our sense of belonging to that particular group (Burke & Stets, 1999, p. 351). This is the theoretical basis for our third hypothesis: students with a strong engineering identity are more likely to have experienced trust in a formative relationship. A person's identity becomes stronger when it is verified repeatedly. Lack of identity verification generates negative emotions linked to feelings of low self-esteem and low mastery (Cast & Burke, 2002).

The literature review presented above provides a general understanding of identity theory. Let us consider an individual engineering student as an example; she does well in her engineering studies, obtaining good grades and is in line to graduate with a first-class honours degree but, is that enough to validate her identity as an engineer? Academic achievement may not be enough, as being an engineering student invokes more than one single identity. Identity theory proposes that there are three different types of identities: role, group, and person identities. Burke and Stets (2009, p. 114) define role identity as "the internalized meaning of a role that individuals apply to themselves." As different people will internalize meaning in a different way, the same role identity may have different meanings for different individuals. This is clearly the

case in engineering, as there is a lack of clarity as to what it means to be an engineer. Group identity relates to how individuals identify themselves with a social group, in this case the engineering profession and finally, person identity is "the set of meanings that define the person as a unique individual rather than as a role-holder or group member" (Burke & Stets, 2009, p. 124). Going back to our engineering student, for her engineering identity to be validated she needs to see herself as an engineer, but she also needs others (classmates, lecturers, colleagues in the workplace, etc.) to see her as one. When someone validates our identity, we respond by generating trust in that person, and over time, this fosters greater commitment to the relationship (Burke & Stets, 1999). Identity verification of a role identity generates feelings of mastery and efficacy. Verification of a group identity generates feelings of self-esteem and integration (Burke & Stets, 1999) and verification of person identities generates feelings of authenticity.

Research Methodology

The researcher's interest in the study of identity led her to explore life stories as a possible methodology for this research. Narrative enquiry, which uses personal stories as data, is well suited to the study of identity (Goodson & Sikes, 2001) and particularly since the 1990s, it has become a widely used methodology for "understanding the meaning of human experience" (Merriam & Tisdell, 2016, p. 34). In retelling their stories, individuals are constructing their identities (Chaitin, 2004). Life story interviews allow individuals to tell their life story in their own way, charting the path that has taken them to where they are today. Those stories are not set in stone; as we tell our stories, we choose what is important at a given point in time, in a particular setting and with a specific audience. Inspired by a narrative approach, the researcher undertook semi-structured interviews using a modified version of The Life Story Interview, an instrument developed in 1995 by Dan McAdams (2007) at Northwestern University, in which participants are interviewed about 'the story of their life' in the form of life chapters, key scenes, turning points, hopes, plans, challenges, etc. Students were asked to talk about: the path that took them to their engineering degree apprenticeship; their childhood interests and school experience; highs and lows of their time at the degree apprenticeship and their dreams and aspirations for the future. In narrative research, the relationship between the researcher and the researched has epistemological implications that shape the way in which the research is conducted, and this study is no exception (Patton, 1990). In this case, the researcher was known to the students as an employee at the institution providing the degree apprenticeship. However, her role was outside the students' academic experience, and they could not expect to benefit from taking part in the research. The researcher's coaching training helped to generate an environment of trust during the interviews, enabling students to speak at length and freely about their experiences.

To select participants for this preliminary study we used purposeful sampling, a technique widely employed in qualitative research in which researchers select a sample "from which the most can be learnt" (Merriam & Tisdell, 2016, p. 96). The researcher looked for participants who were willing to participate and were perceived to be good communicators by their Student Support Team, who knew them well. This is recommended by Palinkas (2015, p. 534), who highlights the importance of selecting research participants who have "the ability to communicate experiences and opinions in an articulate, expressive, and reflective manner". Purposeful sampling requires in-depth knowledge of the individual students to be selected. The Student Support Advisors for each year group identified students who they felt may be

interested to contribute to this research. Out of the shortlist provided, one male and one female participant from years one and four of the degree apprenticeship were randomly selected for interview for the initial study reported in this paper.

