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Exploring the development of engineering identity in students in two educational settings using narrative enquiry

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Exploring the development of engineering identity in students in two educational settings using narrative enquiry

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Declaration of authorship

I am the author of this thesis, and the work described therein was carried out by myself personally.

Candidate's signature [redacted]

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ABSTRACT

Every year around 35% of new engineering graduates (mainly females and ethnic minority graduates) pursue careers outside engineering. Why does that happen? Could it be that those graduates did not develop an engineering identity during their studies? In the UK there are two paths to becoming an engineer: studying for a BEng or an MEng at university and since 2015, completing a degree apprenticeship. However, engineering education in England largely overlooks the development of students' engineering identity. This research studies how first and final year students enrolled in a traditional engineering degree at a university and a degree apprenticeship at DA provider in England develop their engineering identity.

The research follows a qualitative approach, using narrative enquiry to gain insights into the process of engineering identity development, a methodology that has been used extensively in social science research but rarely in engineering education. The research examines students' perceptions of the people and the experiences that support or challenge the development of their engineering identity, concluding that an engineering degree or degree apprenticeship do not guarantee the development of an engineering identity.

The research findings suggest that developing an engineering identity requires the development of all three kinds of identity: person, role and group and this makes it more challenging, particularly for underrepresented groups in engineering who, by virtue of their low representation, could have a greater difficulty in having their engineering identities validated. An unexpected finding from this research is that female and ethnic minority students seek different objectives from their engineering education than do white males. Engineering identity is largely ignored in the engineering curricula of higher education institutions in England; this project concludes by providing some suggestions of interventions engineering educators may consider to encourage the development of an engineering identity in their students and by exploring how identity theory may support greater diversity in the engineering profession.

LIST OF ABREVIATIONS

AFBE-UK	Association for BME Engineers
BEng	Bachelor of Engineering
BME	Black and minority ethnic
BME	Black and minority ethnic
BTEC	Business and Technology Education Council
CEng	Chartered Engineer
DA	Degree Apprenticeship
D&T	Design and Technology
DfE	Department for Education
BEIS	Department for Business, Energy & Industrial Strategy
EEG	Electroencephalography
ENAEE	European Network for Accreditation of Engineering Education
EPA	End Point Assessment
ESFA	Education and Skills Funding Agency
EU-ACE	European Accredited Engineer
HDA	Higher degree apprenticeship
IB	International Baccalaureate
IED	Institution of Engineering Designers
IET	Institution of Engineering and Technology
IfATE	Institute for Apprenticeships and Technical Education
IMechE	Institution of Mechanical Engineers

LSI	Life story interviews
MEng	Master of Engineering
NMITE	New Model Institute for Technology and Engineering
NVQ	National Vocational Qualification
OfS	Office for Students
QAA	Quality Assurance Agency for Higher Education
QDAS	Qualitative Data Analysis Software
SSI	Structural Symbolic Interactionism
SSREC	Social Science Research Ethics Committee (University of Bath)
TEDI-London	The Engineering & Design Institute London
TST	Twenty Statements Test
UCAS	Universities and Colleges Admissions Service
UK	United Kingdom
UK-SPEC	UK Standard for Professional Engineering Competence

CHAPTER 1 INTRODUCTION

Engineering is a rewarding profession with excellent career prospects and yet it fails to attract recruits in sufficient numbers. Successive governments, engineering bodies, universities and employers have over the years launched different initiatives to increase the number of engineering students with little success. The UK Industrial Strategy announced by Prime Minister Teresa May in 2017, focuses on innovation, building a high-calibre workforce, creating the best environment to start and grow a business, upgrading the UK's infrastructure and developing prosperous communities across the UK. Engineers play a key role in delivering the UK's industrial Strategy and the strategy paper announces some measures to address the shortage of engineers (BEIS, 2017) and to this day engineering roles feature prominently in the UK Government's Shortage Occupation List (GOV.UK, 2022). Lack of understanding as to what engineers actually do may be part of the problem but does not paint the whole picture; every year, around 35% of engineering graduates (mainly women and ethnic minority graduates) choose roles outside engineering (EngineeringUK, 2019). Given that the engineering profession struggles to attract recruits, this leaky pipeline represents a significant loss of qualified talent the profession can ill afford and has the potential to damage the country's economic future. An engineering degree can open doors to careers in other sectors such as banking and consulting, but the question remains, why would someone study such a demanding degree and then not practice? Is it possible that they did not develop a connection with the profession, an engineering identity, during their studies? And why is it that more women and ethnic minority graduates leave the profession upon graduation?

The focus of engineering education remains fundamentally technical, paying no attention to the development of an engineering identity. It reflects a positivist world view in which "the educator's task is to present course material as clearly as possible and the students' duty is to learn and understand it", with curricula focusing on technical content to the detriment of professional skills development, as suggested by Zarei et al. (2017, p.455). Gray, Tuschscherer and Gray (2018) posit that engineering education is heavily influenced by the thinking of 17th century philosopher John Locke, whose work suggests that the minds of students are empty vessels that need to be filled with knowledge by their teachers. Their research suggests that this "traditionalist" way of teaching and learning "influence many aspects of students' experiences, feelings, and outcomes, including the identities that students form as students and as pre-professionals" and that developing a sense of belonging is more difficult for students who do not fit “the dominant norms and values” or for students who learn differently. In a multi-year study of undergraduate engineering education in the USA, Sheppard et al. (2008) concluded that engineering education is not effective in preparing students for the profession and propose redesigning engineering education with a focus on the development of an engineering identity.

The traditional mindset seen in engineering education is also reflected in the requirements of national and international engineering accreditation bodies, who share a competency-based approach to engineering certification as I explore in more detail in Section 1.6. Their underlying assumption seems to be that once engineers are able to exhibit those competences, they have acquired an engineering identity, an idea that is not supported by research as reported by Tonso (2014, p.274). This is not the case in other professions, where the development of a medical identity (Monrouxe, 2010; Jarvis-Selinger et al., 2012; Cruess, Cruess and Steinert, 2019) or a teacher identity (Gohier, Chevrier and Anadon, 2007; Beauchamp and Thomas, 2009) are 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 in engineering education damaging the profession?

1.1 The evolution of Higher Education

Higher Education (HE) in Europe expanded substantially after World Word II and the UK was no exception; whilst the country had only 18 universities in 1950, today there are 145 (Hillman, 2022). Student numbers have also grown significantly, from 400,000 in the 1960s to close to 2,000,000 by the turn of the new century (Bladen and Machin, 2003), increasing participation in HE from 5% in the 1960s to 37.9% in 2021 (UCAS, 2021). This substantial growth raises a number of questions about the nature and purpose of higher education that were not so apparent when universities served a very small percentage of the population. Trow (1973) described three forms of higher education: elite, mass and universal. Elite focused on “shaping the mind and character of a ruling class”, mass on providing technical and professional skills to a larger group and universal on preparing the larger population for social and technological change (Trow 2005, p. 244). He understood these phases as “sequential stages” but also as practices that can coexist at the same time and even in the same institution. In the UK as HE expanded, elite institutions grew to respond to the increasing demand that they alone could not meet, and hence non elite institutions developed to provide access to mass higher education. The growth in mass higher education is seen by some authors as responsible for the dominance of technical and vocational education over liberal and general education.

According to Trow (2005, p.249) *"Elite higher education today has more to do with the forms of teaching and learning, with the settings in which it is carried on, and with the relations of teacher and student, than it does with the content of the curriculum"*. In elite institutions the relationship between teachers and students is crucial and extends beyond the content of the curriculum, as teachers seek to shape the mind and character of their students. By contrast, mass higher education focuses on the transmission of knowledge and skills, and relationships between teachers and students are more transactional. He sees most undergraduate courses in the UK as falling into the mass HE category (Trow, 2005, p. 249). The massification of higher education is likely to bring a distance between lecturers and their students and this in turn will have an effect on students' ability to develop their engineering identity. Whilst knowledge may effectively be transmitted in a class of over two hundred students, that environment does not support the development of meaningful relationships between teachers and learners required to support the development of an engineering identity.

Growth in HE has been linked to the transition from industrial to knowledge-based economies, with economic growth increasingly associated with advances in science and technology. in which universities take on new roles creating technologies, launching companies to commercialise those technologies, and hence becoming an engine for regional renewal and job creation. The Massachusetts Institute of Technology was seen as the first example of the entrepreneurial university, bridging the gap between university and industry by generating start-ups to commercialise technologies developed at the Institute. Etzkowitz and Leydesdorff (1995) realised that in order to fulfil the potential of a knowledge-based economy, new relationships between universities, industry, and government were needed in what they called the triple helix model. In this model, universities, industry and government take on roles that go beyond their traditional functions: commercial firms get involved in research and high-level training;, the government is responsible for providing a suitable infrastructure by improving transport and housing, for instance, as well as providing venture capital for new enterprises;, whilst universities go beyond teaching and research to file patents and create start-ups, setting up incubators and incorporating entrepreneurship into the curriculum (Cai and Etzkowitz, 2020, p. 203). Engineering education seems well placed to become a good example of the triple helix model, given the important role of science and technology in supporting the government's industrial strategy. The two institutions that participated in this research, a university and a degree apprenticeship provider, have strong links with industry, and all their students have work experience as part of their education. As almost all research in engineering is funded by the government, there is a strong connection between the universities and the country's industrial strategy. Another good example of the triple helix model at work in engineering education is the UK government's provision of £15m in funding for the New Model in Technology & Engineering (NMiTE), the first new greenfield university in the UK in thirty years, with courses co-created with employers and mandatory work placements.

1.2 The research opportunity

In England there are two routes to qualify as an engineer: a university degree and since 2015, a degree apprenticeship. In this dissertation, I explore how students develop their engineering identity at two different institutions in England, a degree apprenticeship provider and a university. Throughout this document, I refer to them as the DA Provider and the University, and to their students as apprentices and students respectively. Apprentices who follow the degree apprenticeship route and successfully complete their studies gain two qualifications: an apprenticeship and a BEng (Hons) in Engineering. The idea of incorporating work experience into engineering education is not a new one; many engineering degrees in England include the option of a year-long placement in industry halfway through the degree. However, given the brief history of degree apprenticeships, we do not yet know which path to an engineering qualification may be more effective in supporting the development of an engineering identity, producing not just engineering graduates but engineers who want to remain in the profession. Inevitably, some comparisons between the two different paths emerge through this research, and many others could be considered (for instance looking at teaching methodologies or the financial implications of choosing one or the other). However, early on in my research, I decided to focus on the students' and apprentices' experience of the two different qualifications in relation to the development of their engineering identity rather than focusing on a broader comparison between the two degrees.

The opportunity to research this important topic came up as I joined the staff at one of the institutions under study at the time I was looking for a subject for my DBA thesis at the University of Bath. Being in the privileged position of having access to both groups of students, degree apprentices at the DA Provider and undergraduates studying engineering at a university in England, seemed too good an opportunity to miss. I was curious as to why so many engineering graduates chose not to join the profession after they qualified, and I wondered why so many of them were female and ethnic minority graduates. With these and many more questions going around my mind, I set out to investigate if this would make a suitable topic for a DBA dissertation. Months of reading and research followed, striving to find an appropriate theoretical framework and a methodology that would suit the subject of study. I chose Identity Theory, a social psychological theory that studies how social interaction influences behaviour in social structures, as the theoretical framework for this research as it provides an explanation of what identities are, how they develop in social interaction and how they operate, as well as the processes involved in identity verification or non-verification, therefore providing a useful framework to support the study of identity development in undergraduate students and apprentices. A qualitative research methodology seemed more appropriate, as my research was seeking to understand how engineering students and apprentices develop their engineering identity rather than looking to measure standardised outcomes. As a methodology that uses personal stories as data, narrative enquiry seemed well suited to the study of identity development in undergraduate students and apprentices, allowing research participants to explore their identities as they share their stories. The underlying interest in pursuing this research is to understand what students and apprentices understand by their engineering identity, what experiences shape their professional identity as engineers, who plays a role in supporting the development of students' and apprentices engineering identity and the impact of engineering identity to how they envision their future, inside or outside engineering. Studying two different paths to engineering qualification may provide useful insights as to the ways in which they support the development of an engineering identity in their students and apprentices.

1.3 The degree apprenticeship

The Higher Education and Research Act 2017 changed the regulatory landscape for higher education, making it easier for new providers to gain degree awarding powers. The DA Provider in this study delivers a four-year apprenticeship degree in partnership with a university, who confers the degree. Apprentices at the DA Provider work as employees for an engineering company three days per week and study two days per week; they pay no fees and earn a competitive salary, removing financial barriers to studying engineering. The academic requirements to study at the DA Provider are comparable to those of mainstream engineering degrees at English universities (A in mathematics, A in another STEM subject, B in any other subject). Upon graduation, the employer is committed to offering a permanent role to every graduate who achieves a 2:1 or above; however, graduates are free to stay or seek opportunities elsewhere. During the first two years of their degree apprenticeship, apprentices complete a generalist engineering curriculum, specialising in one of four streams from year three (mechanical, electronics hardware, electronics software or electromechanical). The structure of the degree apprenticeship is as follows:

	Year 1 Engineering Mathematics and System Modelling Applied Programming 1 Electrical Circuits and Machines Electrical Circuits and Applications Mechanics 1 - Statics and Structures Thermodynamics	**Year 2** Engineering Mathematics and Technical Computing Applied Programming 2 Digital Systems and Computer Architecture Control Systems Mechanics 2 - Dynamics and Vibration Fluid Dynamics
MECHANICAL	**Year 3** - **Mechanical Stream** Manufacturing and Metrology Acoustics Heat Transfer and Thermodynamics Advanced Fluid Dynamics	**Year 4 – Mechanical Stream** Stress Analysis and FEM Vibration and Rotordynamics CFD and Turbulence Mechanical Design Work Based Project
SOFTWARE	**Year 3 – Software Stream** Software Development for Engineers Embedded Systems Systems, Networks and Architecture Big Data Analytics	**Year 4 - Software Stream** Machine Learning Vision and Processing Internet of Things Crypto and Cybersecurity Work Based Project
ELECTRONICS & HARDWARE	**Year 3 - Electronics Hardware Stream** Energy Storage Systems Embedded Systems Analogue Systems Power Electronics	**Year 4 - Electronics Hardware Stream** High Power Electrics Electronic, Manufacturing and Assembly High Performance Electric Drives Internet of Things Robotics Work Based Project

ELECTRO-MECHANICAL	**Year 3 – Electromechanical Stream** Software Development for Engineers Embedded Systems Analogue Systems Advanced Fluid Dynamics	**Year 4 – Electromechanical Stream** Stress Analysis and FEM Vibration and Rotordynamics Internet of Things Robotics Work Based Project

Table 1 DA course structure (2021-2022 academic year)

The degree offered by the DA Provider is not yet accredited by any engineering bodies as at the time of writing this dissertation, the DA Provider had no graduates.