During the interviews, students talked at length about the path that led them to study engineering at degree level, the choices they considered, the people who influenced their choices and the process they followed before finally deciding to study engineering. However, during the analysis phase, it became clear that students do not think in terms of "identity" and that it was not obvious from the transcripts what other identities the students claimed for themselves. In order to gather more insights into this area, the Twenty Statement Test (TST) was used during a second, follow up call, asking research participants to complete the Twenty Statement Test (TST), a tool developed from a symbolic interactionist stance by Kuhn and McPartland (1954) to conduct empirical research on identity. When individuals think about themselves, they describe who they are by explaining what they do, how they do it and the values that locate them within a shared cultural frame. The TST explores the most salient aspects of the symbolic system that individuals apply to themselves (Rees & Nicholson, 2011). Research participants were asked to answer the question "who am I?" twenty times, or as many as they could come up with in a few minutes. All participants provided twenty statements, and their responses were analysed following Kuhn and McPartland's guidelines (1954) which classifies responses as consensual or sub-consensual statements. They define consensual statements as "those which refer to groups and classes whose limits and conditions of membership are matters of common knowledge," and sub-consensual as those "which refer to groups, classes, attributes, traits or any other matters which would require interpretation by the respondent to be precise or to place him relative to other people" (Kuhn & McParland, 1954, p. 69). Although the TST is not without its critics, this instrument has regained popularity recently in qualitative research due to "uniquely combining a structured approach with maximal response openness" (Rees & Nicholson, 2011, p. 88) and it was included in this study to gather more insights into the various identities of engineering students. Following Kuhn and McPartland's approach to analysing the test results provided little light on the responses, and a second classification followed based on the three different types of identities defined by identity theory and explored earlier: role, group, and person identities.

Data Collection and Analysis

The Covid-19 pandemic and subsequent lockdowns and restrictions in England meant that interviews had to be conducted using MS Teams rather than in person. Research on the use of computer mediated interviews seems to indicate that they can be a "viable alternative to the face-to-face interview" (Curasi 2001, p. 372). The researcher feels confident that this research has not suffered as a result of having to conduct interviews online. What is harder to predict, however, is the impact that online teaching during the pandemic, and therefore reduced levels of personal interaction with classmates and faculty, may have had on the development of engineering identity for the class of 2020 and this is something that may need to be revisited at a later stage in this research. Four ninety-minute interviews with four students enrolled on the same engineering degree apprenticeship in England were conducted using a modified version of The Life Story Interview instrument (McAdams, 2007) a semi structured interview tool for life story research; two students were in their first year and two in their fourth and final year. In each year group, one student was male and one was female. Each video interview generated around seventeen pages of interview transcripts. Transcripts were analysed manually, reading

them several times, seeking to reduce the data inductively, looking for themes in the different stories.

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Three out of the four undergraduates identified themselves with the engineering profession and saw their future as engineers; the fourth student was not so sure. Contrary to what may have been expected (Beam, Pierrakos, Constantz, Johri & Anderson 2009, p. 14), the students with a strong engineering identity already had it by the time they started their apprenticeship. The time invested in their degree apprenticeship, which includes exposure to an engineering workplace as well as academic study, only seemed to serve to clarify in the students' minds what aspects of engineering they enjoyed more than others. The fourth student started her engineering studies unsure about engineering as a career and remained unsure as the end of the degree apprenticeship loomed: "I'm kind of currently at the stage where I am deciding whether to stay… in engineering or whether to just change completely, going to like investment banking".

The three students who identified themselves with engineering had attended different schools in different parts of the country, came from different socioeconomic backgrounds and had different interests. However, their stories had one thing in common: all three had built trusted relationships with an adult whilst at school (a teacher in two cases, a scholarship mentor in the third) who had encouraged them to consider engineering as a profession before they had thought about it themselves. A first-year student said:

The (scholarship) mentor pushed me to apply, despite my response being that I was convinced maths was for me and that I was really unsure about engineering. He told me that strong mathematicians that loved problem solving were exactly what they were looking for and that getting the scholarship could open a wide array of opportunities for me. He convinced me that there was nothing to lose … I'm definitely indebted to him for doing so, I wouldn't have had that platform for industry connections and insights. Without that I think I would really have struggled to break down the misconceptions that I had of engineering.

For another student, it was a design and technology teacher: "My DT teacher… I spent an immense amount of time with him… and I started getting recognized within the classroom as the DT guy that everybody came to …". A year-four student commented: "My physics teacher, …, he kind of pushed me a little bit more towards engineering. And that's when I flipped from physics to mechanical engineering". Through those relationships, the students had been

encouraged to push their boundaries and go beyond their academic curriculum. This also resulted in the three students having more or less formal teaching roles with their peers and, in one case, students at other colleges. These activities can be interpreted as a form of Peer Assisted Learning, defined as "the acquisition of knowledge and skill through active help and support among status equals" which has been found to enhance cooperative learning and communication skills as well as improving the student's understanding of the subject under study (Gazula, McKenna, Cooper, & Paliadelis, 2017). By seeing their potential and encouraging them to do more for their peers, those adults had validated the students' identity. By trusting them with additional responsibility, they had reinforced that identity. According to identity theory, the validation of role and group identities generate different results: whilst doing well in a class would generate feelings of self-efficacy, helping others to learn would also have a positive impact on the students' self-esteem (Burke & Stets, 2009, p. 79). As the students had opportunities to do more of this, a positive feedback loop was established that led to greater trust and commitment.

One of the students in the first year often referred to herself and to her classmates as engineers: "sitting down in the kitchen with five other engineers I've never met before of my age and immediately you just have that 'click'." In contrast, despite being close to graduation, the fourth-year student who did not identify with engineering, never referred to herself as an engineer during the interview: "I know I can do engineering and I can be an engineer … it's just not necessarily where I see myself going 100%".

In their responses to the TST, the three students with a strong engineering identity gave "I am an engineer" as one of their first four responses, whilst the student with low identification in engineering said: "I am an engineer by education". Her reluctance to describe herself as an engineer would seem to confirm her lack of identification with engineering as a profession. She was also the only student to mention gender in her TST response ("I am a woman"). Research has found gender to be more salient for women in technical environments (Rees & Nicholson, 2000, p. 95) and it seems interesting that the female student who identified herself as an engineer did not feel the need to define herself as a woman, whilst the student with low identification with engineering did.

The research also sought to establish whether students with a strong engineering identity were more likely to report person identities that supported their role identity as an engineer (hypothesis three) (Burke & Stets, 2009, p. 124) and here the results were inconclusive; two of the three students with high identification with engineering gave more responses that aligned with the personal characteristics of engineers (analytical, hardworking, committed, dedicated) than the student with low engineering identification. However, some of the answers from the third student were hard to code ("I am saving for a house" or "I am motivated to finish my university degree") and in that sense less helpful.

Conclusions

Degree apprenticeships expose students to academic learning in engineering disciplines and give them the opportunity to work in an engineering setting for the four years of the program, engaging students in multiple projects working with different engineering teams. It would be reasonable to expect that such exposure would have an impact on the engineering identity of degree apprentices. However, this initial study seems to indicate that it may not be the case

and that students' engineering identity was already set by the time they started their degree apprenticeship. The students interviewed who arrived with a strong engineering identity, maintained it and the one who did not, failed to develop it. The findings of this initial study seem to confirm the following two hypotheses:

- Students with a strong engineering identity are more likely to have experienced trust in a formative relationship.
- Students with a stronger engineering identity are more likely to be committed to a future in engineering.

A fundamental premise of identity theory is that identity emerges in social interaction (Burke & Stets, 2009, p. 9) and this research would seem to confirm that. The results highlight the importance of relationships with teachers and mentors in fostering an engineering identity and would seem to confirm what identity theory proposes. It is interesting to note that the length of study does not seem to make a difference to the strength of the engineering identity; whilst first year undergraduates with a strong engineering identity happily describe themselves as engineers in the TST, a final year student chooses to describe herself as "an engineer by education". For the second hypothesis - whether students with a strong engineering identity are more likely to have personal identities that support their role identity as an engineer - the results are inconclusive and further research is needed.

Identity in general, and engineering identity in particular, is something that is not generally discussed in engineering education. It seems likely that engineering programmes would benefit from exploring and supporting the development of an engineering identity alongside the technical expertise associated with engineering qualifications. These findings would suggest that engineering educators need to build opportunities for students to explore and validate their engineering identities into their programs. For example, this might be achieved by developing closer relationships with students and by creating opportunities for students to verify their engineering identities through the integration of Peer Assisted Learning into the curriculum. Supportive personal relationships in an engineering setting develop trust, which in turn, develops students' commitment towards engineering as a profession.

The findings presented in this paper are from an initial study that focused on degree apprentices. This research is being expanded by including students enrolled on a conventional engineering degree at a university in England, and by conducting a larger number of interviews with both cohorts of university students and degree apprentices. The larger sample will enable further comparison between the early and later year students in order to extrapolate how engineering identity typically evolves during the four years of their education and will investigate in more depth students' future visions. In general, the methodology combining narrative enquiry and TST provided rich insights. The openness showed by the students who participated in this study and the depth of the insights they shared suggest that narrative enquiry is indeed a valuable methodology for the study of this important topic.

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