1.4 Engineering at a University in England

The Faculty of Engineering and Design at the University under study offers courses in architectural, engineering and design specialisms. Students wishing to qualify as engineers follow the same curriculum during their first two years, have the option to complete a year in industry in year three, and can specialise in years four and five by choosing one of the options available, which lead to different qualifications: mechanical engineering, aerospace engineering, integrated design engineering, mechanical engineering with manufacturing and management and mechanical with automotive engineering. The degree is available as a BEng and as an MEng, with or without a placement year, in the same areas of specialisation. To study engineering at this university, candidates must secure A*AA in three A levels, including mathematics and physics, with A* in mathematics or physics.

Year 1	Year 2
Experimentation, engineering skills and applied engineering Thermodynamics Solid mechanics 1 Design materials and manufacturing 1 Mathematics 1 Fluid mechanics Solid mechanics 2 Design materials and manufacturing 2 Instrumentation, electronics & electrical drives Mathematics 2	Systems and control Modelling techniques 1 Solid mechanics 3 Design 3 Fluid dynamics with historical perspective Thermal power and heat transfer Modelling techniques 2 Solid mechanics 4 Design 4 Manufacturing operations and technology

optional placement year	
Year 4 Different courses depending on the area of specialism: Mechanical engineering Aerospace engineering Integrated design engineering Mechanical engineering with manufacturing and management Mechanical with automotive engineering	**Year 5** Engineering project Plus optional units

Table 2 University degree course structure (2021-2022 academic year)

The degrees are accredited to fulfil the educational requirements for a Chartered Engineer (CEng) by the Institution of Engineering and Technology (IET), the Institution of Engineering Designers (IED), and the Institute of Mechanical Engineers (IMechE).

This research studies how students enrolled in an engineering degree at a University and apprentices enrolled in a degree apprenticeship in England develop their engineering identity during their education, the experiences that facilitate or impede the development of such an identity and the roles different people play in supporting or challenging that development. The research looks at the impact of the students' and apprentices' engineering identity in how they envision their future – inside or outside engineering. In order to gain deeper insights into the development of an engineering identity, this research follows a narrative enquiry approach. The findings from this research can be used by engineering educators to inform a new approach to programme design that better supports the development of engineering identity in engineering education, helping to retain qualified talent to the profession.

1.5 Engineering education in context – the role of engineering identity

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 water scarcity or cyber security. The importance of engineering to the UK economy is well understood; in 2015, the engineering sector generated 25% of the UK's GDP and employed 19% of the total workforce (EngineeringUK, 2018). Although engineering graduates have great 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. EngineeringUK, a not-for-profit organisation aiming to increase the talent pipeline into engineering, estimates that there are 200,000 fewer graduates entering engineering than are needed, with 46% of engineering employers reporting difficulties to recruit the engineers they need. To make matters worse, not all engineering graduates develop their careers in engineering roles; a 2019 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 graduates from a BME (black and minority ethnic) background "were in roles that were neither engineering-related nor within the engineering sector" (EngineeringUK, 2019). The report notes the existing gender disparity in engineering: whilst in 2018 in the UK women made up 47.1% of the total workforce, only 12% were in engineering occupations. In their study of engineering students who persist or abandon their studies, Pierrakos et al. (2009) suggest that those students who pursue careers outside engineering did not develop an engineering identity during their studies. Engineering identity has been shown to play an important role in persistence in engineering education and the engineering profession (Eliot and Turns, 2011; Cook et al., 2018; Godwin, 2016; Beam et al., 2009; Cech et al., 2011, Matusovich, Streveler and Miller, 2010; Sheppard et al., 2008). I will explore engineering identity in more detail in the next chapter.

1.6 Engineering education in England

Education in the UK is devolved to its four nations, and this means that each nation takes a slightly different approach. As I am based and have access to students and apprentices in England, the focus of this research is engineering education in England. Nevertheless, degree apprenticeships are offered in all four nations with some slight variations in the nomenclature (degree apprenticeships are called graduate apprenticeships in Scotland and higher-level apprenticeships in Northern Ireland) so the findings from this research should be of interest to higher education providers across the UK. Traditionally, there were two routes into the engineering profession: the vocational route via apprenticeships, further education colleges or work-place learning, and the academic route via a university degree. It may be useful to clarify each of those routes: "An apprenticeship is first and foremost a job with substantial training and the development of transferable skills" (Skills Funding Agency, 2015). Prior to the reforms of 2015, apprenticeship frameworks developed by sector bodies were used to assess apprenticeships. Apprenticeship frameworks were criticised for being qualification-led rather than occupation focused, as the main aim of an apprenticeship framework was to achieve a competency-based qualification such as an NVQ (National Vocational Qualification), and a technical qualification such as a BTEC (Business and Technology Education Council). Critics argued that apprentices could gain such qualifications without having the skills required to fulfil their roles. Apprenticeship frameworks were also criticized because of their complexity: by 2015, there were 230 apprenticeship frameworks developed by sector bodies and over 700 pathways within then (DBIS 2015, p.12).

The apprenticeship landscape changed after 2015, following the publication of the Conservative government's programme of reforms outlined in the document: "English apprenticeships: our 2020 vision" (DBIS, 2015). A key stated objective behind the reform was "to increase the quality and quantity of apprenticeships" in an effort to "help address our nation's skills shortages and stimulate economic growth" (DBIS, 2015 p.4). The proposed changes aimed to ensure that apprenticeships in England became more rigorous and responsive to the needs of employers. The reforms were based on the recommendations made by Doug Richard's review in November 2012 (Richard, 2012) and extended the apprenticeship offer to include from Level 2 apprenticeships (at GCSE level) to Level 7 (Master's degree level). Degree apprenticeships (those al levels 6 and 7) effectively integrated a degree; it is the integration of on and off the job training that differentiates apprenticeships from part-time learning while at work (QAA, 2018). The vision was to provide two equally respected routes to a career: the academic route and the work-based route, with the expectation that those following the work-based route via a degree apprenticeship would be better placed to succeed in their careers by virtue of the professional experience they would have gained by the time they graduated. In order to fund the expected growth in apprenticeships, the government set up the Apprenticeship Levy, which came into place in April 2017. All large public and private sector employers with a pay bill of more than £3 million would pay 0.5% into an apprenticeship fund, with the government providing a 10% top up (GOV.UK, 2022). Employers have two years to spend their apprenticeship levy funds before they expire.

The regulatory framework for degree apprenticeships is a complex one: the Department for Education (DfE) is accountable for apprenticeships in England with the Education and Skills Funding Agency (ESFA), an executive agency of the Department, being responsible for apprenticeship policy and funding and for overseeing the delivery of apprenticeships. The Institute for Apprenticeships and Technical Education (IfATE) is an employer-led nondepartmental public body responsible for developing new apprenticeship standards. The Quality Assurance Agency for Higher Education (QAA) monitors and advises on standards and quality in higher education in the UK. Each apprenticeship standard includes the knowledge, skills and behaviours required for an occupation. Apprentices collect evidence of the development of that knowledge, skills and behaviours in the workplace in an apprenticeship portfolio. That body of evidence is then reviewed at the End Point Assessment (EPA). The Office for Students, the regulator for higher education in England, defines degree apprenticeships as “a particular type of job, which combines work with higher-level learning, and which leads to an undergraduate or postgraduate degree” (OfS, 2022). Degree apprentices have the same rights as other employees in their organisations and spend a minimum of 30 hours per week at work and at least 20 per cent of their time in off-the-job study or training, although the precise balance of work and study is agreed between the employer and the degree provider. An attractive feature of degree apprentices is that apprentices pay no fees, as these are covered by their employers, and receive a competitive salary. In the 2021/22 academic year, degree apprenticeships (Levels 6 and 7) were approximately 13% of all apprenticeship starts and 14.7% of all degree apprenticeships were in engineering and manufacturing technologies (UK Government, 2022). Although the number of degree apprentices has grown quickly since the qualification was launched in the 2015-2016 academic year, in 2021/2022 there were only 37,800 starts (UK Government, 2022), a very small figure when compared with the 475,915 undergraduate entrants in England in the same year (HESA, 2022).

To follow the academic route to an engineering degree in England has traditionally meant to study three or four years for a bachelor’s degree (BEng) or four or five years for a master’s degree (MEng), depending on whether the degree includes a placement year in industry. As the regulator for the engineering profession in the UK, the Engineering Council sets the criteria that education programmes must meet in order to become accredited and fulfil the requirements for professional registration. The Engineering Council licenses several professional engineering institutions to carry out the accreditation process.

Entry requirements for engineering degree apprenticeships and engineering degrees are comparable, with applicants needing to demonstrate good grades in maths and often physics and other science and technology subjects. The higher education sector in England plays a key role in the engineering talent pipeline, providing the vast majority of new entrants into the engineering profession; in the 2020/21 academic year, 76,340 students (all years) were enrolled in engineering and technology degrees in England (HESA, 2022). A quick search on the UCAS website for mechanical engineering degrees shows that, in England alone, in March 2022 there were 504 courses on offer from 114 providers (UCAS, 2022) and whilst each institution may have a slightly different emphasis, it is fair to say that their approach to programme design is remarkably similar. Appendix A outlines the course content and structure of eight different engineering degrees, and at a glance, one can easily see the similarities. As Lucas, Hanson and Claxton highlight in their report for the Royal Academy of Engineering, most universities generally follow an approach based on "mastering the underpinning science and mathematics basics before attempting problem solving or projects" (Lucas, Hanson and Claxon, 2014, p.38), and as a result of that shared approach, their curricula are remarkably similar. Whilst new institutions such as TEDI-London and NMITE have taken a different approach to course design, with a focus on problem-based learning and a greater emphasis on integration across the various engineering disciplines, it is disappointing to see that they have also overlooked the importance of developing an engineering identity in engineering education, as Appendix A shows.

1.7 Engineering education standards

Engineering education supports a view of knowledge that is "hard, objective and tangible" (Nicholl 2009, p.22) that can be described as positivist. Sheppard et al. argue that engineering education is heavily influenced by traditional academic approaches that fail to prepare students for the profession (Sheppard et al., 2008). This dominant mindset in engineering education is reflected in the requirements of national and international accreditation bodies, who share a competency-based approach to engineering certification. The Engineering Council as the regulator of the engineering profession in the UK, sets the standards of competence and commitment that individuals need to demonstrate to become registered as professional engineers. These standards are outlined in the UK Standard for Professional Engineering Competence (Engineering Council, 2020), which sets out five areas of competence and commitment required: "A) knowledge and understanding, B) design and development of processes, systems, services and products; C) responsibility, management or leadership; D) communication and inter-personal skills and E) professional commitment". The UK-SPEC defines competence as "the ability to carry out engineering tasks successfully and safely within their field of practice" (Engineering Council 2020, p.8). With regards to commitment, the UK-SPEC says that registered engineers "are required to demonstrate a personal and professional commitment to society, to the environment and to their profession" as well as to "have adopted a set of values and conduct that maintains and enhances the reputation of the profession" (Engineering Council 2020, p.9). The requirements outlined in the UK-SPEC include areas that are not explicitly described in the curricula of engineering degrees in England, such as ethics, financial planning, leadership or communication skills. The word "competence" appears one hundred and forty-two times in the UK Standard for Professional Engineering Competence (Engineering Council, 2020) whilst the word "identity" does not appear once.

A number of international organisations have been set up to uphold engineering standards internationally and to ensure the mutual recognition of nationally accredited degrees. They issue guidelines as to the programme outcomes that must be satisfied, generally focusing on knowledge, skills and attributes. These include the Washington and Sydney Accords and EU-ACE Network. However, the word "identity" is absent from the documentation of every one of those engineering accreditation bodies (International Engineering Alliance, 2021; European Network for Accreditation of Engineering Education, 2021). It is sensible to expect engineers to have the knowledge and skills required to be competent practitioners, to expect them to keep learning and to make ethical decisions; professional competence is certainly critical in engineering as indeed it is in any other profession. However, who engineers are as people i.e., their identity, matters because *who* they are influences *how* they practice, it frames *what* they feel able to achieve and *where* they feel they belong (Han et al. 2018) and this is an area largely ignored by engineering education in England.

1.8 What is a profession?

Before we explore professional identity, it may be helpful to clarify what I understand by a profession. Some authors (see Sacks, 2016) focus on the characteristics that differentiate professions from other occupations, in particular a high level of knowledge and expertise and educational credentials. Davis (1991, p.153) defines a profession as "a group of persons who want to cooperate in serving the same ideal better than they could if they did not cooperate." He goes on to distinguish a profession from other organisations in terms of their purpose: a trade union is there to serve the interests of its members; a business exists to profit its owners, and a charity serves the needs of particular groups. In contrast, the purpose of a profession is to organise its members in order to serve the benefits of others, so he understands the professions to be organised for public service. Sullivan et al. (2007, p.21) tell us that the professions have an explicit contract with society by which in exchange of privileges such as setting standards for admission and authorising practice, the professions provide important social services: medicine, nursing and the allied professions maintain and improve the health of the nation, education professionals work towards improving citizens' level of education, law professionals oversee social transactions and dispense justice and engineers develop technologies that improve our lives.

Greenwood (1957, p.46) suggests that a key difference between a profession and another skilled occupation is the existence of "a fund of knowledge that has been organised into an internally consistent system, called a body of knowledge". An aspiring engineer must therefore master the theoretical knowledge that underpins engineering skill. Olesen (2007, p.127) defines professionals as "individuals who embody societal expertise and rationality, and who by a social concordat assume the responsibility for the general availability of this expertise". Olsen (2007, p.131) talks about professions as "monopolies of knowledge and competence", acknowledging that they have their own culture, a culture that "exists in socially articulated meanings and symbols that are attached to artefacts and stabilised in social institutions." He asserts that professions have had a positive effect in the modernisation of societies and that the high legitimacy that the professions have enjoyed is based on a blend of expert knowledge and professional responsibility. Cech and Rothwell (2018, p.586) define professional cultures as "meaning systems built into and around the characteristic tasks and knowledge of a profession", acknowledging that our understanding of what a profession is includes "objective" requirements, generally regulated by the professional bodies governing each profession, as well as a "subjective" understanding of what it means to be a professional, which together provide meaning as to who we are and what we do as professionals. To summarise, a profession is an occupation that requires proprietary knowledge and expertise, achieved via a higher level of education which is guaranteed by associated educational credentials. Members of the profession are expected to conduct themselves responsibly and for the greater good; however, how those behaviours are to be developed is not explicitly defined in most engineering curricula, as illustrated by Appendix A, which outlines the course content and structure of a sample of engineering degrees in England.

1.9 What is professional Identity?

We understand professional identity to be “an individual’s image of who they are as a professional” (Caza and Creary, 2016, p.4) including personal characteristics, work role and membership of a defined professional group requiring a higher level of learning. Eliot and Turns (2011, p.631) define professional identity as the “personal identification with the duties, responsibilities, and knowledge associated with a professional role”. Mael and Ashforth (1992, p.106) define professional identification as ‘the extent to which one defines him or herself in terms of the work he or she does, and the prototypical characteristics ascribed to individuals who do that work’. The literature suggests that individuals gain psychological benefits from identifying with a professional role (Erwin and Stryker, 2001).

In their review of the professional identity literature, Trede and colleagues (2012) found that the study of professional identity tends to be discipline-specific rather than attempting to draw conclusions for generic professional development. They commented on the multitude of theoretical frameworks used, suggesting “an underdeveloped field where there is little agreement among scholars” (Trede, Macklin and Bridges, 2012, p.375). Medicine is perhaps the profession that has studied identity the most; in the USA, the Carnegie Foundation report on the future of medicine was highly influential (Cook, Irby and O’Brien, 2010). The report recommended that professional identity formation should be a key goal of medical education: “Professional identity formation—the development of professional values, actions, and aspirations—should be the backbone of medical education, building on an essential foundation of clinical competence, communication and interpersonal skills, and ethical and legal understanding, and extending to aspirational goals in performance excellence, accountability, humanism and altruism.” (Cook, Irby and O’Brien, 2010, p.6). In their study of professional identity development in medical education, Cruess and colleagues suggest that “medicine is a social structure with its own language, hierarchy, and power structures” and that as such, it works “to reproduce itself, maintaining existing hierarchies, power structures and inequities” (Cruess, Cruess and Steinert, 2019, p.645). I would argue that this idea of the profession as a social structure also applies to engineering, a view supported by Gray, Tuschscherer and Gray (2018) who, in a theory paper reviewing recent scholarship in engineering identity, posit that the engineering profession is indeed a social structure “with a distinctive set of historical norms, values, and beliefs." I will look at engineering identity in more detail in the next chapter.

The Carnegie Foundation's report "Educating Engineers" (Sheppard et al., 2008) highlights the current emphasis on technical knowledge versus preparing engineering students for professional practice. Although the report refers to engineering education in the USA, the challenges it highlights are just as applicable to engineering in the UK: the "increasing complexity of problems" engineers face, the need to work in "multinational, multidisciplinary and multicultural teams", the need for engineers to understand "human and social environments as well as proficiency in technical knowledge" are challenges shared by engineers in both countries. The report concludes that, in following academic traditions, engineering education is not responding to the needs of the profession and suggests a radical redesign of engineering education that integrates technical knowledge with engineering practice through a focus on the development of students' engineering identity.

1.10 Research aims and research questions

This research seeks to better understand the process of engineering identity formation in undergraduate engineering students and apprentices by examining how students enrolled in a Mechanical Engineering degree at a University and apprentices enrolled in a degree apprenticeship in England, develop their engineering identity during the four years of their education at the DA Provider, four or five years at the University(depending on whether they complete a BEng or an MEng), and the impact of their engineering identity in how they envision their future – inside or outside engineering. It aims to answer the following questions:

- What do engineering students and apprentices understand as their professional engineering identity?
- What experiences support/challenge the development of undergraduates' engineering identity?
- Who plays a role in supporting/challenging that identity?

- How does the students' and apprentices engineering identity impact their choice of a future career?

This research is also able to explore the impact of choosing a university degree or an apprenticeship degree on the development of students' and apprentices engineering identity and how different groups (females and ethnic minority students and apprentices, for instance) have different expectations as to what engineering is and what engineers do. This project concludes by proposing interventions that may support the development of an engineering identity in both settings.

1.11 The impact of Covid-19 on this research project

The Covid-19 pandemic that spread worldwide during 2020 and 2021 impacted this research project, forcing me to conduct all interviews online rather than face to face as I had originally intended. Interviews were conducted over Microsoft Teams, a video conferencing tool that all the students and apprentices involved in the research were familiar with, as it was used extensively at both institutions during the pandemic. Research on the use of computer mediated interviews shows that they can be a "viable alternative to the face-to-face interview" (Curasi 2001, p.372) and I feel confident that my 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 consequently a reduced level of personal interaction with classmates and faculty, may have had on the development of engineering identity for the class of 2020/2021.

1.12 Dissertation outline

The dissertation is structured into six chapters which, considered together, provide answers to the research questions and new insights into how engineering students and apprentices develop their engineering identity.

Chapter two begins with a review of the literature on engineering identity before exploring the path that took me to study identity theory as the framework for exploring the development of an engineering identity in undergraduate students and apprentices. The chapter explores the development of identity theory before looking in detail at the various types of identities: person, role, group and social identities. It then explores how identities work and the effects of identity validation or non-validation on individuals, before moving on to explore the impact of status on identity verification. The chapter concludes with suggestions for further research.

Chapter three outlines the methodological design of this study, starting with a research philosophy that is informed by my own experience of living in two different countries. The chapter examines how narrative enquiry through the use of life story interviews can contribute to the study of engineering identity. An explanation of a pilot study conducted prior to the main study is included here, as well as the approach followed to gather and analyse the data from interviews and the Twenty Statements Test (TST). The chapter concludes with a review of the ethical implications of my research as well as the limitations inherent to the methods chosen.

Chapter four reports the analysis of data from an initial pilot study as well as data from the main study; the pilot was conducted with four apprentices (two in their first year and two in their final year) whilst the main study included six first year and six final year students at the University and the same number of apprentices at the DA Provider. In both cases the data analysed included interview transcripts as well as their responses to the TST. Findings are presented by institution and compared across different variables. In order to convey the research participants' voice, numerous quotes from the interviews are included in this section.

In chapter five I discuss the key findings from my research, outlining the view that an engineering degree or degree apprenticeship does not guarantee the development of an engineering identity. The chapter explores the different identities students and apprentices claimed for themselves and the kinds of experiences and the people who support or challenge the development of their engineering identity. To conclude, the chapter explores some of the limitations of this research and makes recommendations for engineering educators to better support the development of an engineering identity in their students and apprentices.

Chapter six provides a summary of the key research findings and explores the value and contribution of this research project to the wider engineering identity literature, exploring the implications for policy and practice. It also makes suggestions for future research.

CHAPTER 2 LITERATURE REVIEW

This chapter offers a review of the literature on engineering identity and identity theory, exploring the reasons why this theoretical frame was chosen to study the development of engineering identity in undergraduate students. After a brief outline on engineering identity, the chapter explores the development of identity theory, reviewing what identities are and the different types of identities. It outlines how identities work and the outcome of identity verification. The chapter concludes with suggestions for further research.

2.1 What is engineering identity?

It is often said that engineering is a hard discipline to define, and the same difficulty applies to engineering identity, “as there is little consensus among researchers regarding what constitutes engineering identity” (Morelock, 2017, p.1256). If I understand professional identity to be “personal identification with the duties, responsibilities, and knowledge associated with a professional role” (Eliot and Turns, 2011, p 631) then in the context of engineering education, engineering identity would be the extent to which students identify themselves as engineers, something that “involves more than just gaining technical knowledge and skills; it involves the personal and social process of identifying with the profession” (Liptow et al., 2016). Students’ identity, who they are, matters because it influences what they see themselves capable of achieving as well as where and with whom they think they belong (Han et al., 2018).

Engineering identity is not a new field of study but one that has grown substantially in recent years (Morelock, 2017, p.1240), as researchers strive to understand how best to attract and retain engineering talent to the profession. Research shows that engineering identity is an important indicator of persistence in both engineering education and the engineering profession (Pierrakos et al., 2009; Eliot and Turns, 2011; Cook et al., 2018; Godwin, 2016; Beam et al., 2009; Cech et al., 2011, Matusovich, Streveler and Miller, 2010). However, the field is highly fragmented, with different authors choosing different theoretical lenses to study engineering identity whilst others move away from theoretical frameworks to focus on specific issues affecting engineering identity, as Table 3 illustrates.

Research using a theoretical lens	Author
Identity Stage Theory	Meyers et al., 2012 Chemers et al., 2011
Multiple Identity Theory	Gee, 2000 Capobianco, French and Diefes-Dux, 2012
Motivation Theory	Matusovich, Streveler and Miller, 2010
Social Identity Theory	Pierrakos et al., 2009
Cultural anthropology	Tonso, 2014
Research focusing on a specific issue	**Author**
Persistence in engineering education	Eliot and Turns, 2011 Cook et al., 2018 Godwin, 2016; Beam et al.2009 Cech et al., 2011
Campus culture	Faulkner, 2007
Underrepresented groups in engineering	Fleming et al., 2013 Tonso, 2000 Liptow et al., 2016 Cech and Rothwell, 2018 Seron et al. 2016 Faulkner 2000 Patrick, Borrego and Riegle-Crumb, 2020
Impact of male dominance	Powell and Sang, 2015 Eastman, Miles and Yerrick, 2019

Table 3 Different approaches to the study of engineering identity.

To complicate matters further, different authors use terms such as agency, motivation, self-efficacy or attitude as being interchangeable with engineering identity, as highlighted by Patrick and Borrego (2016).

Tallman et al. (2019, p 2) suggest that this “lack of consensus reflects the relative novelty of the field, as well as the extent to which it borrows from adjoining fields.” In their study of professional identity, Trede and her colleagues (2012, p.375) conclude that the fragmentation in the professional identity literature can be interpreted as indicating a field of study that is “underdeveloped.”

In his systematic review of the engineering identity literature, Morelock (2017) categorises existing work to define engineering identity according to four themes:

1 Engineering identity as consisting of several other identities, such as academic, occupational, gender or group.

2 Engineering identity as defined by the individual's perceptions of herself, the profession and how others perceive her.

3 Engineering identity as the integration of cognitive, affective and performance variables.

4 Engineering identity as the consequence of the actions that an individual takes by exercising their agency.

Technical problem solving and creativity and innovation are the traits students more frequently associate with engineering, whilst other areas such as communication, ethics or having a positive impact in society are reported less frequently (Morelock, 2017, p.1248). In terms of the experiences that support the development of an engineering identity, Morelock (2017, pp.1249-1250) reports two main categories: engineering-related experiences (including exposure to engineering prior to higher education, internships, and informal learning experiences, for instance) and engineering related connections (such as peer networks, professional networks and role models). He found two additional factors that were conducive to the development of an engineering identity and that did not fit into the two categories outlined above: one was the students' confidence in their own maths and science capability and the other was that being male was conducive to developing an engineering identity (Morelock, 2017, p.1250).

I found the multitude of different frameworks and approaches to the study of professional identity in general, and engineering identity in particular, intensely confusing and wondered if I may find a theory that explained what identities are and how they work at a generic human level. I hoped that understanding would then enable me to apply the building blocks of identity to the study of engineering identity development in engineering students, and hence the focus of my research shifted from engineering identity and professional identity to identity theory.

2.2 Different lenses to look at identity and why I chose identity theory

Had I expected that changing the focus of my research would have made things easier, I would have been disappointed; the first challenge faced by an emergent researcher in conducting a literature review on identity is the fact that most authors draw from largely different sources. At the start of my research, I found this very puzzling, but I was not alone; Vignoles, Schwartz and Luyckx, (2011) share the personal experience of a developmental psychologist, steeped in Eriksonian identity literature submitting a paper for publication to a prestigious journal. One of the reviewers told him that the paper did not cite the “correct” identity literature and suggested a number of sociological and social psychological sources. Both the author and the reviewer were surprised that they had never heard of each other’s sources and “marvelled at the fragmentation of the identity literature”, concluding that “no matter how well we think we know the identity literature, we only really know one corner of it.” (Vignoles, Schwartz and Luyckx, 2011, p.1). As I progressed with my research, I took care not to mix sources from different theoretical traditions, something that was difficult at first but became easier as I became more familiar with the body of work around identity theory. Identity development is among the most commonly studied concepts in the social sciences (Brubaker and Cooper, 2000; Côté, 2006) and has been examined using many different lenses: sociology, psychology, anthropology, linguistics, political science, education (Vignoles, Schwartz and Luyckx, 2011, p.7). My research follows the sociological school of identity theory as it explores how the roles people play in a society shape their identity, with a view to exploring its application in the context of engineering education. Given that identity theory studies how social interaction influences behaviour in social structures and that, as I explored in the previous chapter, existing research by Olesen (2007), and Cech and Rothwell (2018) has already established that the professions are social structures with their own meanings and symbols, identity theory seems an appropriate lens to study identity development in engineering students.

2.3 The development of identity theory

According to Stryker and Serpe (1982, p.201) “identity theory grows out of symbolic interactionism”, a body of work that can be traced to the Scottish moral philosophers of the eighteenth century, who viewed society “as a network of interpersonal communication” and understood human behaviour to be “a consequence of communication”. In a way, they pre-empted the symbolic interactionist understanding of society as a system of interpersonal interaction and the idea of the individual as the product of that society. This underlying belief is the key in the work of American pragmatic philosophers such as William James (1890) and George H. Mead (1934). The latter is perhaps the most important thinker in the development of identity theory (Mead,1934), which Serpe, Stryker and Power (2020, p.2) characterize as “one of the most vibrant theoretical traditions in contemporary sociology”. Mead theorised that the self arises from social interaction: “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” (Mead, 1934, p.135). Perhaps Mead’s most important insight is that our sense of self emerges from the interaction we have with others and that society emerges from the interaction among people’s selves; the self and society cannot exist without each other. The mind emerges as people engage in problem solving in a social setting and in that process, people as well as things acquire meaning; as we interact with other people, we assign meanings to them that help us to anticipate their responses and to align our behaviour to those expectations. According to Mead, human beings interact through the use of signs and symbols, and it is from that interaction that our sense of self emerges. Stets (2018, p.82) defines a sign as “a non-arbitrary association between a stimulus and the response that it calls forth”, whilst a symbol is “an arbitrary association between a stimulus and response.” The difference is more clearly seen with a couple of examples: a wet pavement on a stormy afternoon is a sign of rain, and this is so independently of the cultural context, whether it happens in England or China. An example of a symbol is the wedding band I wear as a sign of commitment to my husband, a social convention whose roots can be traced back to ancient Egypt. Symbols are paramount for the development of human beings and human society; a world without symbols would be a world without language, communication, or ideas. Charon (2007, p.60) explains the key role symbols play in human experience: “It is the symbol that translates the world from a physical sensed reality to a reality that can be understood, interpreted, dissected, integrated, tested. Between reality and what we see and do stands the symbol. Once we learn symbols, we are in the position of understanding our environment rather than simply responding to it, and once that happens what we come to see and act on is colored by our symbols”. He summarises the importance of symbols to human society: “…symbols create and maintain the societies within which we exist. They are used to socialize us; they make our culture possible; they are the basis for ongoing communication and cooperation; and they make possible our ability to pass down knowledge from one generation to the next” (Charon, 2007, p.61). As I explored in Chapter 1, professional cultures have their own signs and symbols, codified into the objective and subjective requirements of each profession (Cech and Rothwell, 2018, p.586).

When human beings interact, we use signs and symbols to understand what is happening around us. Our world is full of symbols: uniforms, flags, logos, and trophies are some examples but perhaps the most important of all is language, the symbolic system we use to communicate. It is our ability to communicate through language that enables us to understand what the situation is like for others, to "put ourselves in somebody else's shoes" and to see ourselves both as a subject and as an object, as our and others' behaviour acquires symbolic value; it is this reflexivity that enables us to be active participants in society (Mead, 1934). Wood (1992, p.63) describes symbolic interaction as "a process in which humans interact with symbols to construct meanings. Through symbolic interactions, we acquire information and ideas, understand our own experiences and those of others, share feelings, and come to know other people. Without symbols, none of this could happen". The reciprocal relationship between self and society is the focus of structural symbolic interactionism, proposing that the shared meaning developed through contact with others influences social behaviour. If traditional symbolic interactionism enhanced our understanding of how social interaction occurs, structural symbolic interactionism went further to explain how social structures (family, religion, educational institutions, etc.) shape social interaction (Serpe, Stryker and Power, 2020, p.2). Identity is the key concept that connects social structures with individual action (Hogg, Terry and White, 1995, p.257). As not all identities are equally valued (as I explore in Section 2.7.4), the study of identity may help to explain why females and ethnic minority students are more likely to abandon their engineering studies.

Identity theory also draws on the work of William James (1890), who suggested that people have multiple selves "as many different selves as there are different others that can recognize the individual" (James,1890, p.294). Although James did not use the word identity, he talked about "multiple selves" in the way we would now understand as multiple identities. One can be a son, an engineering student, a sailing instructor, a volunteer, a friend, etc. according to the multiple roles he occupies in society. A contemporary of James, Charles Horton Cooley, suggested that we learn to think and feel about ourselves by watching how others react to our actions, what he called the "looking glass-self" (Cooley, 1902). If the reactions of the other (both verbal and non-verbal) support our identity, we will feel a positive emotion such as pride, for instance, but when that is not the case, we will experience a negative emotion such as pain or fear and that influences our view of ourselves. We observe this when an engineering student does well in a test and is praised by her lecturer or when she fails the test, and the lecturer provides negative feedback. The work of Mead and Cooley suggests that we develop our sense of who we are based on our interactions with others, which is to say that the self is the result of a social process. We develop our sense of self by constantly evaluating not just what others tell us about our behaviour but by thinking about what we believe others think of us (O'Brien, 2011, p.109). Every social interaction generates reflected appraisals, i.e., our perception of the evaluative feedback we receive from others (Stets and Burke, 2014; Stets and Serpe, 2013) a concept rooted in the work of Cooley (1902) and his idea of the "looking-glass self" mentioned earlier.

Whilst Mead's work was helpful in expanding our understanding of the self, it did not provide a theoretical framework that could be tested. He never actually published his work, and his ideas have reached us through the compilation of lecture notes taken by some of his students (Blumer, 2004). Identity theory took Mead's concepts of self and society and attempted to organise them in a way that could be tested in empirical research (Stryker, 1968). Blumer (1962, 1969) coined the term "symbolic interaction" to summarise Mead's thinking about the role played by symbols in human interaction. Building on the work of Mead and others, Stryker (1980) developed the term "structural symbolic interactionism" to refer to the study of the relationships between the individual and society, laying the ground for the scientific study of identity. 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 structural symbolic interactionism is that "society shapes self, which shapes social interaction" recognising the reciprocal nature of these relationships (Stryker and Burke, (2000, p.231). Stryker 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 or student. As individuals internalise those identities, they also internalise the meanings and behaviours that are expected of those identities and occupy their position in the social structure. For example, the identity of the university student is closely linked to that of her lecturers; the student understands what is expected of her but also what is expected of her lecturers and can choose behaviours that support her student identity and a smooth interaction with her teachers. The various identities held by an individual as a mother, an engineer, a friend, a runner, a wife, a Christian, etc., make up her self.

Stryker's structural symbolic interactionism shares common roots with traditional symbolic interactionism and agrees on a number of premises, such as the importance of subjective experience to human behaviour, the view of society as basic to the development of the self and as a result of human interaction or the idea that self-concepts guide social behaviour. However, traditional symbolic interactionism sees social life as unpredictable, with individuals constantly constructing and reconstructing meanings of themselves as others. In such an environment, carrying out research that may lead to empirically based theories is not possible, as no theories can be developed when behaviour cannot be predicted. In contrast, the structural approach to symbolic interactionism sees society as stable over time, allowing us to study patterns of behaviour; we can look at individual behaviour and also at how those patterns of individual behaviour interact with each other creating a social structure. As individuals create patterns of social structure, that social structure also influences the behaviour of those individuals through established patterns of action associated with different roles. As a social structure, the engineering profession in the UK has changed little over time, maintaining a pattern of male dominance that stands out when compared to other professions such as law or medicine. Some social structures may limit our choices in terms of the relationships we can have and the resources at our disposal (Stryker and Serpe, 1982, p.208); I will revisit this idea later in this chapter when I look at the impact of status on identity verification in Section 2.7.4.

2.4 Identity definition, types of identities

Stets (2018, p.84) provides a concise definition of identity: "an identity is the set of meanings that persons apply to themselves". For an identity to exist, two fundamental conditions have to be met: first, the individual must place herself as a social object and others must also place her as such and second, she must make her own the meanings associated with that particular positional designation (Serpe, Stryker and Powell, 2020, p.13). I mentioned earlier that William James (1890) was one of the first authors to talk about multiple selves in the way we now understand to be multiple identities. In the early days of identity theory, the focus was on role identity (Burke, 1980; McCall and Simmons, 1978; Stryker, 1980) as early theorist focused on the roles people played in social interactions and the organisation and meaning roles provided to individuals. To understand role identities, I must first clarify what identity theory understands by social positions and roles. Burke and Stets (2009, p.114) define a social position as "a category in a society or an organization that an individual occupies." Different organisations or societies will have different social positions available for people to inhabit and these are generally linked to occupations (teacher, student, doctor), social roles (mother, spouse) and personal interests or activities (sportsman, activist). Burke and Stets tell us that a role is "is the set of expectations tied to a social position that guide people's attitudes and behaviours" (2009, p.114). Attached to the social position of being a student, there are expectations around attending class, passing exams and graduating; attached to the social position of being a mother there are expectations of being caring and looking after her child. The combination of social positions and roles creates social structures: the network of relationships, groups, organisations and communities organised according to social markers such as class, gender, ethnicity, level of education, age, etc. which both enable and constrain social interaction. Our position in the social structure shapes who we interact with, the nature of the interaction and the resources available to us. Serpe, Stryker and Power (2020, p.11) tell us that "social structures shape self-development and motivation, as well as expectations for behavior, resources and meanings attributed to the interactional context". If traditional symbolic interactionism sees social interaction as being in a state of flux and open to radical change, structural symbolic interactionists see it as constrained by social positions, the expectations associated to roles, previous experience, social norms and habit.

Identity theory proposes that we have different identities according to the roles we occupy in society, the groups we belong to, the characteristics that distinguish each one of us as a unique individual and the social category we occupy. I explore the different types of identities in more detail in the next sections.

2.4.1 Role identities

Role identities are the meanings individuals associate with the various roles they occupy within the social structure, with those meanings arising partly from the local culture and partly from the individual's personal interpretation of the role; parent, employee, student, manager, mother and engineer are examples of role identities. Whilst there are clear societal expectations of what it means to be a mother, for instance, my own personal understanding of "my mother identity" informs my behaviour in that role. When someone claims a role identity, the behaviours linked to that identity will guide our social interactions with that person; our expectations of teachers and students, for instance, provide a framework that allows us to understand and organise our social interactions at university; we expect teachers to care about their students' learning and to come to class having prepared their lectures; we expect students to attend their lectures and meet their course deadlines. According to Burke and Stets (2009, p.115) "role identities generally contain a large set of meanings" i.e., a number of different characteristics may describe what the role means to different people. As explored in the earlier example, we expect students to meet the academic requirements of their course and we also expect them to have a busy social life, to be active in university life though membership of clubs and societies, to play sports or to be active in their local community, for instance. Identity theorists now propose that there are two more types of identities: group identity and person identity (Burke and Stets, 2009; Stets and Serpe, 2013).

2.4.2 Group identities

Group identity refers to the meanings associated with belonging to a particular group in a society as repeated social interactions with the same people are likely to generate shared meanings and behaviours; a family, a profession, a club or a sports team are examples of such groups (Serpe, Stryker and Power, 2020, p.17). Individuals in the group share some common characteristics and see things from the group's perspective so that, over time, a certain level of "uniformity in thought and action" develops within the group (Burke and Stets, 2009, p.118). As Burke and Stets explain (2009, p.122) sometimes the distinction between role and group identities is purely an analytical one as in real life both are inextricably linked; I have explored earlier how being a student is a role identity but in a football match against a rival school, being a student from a particular school will also be a group identity. Membership of these groups implies a sense of ingroup and outgroup, enabling differentiation between the two. In his study of social identity theory, Hogg (2006, p.119) put forward the idea of the group prototype: the set of "perceptions, attitudes, feelings and behaviours" that describe and prescribe the similarities within the group and the differences between the ingroup and outgroup, whilst stereotypes are social categorisations of out-groups based on prototypical behaviours. One may assume stereotypes to be unreliable, but they are actually quite accurate as they reflect a shared social reality (Hogg and Reid, 2006, p.11). Prototypes have a depersonalising effect, as we see ourselves and others through the attributes of the category rather than as individuals, changing how we feel and behave in order to conform to the prototype of the in-group (Hogg and Reid, 2006, p.11). Prototypes encourage group members to behave normatively by regulating their behaviour; in identity theory terms, as group members internalise group norms held in the prototype and these become part of their own identity standard, they will regulate their behaviour in order to meet prototypical characteristics, match their standard and validate their identities. Hogg suggests that, within a group, the more prototypical members tend to be more popular and influential whilst less prototypical members tend to be unpopular and have little influence (Hogg, 2006, p.123). Given that engineers in the UK are still predominantly male, Hogg's ideas may contribute to explain why male dominance persists in the profession.

2.4.3 Person identities

Burke and Stets define person identities as "the set of meanings that define the person as a unique individual rather than as a role-holder or group member" (2009, p.124). Identity theory does not understand person identity as a natural disposition to act in a particular way but rather as a cycle controlled by the identity verification process that I outline in Section 2.7, as is the case for role and group identities. Some of the person identities studied by identity theory are honesty, dominance and perseverance, as Stryker and Burke mentioned (2000, p.293) whilst Stets and Carter (2006) focused on the moral self. Each one of us has a unique set of person identities and each individual's set of meanings is based on internalised, socially defined meanings that are culturally framed, as what it means to be honest, friendly or hard working, for instance, has different interpretations in different cultures.

2.4.4 Social identities

Identity theorists make an analytic distinction between group and social identities (Stets and Burke, 2000), with social identities linked to the meanings associated to the social category occupied by an individual in society, mainly referring to ascribed characteristics such as gender and ethnicity. Social identities reflect the attitudes and values linked to a category within society rather than to a particular group identity as explored earlier. Carter (2014) suggests that gender is a "diffuse identity" as it is salient across role, person and group identities and across different social settings. Social and person identities operate across roles and situations, as individuals take their person and social identities into the roles they perform. People with different social identities have different access to resources and experience different societal expectations of how they should behave or how they should be treated, something I will explore when I look at the impact of status on identity validation in Section 2.7.4. It is the meanings we give to the labels we assign to people according to their social identity that affect how we behave towards them. If we wish to change our behaviour, we need to reassess those meanings (Redmond, 2015). If a male engineering manager associates women with being less technically competent, for instance, he will unconsciously assign the women in his team to projects that require less technical competence, creating a vicious circle by limiting their opportunities to improve their technical capability. For that behaviour to change, he needs to reassess the meaning he has given to the label “women engineers”. Identity theory researchers have recently started to evaluate how social categories such as race and gender relate to identity theory (Serpe, Stryker and Powell, 2020, p.17).

2.5 Identity salience and commitment

Each one of us has multiple identities that together shape how we behave and interact in society, and these identities are organised in a salience hierarchy. Stets and Burke (2014, p.59) define identity salience as “the probability that a particular identity will be activated across a variety of situations and thus influence the role choices made by the person”. More salient identities are more likely to be activated across different situations; if my mother identity is salient, it will inform my behaviour even when I am not with my daughters.

Stets and Burke (2014) also explore the concept of identity commitment, which they define as the extent to which a person is tied to others on the basis of a given identity. The number of relationships linked to a particular identity and the strength of those relationships determines the strength of our commitment to that identity. The more committed we are to an identity, the greater its salience is. Empirical research by Stryker and Serpe (1982) showed that identity salience and commitment are linked to “time spent in role”, i.e., those identities that are activated more often become more salient and therefore we develop a strong commitment towards them.

2.6 Engineering identity as a person, role and group identity

If I revisit what Caza and Creary (2016) say about professional identities, as mentioned in Section 1.8 of the previous chapter, they suggest that an individual's professional identity draws on meanings attached to their personal attributes (person identity), group membership (group identity) and work roles (professional identity), hence professional identities can be understood to be group and role identities as well as person identities; they are a role identity because they identify the kind of work someone does, they are a group identity because they signify membership of a particular community, for instance the engineering profession, with all the symbols and status associated with that particular group, and they are a person identity because there are particular meanings associated with being an individual professional in that field, for instance, being hard working and analytical in the case of engineers. In the same way that Carter (2014) suggests that gender is a diffuse identity (as I outlined in Section 2.4.4), it seems possible that an engineering identity is also a diffuse identity as it is activated across different types of identities and in different situations, but this is an area that would benefit from further research.

2.7 How identities work

Identity theory incorporates ideas from control systems thinking developed by Norbert Wiener (1948) in the middle of the twentieth century. A core concept in cybernetics is that the output of actions is taken as input for further action in order for the system to self-regulate, as outlined in Figure 1 below. An example of a cybernetic control system is the thermostat that maintains a room at the desired temperature.

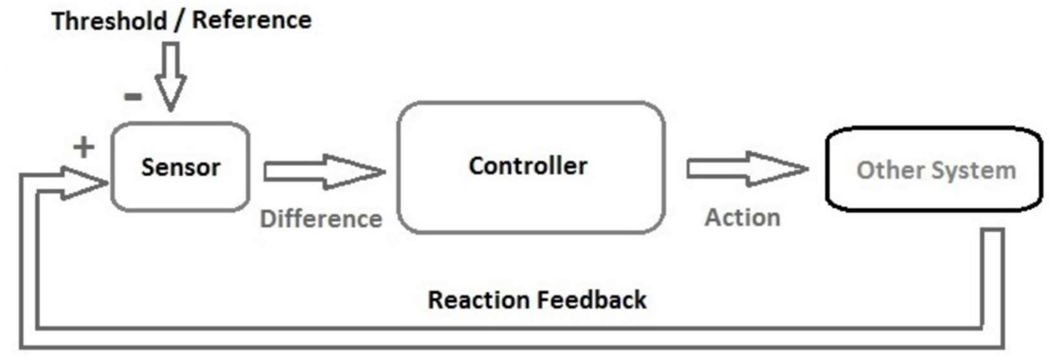


Figure 1 Graphic representation of a cybernetic system.

William Powers (1973) applied the engineering concepts posited by Wiener's cybernetic control model to develop the perceptual control theory. If the cybernetic control model is designed to help us control outputs, Powers' key insight is that when it comes to human beings, it is the control of inputs (perceptions) that matters rather than that of outputs (behaviours) and therefore the system works by modifying the output (behaviour) in order to have an input (perception) that matches the identity standard. According to this model, identities have four basic components: an input, an identity standard, a comparator and an output, organised in a control system as represented in Figure 2 below.

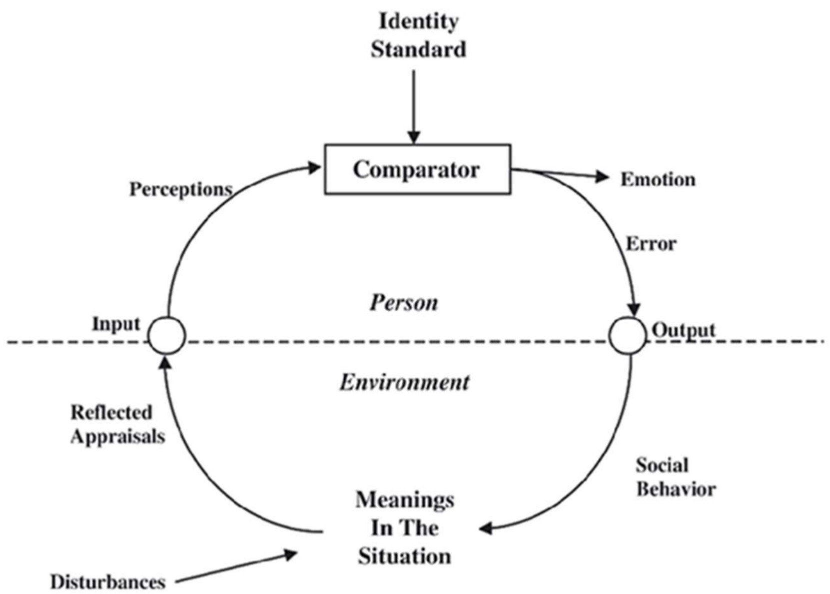
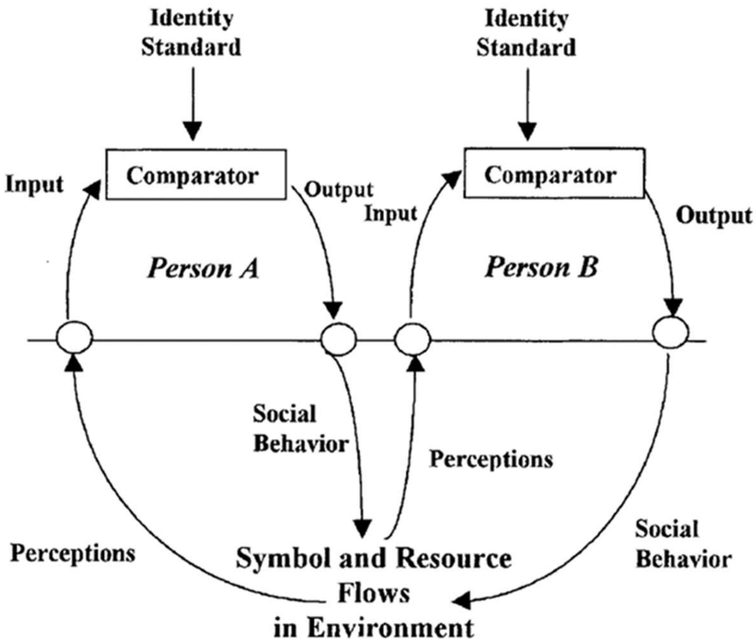


Figure 2 Burke's Identity model (1991)

These four components operate as a feedback loop, managing the meanings perceived in a given situation with the objective of maintaining self-meaning within a comfortable range, in a similar way a thermostat keeps room temperature at a pre-set level. In the model outlined in Figure 2 (Burke and Stets, 2009, p.62), the inputs are our perceptions relative to the standard, i.e., how we see ourselves in the situation and also how we think others see us (that is to say, the reflected appraisals I mentioned in Section 2.3). The identity standard is the set of meanings that defines that identity and includes "one's values, beliefs, and ideals" (Stets and Harrod, 2004, p.158) and remains consistent over time. There is an identity standard for every identity an individual has, and identity standards vary across cultures and in different situations. The role of the comparator is precisely to compare the input perceptions with the identity standard, producing an error message whenever there is a significant gap or discrepancy between them. The output is the behaviour enacted in the environment. When perceptions match the identity standard, the identity is validated; when the identity is not validated, the behaviour may change in response to reflected appraisals. According to the model, changes in behaviour are a direct function of the discrepancy between the standard and the perception but, in order to eliminate the discrepancy, they go in the opposite direction; for instance, an engineering student for whom being assertive is an important part of her identity will increase her assertive behaviour if she believes she is not seen as assertive. However, if her reflected appraisals tell her that her classmates see her as being too assertive to the extent that friendships may be at risk, she will decrease her assertive behaviour. What this model shows is that it is not the behaviours themselves that matter but rather the symbolic meaning given to those behaviours (Burke and Reitzes, 1981). Burke's identity model (1991) shows how 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.

We can explore how the model applies to an engineering student: Student V is doing her placement year, having completed two academic courses at university. Her engineering identity standard may include being a competent problem solver as well as being clever. At work, she was able to solve a problem that had been puzzling her more senior colleagues and they were visibly impressed by her answer. As she subconsciously checks her engineering identity standard against the comparator, she finds that her standard is met, as her reflective appraisals of what her colleagues thought of her as an engineer meet her standard and therefore her engineering identity is validated. Student W's engineering identity standard includes being male and highly specialised in one narrow field. As her reflected appraisals do not meet that standard, she does not see herself as an engineer despite the fact that she has successfully completed her engineering degree.

In their study of identity in married couples, Cast and Burke (2002, p.1044) found that the self-verification of role identities is not achieved in isolation but requires verification from others within the group and that “the behavior of others can inform us about who and what we are". Therefore, the process of identity verification does not happen in isolation and “when a role stands in relation to other roles in a group, self-verification within a group is not just a function of one’s own activity but of one’s activity in relation to others’ activity.” They used Figure 3 (Cast and Burke, 2007, p.1045) to show how the behaviour of person A affects the situation which in turn affects the perceptions for both person A and B. This is an important idea, particularly when applied to education, as the behaviour displayed by others provides us with information about who we are and therefore impacts our own identity verification process. In the context of engineering education, this mechanism can result in the stable patterns of interaction that come to define the structure of the profession, such as the enduring dominance of white males, for



instance.

Figure 3 Identity model for two interacting individuals.

2.7.1 Identity verification and non-verification

Identities involve cognitive and emotional processes and operate at conscious and unconscious levels. The identity model outlined in Figure 2 illustrates a continued flow of meaning through the cycle, aiming to keep the inputs as close to the identity standard as possible in a continued process of identity verification. When identities are verified, this process takes place in an automatic and unconscious manner, generating feelings of high self-esteem and mastery (Burke and Stets, 1999; Cast and Burke, 2002). It is when identities are not verified and negative feelings arise, that we become aware of the disturbance. Imagine a first-year student meeting her lecturer to look at the results of her first assessment in the module; being a good student is an important part of her identity and, throughout her education, she has become used to achieving high grades and has developed high standards for her own academic performance. If her lecturer compliments her work and gives her a high mark, her identity will be validated and she is likely to experience positive feelings, as her self-view is confirmed. Stets and Cast suggest that identity verification “provides an emotional anchor that leaves one less vulnerable when encountering life events” (2007, p.522). When unable to verify their identities, individuals are likely to become upset (Swann, 1983) and to experience distress (Burke and Stets, 1999). The result of identity non verification can be a change of behaviour or output (i.e., dedicating more time to studying or dropping a subject in which the student is less successful) and can also be a change to the perception or input so that it better meets the identity standard (McCall and Simmons, 1966); to change the input, negative feedback may be misinterpreted as positive, ignored or deemed to be irrelevant. Imagine the same student having just completed her first assignment at university but this time she has not done as well as she expected. She may decide that she needs to dedicate more time to study for her next assignment (change of behaviour or output) or she may come to the conclusion that her module leader has been unfair in the way she marked her work or may find comfort in the thought that the grade from that initial assessment does not count towards the final degree classification (change of input). In their neurosociological investigation of identity theory, Kalkhoff et al. (2016) used electroencephalography (EEG) to study identity verification and found that the human brain responds differently to identity verification and non-verification; whilst both processes activate parts of the brain responsible for unconscious, automatic processing, only identity non-verification activates a part of the brain responsible for conscious processing.

Research shows that female students' perceptions of their academic achievements tend to be lower than those of their male counterparts, even when achieving the same grades (Meece and Courtney, 2009; Ehrlinger and Dunning, 2003) and this perception may make it more challenging for female students to validate their student identities. Other factors such as the salience of the identity and the commitment to the relationship with the person providing the feedback, influence whether such feedback is taken on board or dismissed. Identity verification generates positive emotions and trust which in turn leads to the development of committed relationships and positive emotional attachment to the group; elements required for a stable social structure (Burke and Stets, 1999). Burke and Stets (1999) studied the role of trust in identity theory and found that when another person verifies our identity, we start to develop trust in that person. The process of verification of our own identity leads to a positive evaluation of the other person, contributing to the validation of their own identity in a positive feedback loop. Over time, as the identity verification process is repeated, we will see that person as dependable (someone we can trust) and will develop positive feelings towards them, ultimately generating a sense of commitment toward that relationship. A student who is not enjoying his engineering degree may find it harder to abandon his studies if he is deeply connected to his cohort, whilst a student who has not made many friends may feel less committed to his engineering student identity and find it easier to leave. Although there is limited research into the professional identity development of engineering students, work by Pierrakos and colleagues (2009) and Patrick, Borrego and Prybutok (2018) with engineering undergraduates in the USA shows that difficulties in verifying an engineering identity can cause students to abandon their studies.

2.7.2 Self-esteem and identity verification

James' (1890) understanding of the concept of self-esteem is also helpful to identity theory; he suggested that self-esteem is a function of our achievements and our expectations. He worded his well-known formula slightly differently:

Self-esteem = Successes/Pretensions

James' thinking on self-esteem is particularly relevant to the development of engineering identity in engineering students, as high achieving students with very high aspirations may have lower self-esteem than students with more modest achievements but equally modest ambitions. As mentioned earlier, students' perceptions of their academic achievements are not uniform, with female students perceiving their results as lower even when achieving the same grades as their male classmates (Meece and Courtney, 2009; Ehrlinger and Dunning, 2003). Something else that needs to be taken into consideration is that the opportunities for students to validate their identities are impacted by their status and the particular social group the identity is associated to (Stets and Harrod, 2004). I will explore the impact of status on identity verification more fully in Section 2.7.4.

Identity theory understands self-esteem to be an outcome of the identity verification process. Cast and Burke (2002) make the connection between James' thinking and the goal-oriented stance of the identity model, in which the identity standard can be understood as the goal, or pretensions, using James' language, and the self-relevant perceptions of the actual performance are the successes or failures, depending on the outcome. They conclude that "self-esteem can be thought of as a direct outcome of successful self-verification" (Cast and Burke, 2002, p.1046). Erwin and Stryker (2001, p.32) define self-esteem as "an individual's overall positive evaluation of the self" and suggest that it is made of two different dimensions: competence and worth. They understand the competence dimension to be linked to a person's perceived efficacy whilst worth refers to the extent to which a person sees themselves as someone of value. Burke and Stets (2009, p.117) expand on that idea to suggest three key elements behind self-esteem: self-efficacy or our sense of being competent, self-worth or the sense of being valuable and self-authenticity or being true to ourselves. They link each element to a type of identity: self-efficacy to role identities, self-worth to group identities and self-authenticity to person identities. Research by Burke and Stets (1999) confirms that when an individual performs a role well, their sense of self-efficacy and self-esteem are increased by their experience of self-verification of their role identity. We all want to do well in our roles; when our role identities are verified and we are meeting the expectations associated with a particular role, we have a sense of doing well, of achieving our goals (self-efficacy). Burke and Stets (2009, p.118) note that there is a "self-fulfilling prophecy" effect to self-efficacy: people who have it are likely to tackle more difficult and varied tasks, learning more along the way. People with low self-efficacy are less likely to tackle challenging tasks, preferring to stick to what they know and are familiar with. That, in turn, limits their opportunities for learning and development, maintaining their self-efficacy at a low level. Supporting students to develop their own self-esteem may also support the development of their engineering identity.

2.7.3 Feelings generated by identity verification

Role, group and person identities operate in the same way, as we have seen in Section 2.7; however, the feelings generated by the identity verification process change according to the type of identity: role identities generate feelings of mastery and efficacy, group identity verification generates feelings of self-esteem and integration, person identity verification generates feelings of authenticity and social identity verification generates a sense of belongingness and enhanced self-worth (Burke and Stets, 1999, 2009). Table 4 summarises the feelings generated by the validation of different identities (adapted from Burke and Stets 1999, 2009).

Type of identity	Feelings generated
Role identity	• Mastery • Efficacy
Group identity	• Self-esteem • Integration
Person identity	• Authenticity
Social identity	• Sense of belongingness • Self-worth

Table 4 Feelings generated by type of identity.

If identity validation generates positive feelings, lack of validation generates negative feelings, motivating the individual to get rid of the discomfort created by those negative feeling and to act in the pursuit of identity validation. Frequent identity validation makes individuals feel good, as positive feelings are generated, and these feelings can become a resource that the individual can draw from in situations of identity non-verification. On the other hand, frequent failure to validate one's identity would leave the individual feeling bad and more vulnerable to negative experiences. Imagine an engineering student who is highly valued by her classmates and feels well integrated into her cohort; her self-esteem builds up every time her identity is validated, creating a "protective shield" (Burke and Stets, 2009, p.210) that will prevent her from experiencing strong negative feelings when she has an experience of identity non-verification. A student with low self-esteem due to a regular failure to verify her group identity would have the opposite experience; her low self-esteem reinforced over time by lack of identity validation would make her more vulnerable to any stressors she may encounter. I will look at the connection between lack of identity verification and stress in Section 2.7.5.

2.7.4 Identity verification and status

In identity theory, status is understood as our position in a social structure. Research into the role of status in identity verification has shown that higher status individuals are more likely to have their identities verified (Burke 2008) and that their evaluations of others are more influential than those of lower-status individuals (Cast, Stets and Burke, 1999). Research by Stets (2004) also shows that, as high-status individuals are more likely to have their identities validated, they are also more likely to have higher self-esteem. Stets and Harrod (2004) studied the impact of status on identity verification outcomes across different identities and found that status affects multiple identities: “one’s status in the social structure influenced one’s ability to self-verify across multiple identities”. Individuals with a higher status will also have more and better resources they can mobilise to achieve their goals and verify their identities. They found that whites (versus non-whites), males (versus females) and the more educated (versus the less educated) are more likely to achieve identity verification across multiple identities. Their study helps us to see to what extent our status (understood as our position in a social structure) influences the internal process of identity verification, thereby linking two strands of identity theory: Burke’s perceptual control and Stryker’s structural emphasis (Burke and Stets, 2009, p.52). Research by Stets and Cast (2007, p.536) confirms that individuals who have access to more resources are more likely to enjoy greater identity verification, creating a positive feedback loop that places them in a better position to access additional resources and which will enable them to validate their identities in the future. Some of the resources they studied were interpersonal resources, such as trusting each other, liking each other or role-taking (being able to imagine the other’s point of view). Their research gathered evidence of the identity validation of role and person identities, but their work suggests that theoretically, group identities are likely to operate in the same way. In a profession dominated by white, male engineers, it seems likely that females and ethnic minority engineers will find it more difficult to validate their engineering identities (Liptow et al., 2016). However, the effect of status and resources on the development and validation of a particular identity such as engineering identity, has not been widely researched.

2.7.5 Stress as an output of identity non-verification

In Section 2.7 I reviewed how identities are verified when there is a match between the input and the identity standard. In Section 2.7.3 I explored how the lack of identity verification generates negative emotions linked to feelings of low self-esteem and low mastery (Burke, 1991; Burke and Stets, 1999; Cast and Burke, 2002). Burke (1991, 1996) has proposed a model of the relationship between stress and identity verification but before I explore it further, it may be helpful to clarify my understanding of what stress is. Cohen, Kessler and Gordon (1997, p.3) define stress as "the process in which environmental demands tax or exceed the adaptative capability of an organism, resulting in psychological and biological changes that may place persons at risk of disease". This is a widely understood definition of stress, in which the root of the problem is a load that exceeds our capacity. Burke (1991, 1996) offers a different perspective; building on the work of Mandler (1982), who proposed that stress arises as a response to an interruption in the process of identity verification, Burke suggests that when the normal flow of the identity verification process is interrupted by an external event, automatic adjustments are not possible and therefore it is the interruption of the identity verification process that causes stress. He distinguishes four types of interruptions:

1 The first type is caused by external events that break the identity verification loop; the death of a loved one (father, close friend) means that our identity with regards to that person can no longer be validated. The same happens when we go through important life changes: moving house, changing jobs or being made redundant, for instance; any of those changes will impact our identity verification process as our relationships, and the identities linked to those relationships, are disrupted.

2 The second type of interruption is caused by interference from other identities; for instance, a professional woman who is also a mother may experience those identities as competing with each other. She is likely to feel distressed when the demands of her work conflict with the demands of her role as a mother, leading to her identity as a mother being interrupted in order to validate her identity as a professional, and vice versa.

3 The third type is linked to "the tightness of the identity control system" (Burke, 1991, p.843). A tightly controlled identity is one that has fewer meanings associated with an identity standard. For that identity to be verified, a more precise

match between the standard and the input perceptions needs to occur. For that to happen, individuals must monitor their input perceptions constantly and in detriment of other identities. Tightly controlled identities create more interruptions because those identities are less likely to be verified but also because the constant attending to the tightly controlled identity means that the verification of other identities may also be interrupted. A person who is a perfectionist is likely to spend a great deal of time and energy ensuring that his perceptions match his standards and may become upset when they differ, even when they do so by a small margin.

4 The fourth type of interruption results from the “episodic performance of a role” (Burke, 1991, p.844). To some extent, all identities are episodic; given that we have multiple identities, all identities go through a process of activation and deactivation. Nevertheless, when identities are seldom activated, it is difficult to get feedback to check if reflected appraisals match our identity standard. We see this in roles in the emergency services, for instance, or in situations in which roles are evaluated infrequently, such as annual employee reviews.

Engineering students are likely to experience stress as a result of some of the identity interruptions outlined above; as they move away from home to go to university or to join an apprenticeship degree, their identities as daughters, sisters or friends will be interrupted, and is likely to cause them stress. Apprentices, who work three days per week and study two days per week, may find that their student identity and their employee identity interfere with each other, making the weekly identity shift stressful. Students and apprentices who set very high standards of academic achievement for themselves will suffer if they fail to meet those standards, even if it is by a small margin. Lack of feedback can also lead to an interruption in the identity verification loop as may be the case for a student preparing to enter an engineering competition, who is unable to gather feedback on her performance until after the event.

2.8 Change and identity

The work I have explored so far may give the idea that identities are fairly stable and do not change. However, that is not the case and identity theory recognises that identities do change but do so slowly. Burke and Stets (2009) suggest four sources of change:

changes in the situation, identity conflicts, identity standard, and behaviour conflicts and negotiation.

1. Changes in the situation refer to environmental changes that disrupt the meaning of a given identity. Winning the lottery or losing a job are examples of important environmental changes that will impact our identities. Leaving home to go to university, for instance, represents an important change in the life of undergraduates as they leave family and friends behind and is likely to have an impact on their identity.
2. Identity conflicts lead to identity change when the standards of the different identities which are activated at the same time come into conflict. For instance, a female student may perceive her engineering degree as being a male-dominated environment, and this may have an impact on her identity as a female engineer. Identity conflict may also arise from students taking on new identities if some of the meanings associated with the new identities come into conflict with pre-existing ones; for instance, becoming a professional may be challenging for a student whose parents are not educated to degree level.
3. The third source of identity change is created by situations in which there is a conflict between the meaning of one's behaviour and the meaning in the identity standard; a student may pretend to be sick to miss class, creating a conflict with his student identity standard. If this behaviour persists over time, it is likely that his standard will shift a little at the time to accommodate his behaviour.
4. The fourth source of identity change is negotiation with others in mutual verification context and is particularly relevant to undergraduate education, where students validate each other's identities in the different roles they undertake during their university years.

In all four sources of change, it is the meanings held in the standard that need to adjust in order for change to occur. How identities change has been a neglected area of research (Burke and Stets, 2009, p. 234) and yet an area that seems particularly relevant to the study of engineering identity development in undergraduate students, as they enter a new stage in their lives on their path to adulthood and the engineering profession.

2.9 Conclusions and questions for further research

Identity theory provides a useful framework to study the development of an engineering identity in undergraduate engineering students, enhancing our understanding of how identities work, how they interact with each other, the kinds of experiences that support or challenge the development of that identity and the positive and negative effects of identity verification and non-verification. Looking at engineering identity development through the lens of identity theory, we can better understand how minorities, traditionally associated with lower status groups in society (i.e., women and ethnic minority groups) may find it harder to verify their engineering identities than individuals of higher status (white men). The literature also provides clues as to how educators can support the process of identity development in undergraduate education by developing interventions that support person, role and group identity development and the feelings of self-efficacy, self-worth and self-authenticity that are an output of the verification of those identities. Educators can help their students to become part of the engineering community by providing them with networking opportunities, supporting the students' greater commitment to their engineering identity. Educators could also strive to develop meaningful relationships with their students that are built on trust and therefore conducive to the validation of their identities.

Whilst the literature on identity theory is vast, some areas still require further study; traditionally, identity theory research has focused on role identities and more work needs to be done to learn more about person and group identities. It would also be of interest to study identities that invoke all three types of identities (role, group and person) and in different situations, such as engineering identity, an area that has not been widely researched and that has particular interest for the professions. The identity validation of interacting individuals is also an area that would benefit from further research and that would throw light onto the process of identity verification in the professions, of which engineering is the focus here.

How identities change over time is another little explored area and one that is particularly relevant to the study of professional identity in undergraduate students. Starting university or joining a degree apprenticeship marks the beginning of a period of intense growth and development for young people on their path to becoming professionals and it is an area that would benefit from further research. There is little research into the impact of group prototypes as defined by Hogg (2006); this is an area of clear interest to professional identity in general and engineering identity in particular, as there are clear societal expectations of what it means to be an engineer.

Most of the research into the factors that influence the development of an engineering identity has been qualitative (Morelock, 2017, p. 1254) and the field would benefit from quantitative research to study the generalisability of those factors and how they may relate to one another. Finally, another area that has not been well researched is the role of intersectionality (how individuals as members of multiple social groups according to race, class, sexuality and gender experience disadvantage) in the context of professional identity development. Engineering in the UK is still very much a profession dominated by white, heterosexual men and therefore it seems likely that it may be harder for a woman of colour or for a gay man to verify their engineering identity. In these two examples, it is not clear what the effect of gender, ethnicity or sexual orientation may have on the development of an engineering identity.

In summary, identity theory tells us that social structure determines social behaviour by influencing the opportunities we have to enact different identities (Stryker and Serpe, 1982). We develop our identities in a social context and those identities cannot be validated in isolation, as we need reflected appraisals to compare against our own identity standards. When our identities are frequently validated, we experience positive feelings of mastery, self-esteem or authenticity that can build up a reservoir we can tap into when required. Equally, when our identities are infrequently validated, we experience negative feelings and are more vulnerable to life's stressors. Whilst the process of identity validation happens almost automatically, when an identity is not validated we experience stress or discomfort, and this encourages us to take the relevant action in search of validation.

In the next chapter, I outline the qualitative methodology I followed to study the development of engineering identity in a group of students at a University and a DA Provider, sharing some of the challenges I experienced as a novel researcher in the field. Conducting research in the middle of the Covid-19 pandemic posed some methodological challenges that I also discuss in Chapter 3.

CHAPTER 3 METHODOLOGY

This chapter outlines the methodological design of my research. It begins by setting out the context of the study and its research questions and providing an explanation of the research paradigm. In this chapter I discuss the use of narrative enquiry as a methodology for the study of the development of engineering identity and include a full explanation of the research procedures followed; I start by outlining the preliminary pilot study I conducted before explaining the approach to sampling, data collection, management and analysis followed in the main study. I then explore the ethical considerations of my research and discuss its validity and reliability. The chapter concludes with a brief discussion of the limitations of my research.

3.1 Introduction

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 at a DA Provider and an engineering degree at a University in England. The research seeks to answer the following questions:

- What do engineering students understand as their professional engineering identity?
- What experiences support/challenge the development of undergraduates' engineering identity?
- Who plays a role in supporting/challenging that identity?
- How does the students' engineering identity impact their choice of a future career?

As I am interested in the unique outcomes for individual students, rather than in measuring standardised outcomes across all students studying engineering, a qualitative methodology seemed best suited to my research objectives. I did explore the possibility of undertaking a longitudinal study, as this is often the methodology of choice when researching changes in individuals over a period of time (Saunders, Lewis and Thornhill, 2016, p.200). However, the time constraints of a DBA dissertation made it impractical and

I decided against it, choosing to study students and apprentices in the first year and in the final year of their studies as an alternative. In the search for the most appropriate qualitative methodology, I selected a narrative inquiry approach through the use of life story interviews (LSI), as numerous researchers have explored the use of narrative inquiry in the study of identity (Huber et al., 2013; Goodson and Sikes, 2001; Chaitin, 2004) and in particular professional identity (Olesen, 2007, p.139) although not in engineering education research (Foor, Walden and Trytten, 2007, p.104).

This research project started once approval from the University of Bath's Social Science Research Ethics Committee was received on twenty fifth January 2021 (SSREC reference number: S20-094). Additional approval was sought to modify the interview script following the pilot study and granted on the fifteen of March 2021.

3.2 Research philosophy

The underlying interest in pursuing this research is to learn more about what students understand by engineering identity, how they make sense of the experiences that shape the development of their engineering identity, who plays a role in supporting or challenging that identity and how they envision their future, inside or outside engineering, with a view to proposing changes to engineering education that may better support the development of an engineering identity. My own experience of working in higher education for many years has showed me that undergoing the same programme of study can render very different personal interpretations, as every student constructs their own reality in their own minds. This experience led me to believe that reality is subjective and constructed by individuals as they go about their daily business; as Guba and Lincoln (1994 p.125) assert: "realties are apprehendable in the form of multiple, intangible mental constructions… and dependent for their form and content on the individual person or groups holding the constructions". In developing my own epistemological stance, I found myself closely aligned to that of Merriam, who says that "the key philosophical assumption upon which all types of qualitative research are based is the view that reality is constructed by individuals interacting with their social worlds" (Merriam, 1998, p.6) and that "reality is not an objective entity; rather, there are multiple interpretations of reality" (Merriam, 1998, p.22). As an emerging researcher in higher education, I believe that constructivism should be the epistemology that orients my qualitative research as I seek to understand the meaning undergraduate engineering students assign to their experiences on their path to becoming engineers. I believe that knowledge is constructed by the learners rather than discovered. My ontological stance assumes that reality is not unitary and independent from our perceptions; as each one of us experiences things differently, we experience different realities. W. J. Thomas, a symbolic interactionist, explains this in what has become known as Thomas' Theorem: "What is defined or perceived by people as real is real in its consequences" (Thomas and Thomas, 1928, p.572). My stance is influenced by my own personal experience of growing up in Spain and living and working in both England and Spain as an adult. Ideas that are firmly believed to be true in Spain are not so in England and vice versa; as a small child, my mother would tell me to wait for a pie to cool because "hot pastry is bad for your tummy", as pies in Spain are always eaten cold. I grew up believing that one should not eat hot pastry until I moved to England, where pies are a popular dish and eaten hot; my own experience showed me that hot pastry was not only harmless but delicious. This anecdote illustrates something I have encountered often as I moved between the two national cultures; my beliefs as to what were the best ways to raise children, conduct personal relationships or behave appropriately at work were often called into question by my actual experience in different cultural settings. Being aware that my own "reality" is not necessarily the same as the next person's encouraged me to be curious and reflective, both useful qualities for an emerging qualitative researcher. Moreover, my formal training as a coach means that I am a good listener and can develop good rapport quickly with my interviewees.

Narrative research tends to focus on the way in which knowledge is created in social settings and epistemological approaches to narrative research vary (Dwyer and emerald, 2017). I acknowledge that, in seeking to gain in-depth understanding of the process of identity development in undergraduate engineering students and apprentices, my relationship with my interviewees may influence the outcomes, as the relationship between the researcher and the researched has epistemological implications that shape the way in which the research is conducted. In qualitative research, the role of the researcher is particularly important because "the researcher is the instrument of both data collection and data interpretation" (Patton, 1990, p.54) and therefore the credibility of the researcher has significant impact upon the credibility of the research. As an internal researcher i.e., employed by one of the institutions I am researching, it is important to be aware of the "hidden ethical and methodological dilemmas of insiderness" (Labaree, 2002, p.109). Insider research has become more common in recent years, with the increased popularity of professional doctorates, such us the Doctorate in Education (EdD) or the Doctorate in Business Administration (DBA), in which professionals studying part time often complete their research at the institutions in which they are employed (Hanson, 2013, p.388), as it is indeed my case. Mercer (2007) provides a helpful examination of the challenges of insider research and the evolution of views on insider and outsider research in the academic community over the years. Whilst insider researchers may benefit from easy access to their research participants and a good understanding of the organisational setting, they risk falling prey to their own preconceptions and to those that research participants may have about the researcher, as a result of their shared history. Mercer proposes that we move away from viewing insider or outsider roles as dichotomous and instead we "consider the two terms as poles of a continuum that is more or less fluid" (Mercer, 2007, p.7), a view supported by Hanson's research, as she reports that "it is not possible to be absolutely either an insider or an outsider in the research environment of the organisational practitioner" (2013, p.396). I tend to agree with Hammersley's view that "there are no overwhelming advantages to being an insider or an outsider. Each position has advantages and disadvantages, though these will take on slightly different weights depending on the particular circumstances and purposes of the research" (Hammersley, 1993, p.219). In my own role, I often feel both as an insider and an outsider in different situations, particularly as someone who is not an engineer, but is surrounded by engineers. This seems like an appropriate time to explain my role as doing so will clarify my positionality in relation to the exploration of engineering identity development in engineering education. I am employed by one of the institutions I am researching, however, in my role I have little direct interaction with students or apprentices. The activities I oversees are extra-curricular and not for credit and therefore I have no power to influence academic outcomes for any students or apprentices. As I outlined in the Introduction, at the time I was searching for a dissertation topic for my DBA I became curious as to why so many women and BME engineering graduates chose roles outside engineering. Whilst exploring the literature looking for clues, I came across identity theory and wondered if perhaps some students did not develop their engineering identity during their studies and were therefore less likely to practice. My interest in the study of identity led me to explore life stories as a possible methodology for this research project. Huber et al. (2013, p.214) see stories as closely linked to identity: "Throughout the ages and across cultures story continues to express the fundamental nature of humanity. Our very identities as human beings are inextricably linked to the stories we tell of ourselves, both to ourselves and with one another". We tell stories to make sense of the world, "Humans are storytelling organisms who, individually and collectively, lead storied lives. Thus, the study of narrative is the study of the ways humans experience the world." (Connelly and

Clandinin, 1990, p.2). There are different types of life stories; the ones used in this research are what Plummer (2011, p. 4) calls "researched life stories", these are life stories that do not occur in a naturalistic setting like a conversation between friends, but are gathered by a researcher in the context of a research interview using a particular tool such as a recorder or, in this case, a computer and Microsoft Teams software. Plummer reminds us of the key role played by the researcher in these types of life stories, as "they shape and assemble them, and indeed without them there would be no life story". What I understand by life stories is also referred to by a plethora of different terms, such as self stories, life histories, auto/biographies, life narratives, oral histories etc. as Plummer points out (2011, p. 3).

Narrative enquiry uses personal stories as data and Merriam and Tisdell (2016, p.34) suggest that particularly since the 1990s they have become a popular methodology for "understanding the meaning of human experience". As Plummer advocates (2011, p.8), we study lives in the hope that they will help us to develop our understanding of an issue that is of interest to us. Narrative enquiry is particularly well suited to the study of identity (Goodson and Sikes, 2001) as Chaitin (2004) proposes that in retelling their stories, individuals are constructing their identities. 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. However, 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. Atkinson (2012, p.16) suggests that narrative enquiry as a research methodology offers a way of interpreting someone's experience and has been used extensively in social science research although rarely used in engineering education, as Foor, Walden and Trytten assert (2007, p.104).

3.3 Research approach

There are different approaches to the structure and duration of life story interviews. Initially, I was attracted to an open-ended approach, allowing interviewees the freedom to develop their own narrative without interruptions, as advocated by Bogdan and Taylor (1975). However, the young age of my research subjects led me to believe that they may need more guidance, and I decided to use a modified version of The Life Story Interview instrument developed by McAdams (2008) at the Foley Center for the Study of Lives at

Northwestern University, a semi structured interview tool for life story research. During the interviews, I endeavoured to use open questions, allowing respondents time to think about their answers even when that meant long pauses, and avoided putting words in their mouths, finishing their sentences or interrupting them as they spoke. Respondents were allowed to follow their own thoughts rather than impose the order of the script, and I later went back to parts of the script that had not been covered or discussed fully.

3.3.1 Pilot study

As a novel researcher, the idea of conducting a pilot study before committing to a research programme seemed appealing, as it would allow me to practice my skill as an interviewer, to check if the research documentation I had put together was clearly understood by the research participants and whether the interview script engaged research participants and provided information that was relevant to this study (the pilot interview script is available as Appendix D). With that in mind, four apprentices at the DA Provider were selected for a pilot study: two in their first year and two in the final year of their engineering degree apprenticeship. In each year group, one apprentice was male and one female. The four apprentices for the pilot were selected following a purposeful sampling approach, a technique widely used in qualitative research in which a sample "from which the most can be learnt" is selected, as Merriam and Tisdell advocate (2016, p.96). Palinkas, Horwitz and Green (2015, p.534) highlight the importance of selecting research participants with "the ability to communicate experiences and opinions in an articulate, expressive, and reflective manner" and this was indeed the focus. Given that purposeful sampling requires an in-depth knowledge of research subjects, I relied on the assistance of the Apprentice Support Team from each year group to identify students who may be interested in contributing to my research and were good communicators. At the DA Provider, the Apprentice Support Team is responsible for providing pastoral care to the apprentices, meeting with each student individually at least once per month. As the Apprentice Support Team get to know the apprentices they work with very well, they were ideally placed to identify suitable apprentices for my research and therefore I enlisted their help. The pilot study also allowed me to test the effectiveness of the research documentation that I had prepared: the consent form, participant information sheet and participant debriefing form (all forms are included in Appendix B). From a shortlist provided by the Apprentice Support Team, I randomly selected one male and one female apprentices from each year group, I scheduled interviews and sought and received the apprentices' consent ahead of each interview. Interviews lasted around ninety minutes and generated about seventeen pages of interview transcripts. I analysed the transcripts manually, reading them several times and looking to reduce the data inductively.

The pilot showed that apprentices did not seem to think in terms of "identity" and therefore interview transcripts provided little information as to the different identities apprentices claimed for themselves. To address this gap, I explored the possibility of integrating the Twenty Statements Test (TST) into my research, a tool developed from a symbolic interactionist stance by Kuhn and McPartland (1954) to facilitate empirical research on identity. The TST explores the most prominent aspects of the symbolic system that individuals apply to themselves (Rees and Nicholson, 2011) and has been used in many studies to explore the self-concept (Carpenter and Meade-Pruitt, 2008), becoming widely used in qualitative research recently due to "uniquely combining a structured approach with maximal response openness" as Rees and Nicholson propose (2011, p.88). When we talk about ourselves, we generally describe who we are by talking about what we do, how we do it and the values that position us within a particular culture. I requested approval to include the TST in my research from the University of Bath's Social Science Research Ethics Committee (SSREC) and as soon as it was granted, I set up a follow-up call via Microsoft Teams with each of the four apprentices who took part in the pilot study, asking them to complete the Twenty Statements Test (TST). During the call, I gave the apprentices a Word document that contained the question: "who am I?" and spaces for twenty answers (this form is available in Appendix C). Apprentices were asked to complete as many statements as they could as quickly as they could; all four apprentices provided twenty statements.

Over the years, different ways of classifying the statements from the TST have been used (Rees and Nicholson, 2011) and I decided to follow the approach developed by the test's creators, Kuhn and McPartland (1954), which classifies responses as "consensual" or "sub-consensual." 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 and McParland, 1954, p.69). However, I found that following that approach shed little light on the apprentices' responses and I undertook a second classification according to whether the answers referred to role, group or person identities as defined in Chapter 2.

The pilot study gave me more confidence as an interviewer and confirmed that the research documentation that I had drafted (consent form, participant information sheet and participant debriefing form) was clear and well understood by the apprentices. It also showed that some of the questions included in the interview script (questions about their health history or their experiences of loss, for instance) were less relevant to the study of how engineering identity develops in young engineering apprentices, and consequently I adapted McAdams' (2008) interview instrument by eliminating such questions and developed a shorter, more focused interview script (available as Appendix E). As the addition of the TST had provided valuable information, I decided to include it in the main study.

Data from the pilot study was not included in the main research project, as the interview script had been significantly shortened and are reported separately in Chapter 4. Initial findings from the pilot study were presented at the International Conference on Engineering and Product Design Education at Via University College, Denmark, in September 2021 and the conference paper subsequently published (Liquete, Dekoninck and Wisker, 2021). A second article including the findings from the TST analysis was published in Design and Technology Education: An International Journal (Liquete, Dekoninck and Wisker, 2021).

3.3.2 Sampling

Purposeful sampling worked well in the pilot study and therefore I followed the same approach to select research participants for the main study. According to Patton (2015, p.53) "the logic and power of qualitative purposeful sampling derives from the emphasis on in-depth understanding of specific cases: information-rich cases. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the enquiry, thus the term purposeful sampling". This approach fits well with this research project, as the objective is to gain insights into the process of engineering identity development rather than to be able to make empirical generalisations.

As discussed earlier, purposeful sampling requires in depth knowledge of the individual students to be selected. As I did not personally know the students nor the apprentices, I was supported by different people at the two institutions under study: Personal Tutors at the University and the Apprentice Support Team at the DA Provider. At the University, Personal Tutors have regular meetings with students to guide their academic progress and support their personal and professional development. The Apprentice Support Team at the DA Provider offer pastoral care, supporting apprentices through the duration of their studies. Both people acted as gatekeepers, as they were well placed to identify those students and apprentices who were likely to be interested in reflecting and engaging with the research topic. They were asked to identify students and apprentices from different demographics in terms of gender, ethnicity, perceived strength of their engineering identity and who were happy to share their stories. As the salience of a particular identity can vary between cultures (Greenfeld and Eastwood, 2009) and in order to study the development of engineering identity in the context of a single national culture, all the students selected for this research were British nationals, although some of the students had a different ethnic heritage. The strength of engineering identity may differ according to the stage of the degree, as students and apprentices complete a variety of assignments and interact with a larger group of engineers as they progress through their engineering education, and therefore the sample included students and apprentices at the start of their degree (year one) and in the last year of the education (year four at the DA Provider and year four or five at the University, depending on whether the students were studying for a BEng or an MEng).

Andoh-Arthur (2019) acknowledges the important role played by gatekeepers in social research as they can provide access to both study settings and participants. He asserts that “there is no conventional or standard way in which to negotiate gatekeeper roles”. The people who played the role of gatekeeper at both institutions (the personal tutor at the university and the apprentice support team member at the DA provider) were chosen for this role because they knew their students well and were therefore well placed to identify suitable research participants. They were also supportive of my research aims and interested in the research topic. Nevertheless, it is possible that in selecting research participants, they may have avoided choosing students who could reflect badly on their institution and therefore their choice of students may bring a bias to the study that a randomised sample would have avoided. The main advantage of using gate keepers for this project was a very high response rate, which may have been hard to achieve through other means, and a high level of engagement from the research participants. Working with gatekeepers was also a very time efficient way of recruiting research participants. The choice of gatekeepers can have a significant impact on research findings, particularly when the research can throw light on the gatekeepers' actions and therefore it is in their interest that research participants convey a positive message. Gatekeepers may also restrict access to research participants when the research topic is perceived as highly sensitive, as they may wish to protect some people they may perceive as being vulnerable, or when their own positionality may lead them to choose participants in a way that does not support the research interests, for instance when studying abortion, choosing participants who align with the gatekeeper's stance on the topic. In the case of this particular research project, it is inevitable that gatekeepers would bring their own bias to participant selection as well as consciously or unconsciously selecting research participants who would show their institution in the best possible light, and it is therefore impossible to know to what extend my findings would have differed had the gatekeepers selected a different group of research participants.

Sample size is a thorny issue for a novel qualitative researcher as guidance is sparse and often seems contradictory. I had already spent a significant amount of time researching sample size when I came across Patton's assertion that "There are no rules for sample size in qualitative inquiry" (Patton, 1990, P184). Whilst Patton's statement initially filled me with dread, it also made me think that the best course of action was to find an appropriate sample size for my research and to provide a good rationale for my choice. Based on the experience gained during the pilot study, I decided to follow a purposeful approach to sample selection whilst aiming to achieve maximum variation sampling, making sure the sample included British nationals from different genders and ethnic backgrounds as well as different perceived levels of engineering identity. A sample size of twelve students or apprentices per institution seemed appropriate to fulfil my research goals. At each institution, six students in the first year and six students/apprentices in their final year were interviewed; in each year group, three students/apprentices were male and three were female. The following tables show the students and apprentices who took part in this research.

Apprentices	**Year of Study/Specialism (final year students only)**	**Gender**	**Ethnicity**
A	Year One	Female	White
B	Year One	Female	White
C	Year One	Female	White
D	Year One	Male	White
E	Year One	Male	Asian
F	Year One	Male	White
G	Electromechanical Stream	Female	Latina
H	Mechanical Stream	Female	White
I	Mechanical Stream	Female	White
J	Mechanical Stream	Male	White
K	Mechanical Stream	Male	Asian
L	Software	Male	White

Table 5 Apprentices by gender, ethnicity and degree specialism.

University Students	Year of Study	Degree Specialism	Gender	Ethnicity
M	Year One	MEng Aerospace Engineering	Female	Asian
N	Year One	MEng Integrated Design Engineering	Female	White
O	Year One	MEng Mechanical Engineering	Female	White
P	Year One	MEng Aerospace Engineering	Male	Asian
Q	Year One	BEng Mechanical Engineering	Male	White
R	Year One	MEng Aerospace Engineering	Male	White
S	Final Year	MEng Mechanical with Automotive Engineering	Male	White
T	Final Year	BEng Mechanical with Automotive Engineering	Male	White
U	Final Year	MEng Mechanical Engineering	Male	Asian
V	Final Year	MEng Integrated Design Engineering	Female	White
W	Final Year	MEng Integrated Mechanical and Electrical Engineering	Female	White
X	Final Year	MEng Mechanical Engineering	Female	White

Table 6 University students by gender, ethnicity and degree specialism.

3.4 Data collection

The Apprentice Support Team at the DA Provider and the Personal Tutors at the University provided the names and email addresses of students or apprentices who were happy to be involved in my research; I contacted the students and apprentices by email, including in the communication the participant information sheet and the consent form. All apprentices responded positively to my initial request and only one student from the University failed to respond, and therefore I asked the Personal Tutor to provide an additional contact. The next step was to schedule one-hour long interviews over Microsoft Teams with each participant at a time that was convenient to them, making sure that they had signed and returned their consent forms prior to the interview; some participants required a number of reminders before returning their forms, but all consent forms were received ahead of interviews taking place. Every participant received The Student Information Sheet (included in Appendix B) in the first email communication, providing information about the project and making it clear that participation was entirely voluntary and that they could withdraw from the research at any time. I used an Excel sheet to keep track of the interview schedule and all the research documentation, keeping a record of when information had been sent to the students and when I received it back from them. Working with twenty-four respondents at two different institutions and multiple research documents was a complex task and the Excel file became a very useful tool to keep track of interview schedules and related documentation, helping to ensure that no interview went ahead before receiving written consent and that every student received all the relevant documentation in a timely manner.

At the start of every video call, research participants were asked for their consent to record the interview; I explained to them that I would only use the recording to generate an automatic transcript of the interview and that I would securely delete the recording two weeks after they received their transcript for review, and every participant gave their consent. Towards the end of the interview, I explained that I was going to share with them a Microsoft Word document containing the Twenty Statement Tests (TST) (Kuhn and McPartland, 1954) in which they were asked to answer the question “Who am I?” twenty times or as many as they could manage. I stayed on the Microsoft Teams call whilst the students and apprentices completed the TST, giving them encouragement if they struggled to come up with answers whilst reminding them that it was not a problem if they could not provide twenty responses. Every student and apprentice who took part in the research completed the TST; five students (one female and four male) and two male apprentices provided less than twenty statements (the lowest number of statements provided was eleven). After the interview, I sent each participant a copy of the Participant Debriefing Information Form by email (included in Appendix B).

The interview transcripts automatically generated by Microsoft Teams were often highly inaccurate and difficult to read, and on average required at least two hours of editing per interview; this involved making corrections to the text as I listened to the entire recording. Whilst this was a very time-consuming process, it did enable me to become more familiar with the data. Once I was happy with the quality of the transcripts, I sent each student a copy of their transcript by email as a Microsoft Word file asking them to check that it was an accurate reflection of their interview and to seek clarification when required. Video recordings were securely deleted two weeks after emailing the transcripts to the students. The data set for this research project therefore consists of interview transcripts and Twenty Statement Test responses.

Every student and apprentice who took part in this research seemed to enjoy the opportunity to talk about their own experiences and to reminisce about the path that led them to engineering. They often became animated when remembering teachers who played a significant role in their lives or when recalling some of the successes they were particularly proud of. A small number of students and apprentices shared painful experiences of being bullied or feeling excluded by peers at school but did not become distressed during the interview. Nevertheless, I signposted them to the wellbeing services provided by their institutions in case they needed support. By the time the interviews concluded, students and apprentices seemed quite appreciative of their own achievements, and they thanked me for the opportunity to take time to reflect on their experiences, something they felt they rarely had time to do in their busy lives.

3.5 Data analysis and management

Merriam (1998, p.178) defines data analysis as “the process of making sense out of the data. And making sense out of data involves consolidating, reducing, and interpreting what people have said and what the researcher has seen and read – it is the process of making meaning". In narrative enquiry, analysis starts the moment fieldwork starts (Floyd, 2012, p.228) as ideas occur, and patterns start to gather shape. For this reason, it is important to record field notes and what Patton calls "the power of field based analytical insights" (Patton, 2002, p. 436). He encourages researchers to record any insights they have during fieldwork to avoid losing them altogether; I followed his advice and kept notes with reflections and any questions that arose in my mind as I carried out the interviews. Merriam and Tisdell (2016) suggest that "the preferred way to analyze data in a qualitative study is to do it simultaneously with data collection" and this was indeed my intention. However, after securing SSREC approval and briefing Personal Tutors at the University and the Apprentice Support Team at the DA Provider, I realised that University students were coming to the end of their academic year and therefore graduates would be leaving the University very soon, whilst first year students were also getting ready for their summer break. This meant that I had to prioritise interviewing University students and I focused on completing all their interviews between May and early June 2021. There was less urgency to interview apprentices, as they remain on site all year round. During the months of May and June 2021, I completed a total of eighteen interviews (all twelve interviews at the University and six interviews with apprentices at the DA Provider) whilst working full time; this intense interview scheduled left no time for analysis, although I did continue to make notes to myself as I carried out the interviews.

Savin-Baden and Howell Major make it clear that there is no one single method of analysing narrative data; they define a narrative approach as "the way in which researchers conceive, capture and convey the stories and experiences of individuals" (2013, p.231). Floyd, who explored the use of narrative analysis in educational research, argues that there is "no 'right way'" to analyse narrative data (2012, p.228). One of the approaches he explores requires coding the data and organising it according to themes and this is the approach I decided to follow. Savin-Baden and Howell Major (2013, p.431) highlight the importance of doing some analysis by hand, particularly for novice researchers, encouraging them to code and analyse a few transcripts manually before using a computer, and I decided to follow their guidance. However, within a few days I found myself lost in the data and concluded that twenty-four transcripts were too many to manage manually. Adu (2019, p.66) suggests that qualitative data analysis software (QDAS) should be used when "all transcripts total 30 pages or more" and this project had generated well over two hundred pages. Davidson and Jacobs (2008) advocate the use of QDAS not just for data analysis but also for the management of the research project, and I decided to explore the different software available. I found Adu's guidance (2019) particularly helpful, as he provides a clear and detailed explanation of the steps he follows when conducting data analysis with QDA Miner Lite, a free qualitative analysis software, and decided to use it. I found QDA Miner Lite to be user-friendly and easy to use for the data coding stage; however, once I concluded the data coding and moved to the analysis phase, I found that some of the functionalities, such as making comparisons across different variables, were not available and I decided to invest in the full licence for QDA Miner.

I imported all the transcripts into the QDA Miner Lite and followed a description-focused coding strategy; this is an approach that "summarizes in a word or short phrase, most often a noun, the basic topic of a passage of qualitative data" as proposed by Saldaña, (2016, p.102). I found description-focused coding attractive because it allows the data to speak for itself, presenting what was found in the data rather than the researcher's own thoughts, and Adu (2019, p.28) suggests that this approach is particularly well suited to the analysis of narratives. I then developed a coding frame following Adu's (2019) procedure, starting with creating anchor codes linked to the research questions as this approach facilitated the organisation of the coding process. For each code, I identified an empirical indicator, a section of the data that was particularly helpful in the context of the research question as Adu (2019, p.27) recommends. I started with a small number of codes based on the research questions, and new codes emerged as I worked with the data. I then developed categories and themes, grouping codes based on common characteristics. After four rounds of coding, I merged codes that were duplicated and deleted those that appeared only in a couple of cases. The codebook can be found in Appendix F.

3.5.1 Analysis of TST responses

As I mentioned in Section 3.3.1, I found Kuhn and McPartland's (1954) approach to analysing TST responses unfruitful, and the approach I used in the pilot study (classifying responses according to the type of identity they referred to), which had worked well with a few respondents, was not so helpful for the main study and I decided to follow a classification based on McPartland, Cumming and Garretson's approach (1961). They suggest classifying TST responses according to four categories:

- Category A describes the self as a physical entity and are generally statements that describe physical characteristics (I am tall),
- Category B describes the self in terms of social roles (I am an engineer),
- Category C describes more abstract attributes that describe how someone is feeling or acting (I am confident),
- Category D deals with more abstract statements (I am working to make the world a better place).

I was attracted to this categorisation of responses to the TST because it provides a comprehensive framework to analyse the students' statements: from looking at the self as a physical person existing in a particular time and space (A), to a view of the self with regards to the social structures in which it exists (B), the self as a social actor abstracted from social structures (C) to ideas of the self removed from being a physical person, a social being or removed from social interaction (D) (McPartland, Cumming and Garretson, 1961, p.115).

I then used a word cloud generation tool (WordItOut) to analyse the different statements provided by male and female students at both institutions. Word clouds have been found to be a useful tool in educational research (McNaught and Lam, 2010) as they provide a quick visualisation of general patters in the text. To prepare the text for the word cloud tool, I created a Word document to which I copied all TST responses organised by gender. I deleted responses which were long sentences ("going to make the most of being with my family when I'm home") and left those that included only one or two words ("active", "strong minded"). Grouping together responses by gender, this provided a total of eighty-nine words from female students and fifty-seven words from males. I set the filters in WordItOut to display only words that appeared at least twice, which gave a total of thirteen words for female students and eight words for males. I then generated two word clouds, one with male and one with female responses. The word clouds are included in Section 4.3.

3.6 Ethical implications

I have to confess that my initial approach to the ethical implications of my research may have been rather transactional: I needed to secure ethical clearance, and the ethical approval processes at the University of Bath seemed to focus primarily on ensuring informed consent and confidentiality, reinforcing my belief that once ethical approval was secured, all I needed to do was to file the forms appropriately and get on with the research. As I learnt more about my choice of methodology, I realised how wrong I was. As Clandinin and Connelly (2000, p.170) point out: “Ethical matters need to be narrated over the entire narrative inquiry process. They are not dealt with once and for all, as might seem to happen, when ethical review forms are filled out and university approval is sought for our inquiries. Ethical matters shift and change as we move through an inquiry. They are never far from the heart of our inquiries no matter where we are in the inquiry process.” In qualitative research generally, and in narrative research in particular, ethical considerations are present at every stage of the research. As Plummer says: “All life story collection involves ethical troubles and no life story telling is ethically neutral” (2001, p.15). Savin-Baden and Howell Major (2013, p. 332) provide a holistic view of ethical concerns in qualitative research, outlined in Figure 4 below.

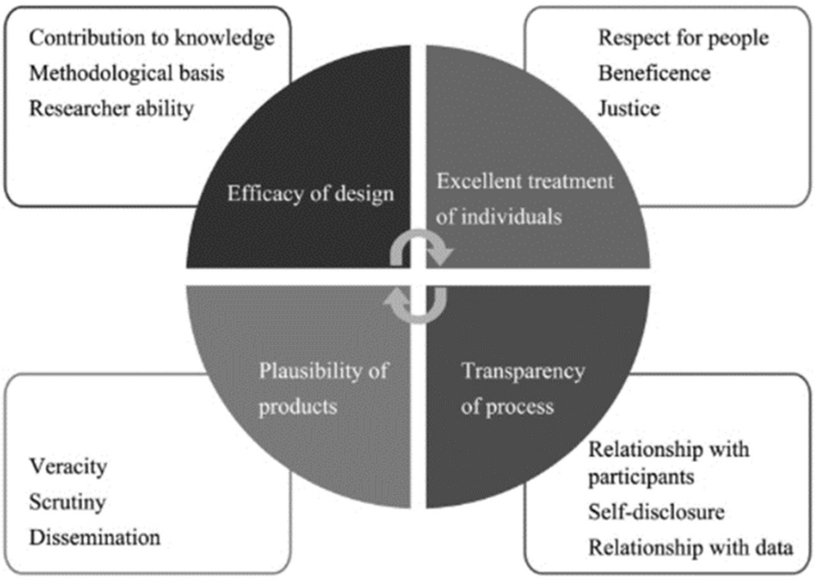


Figure 4 Ethical considerations in qualitative research.

They highlight the importance of keeping ethical considerations in mind whilst designing qualitative research, the ethical responsibility of qualitative research to contribute to the development of knowledge, the need for a sound methodological basis and the importance of the researcher's ability and qualifications to conduct the research. They go as far as to say that "knowingly lacking these while undertaking research could make the study unethical" (Savin-Baden and Howell Major, 2013, p.333). With regards to the relationship between the researcher and the researched, they talk about the need to provide "excellent treatment of individuals" (Savin-Baden and Howell Major, 2013, p.333). As my own experience as a novice researcher attests, this approach goes beyond merely meeting ethical requirements to seeking excellence in terms of respect and care towards research participants, and I endeavoured to follow their advice. Whilst ethical approval processes may be satisfied by signed consent forms, Savin-Baden and Howell Major suggest that is not enough, and that researchers must move away from the tick-box exercise of gaining consent and ensuring confidentiality to a mindset that focuses on the needs of the interviewees as the research progresses, checking and rechecking that they understand the information they are given and that their confidentiality is guaranteed, and that is indeed the approach that I followed. Savin-Baden and Howell Major (2013) propose that another important area for consideration is the transparency of the process; here the researcher's willingness to acknowledge and disclose their positionality towards the participants and also in relation to the data is important and likely to have an impact on the relationship between the researcher and the researched and hence, on the quality of the data.

An important ethical decision that the researcher needs to make in the context of the transparency of the process is whether to engage in member checking. Dwyer and emerald (2017, p.8) define member checking as "the process of going back to the participants and asking them to check the accuracy of the texts". Although there is no universal agreement among qualitative researchers as to whether member checking is always desirable, I decided to share interview transcripts with the participants in this project as I believed that it would contribute to generating trust in the relationship as well as ensuring that transcripts were an accurate reflection of the thoughts and feelings of the participants.

Savin-Baden and Howell Major (2013) see the wellbeing of the interviewees as a key consideration for researchers, an approach I wholeheartedly agree with. Whilst conducting interviews, I paid close attention to the participants and how they were feeling. In most cases, they found the chance to reflect on their past enjoyable and appreciated the opportunity to talk about their achievements, but there were a couple of instances in which participants revisited painful experiences from their early life. In these cases, I asked them if they needed additional support and signposted them to the resources available at their institutions. The following table outlines the ethical considerations I followed guided by Savin-Baden and Howell Major's model (2013, p.332)

Efficacy of design • I was aware of the needs of female and ethnic minority participants as they may feel marginalised in the engineering profession. • I am committed to contribute to knowledge development in engineering identity. • I believe my coaching training is an asset in my role as a researcher, as I am trained to be a good listener, to ask open questions and build rapport.
Excellent treatment of individuals • I made sure consent was not only given but well understood by participants. • I treated all participants with respect and conducted the interviews in a professional and timely manner. • If during an interview I was concerned about a participant's wellbeing, I signposted them to the relevant student support services. • Interview transcripts were anonymised, and I made sure anonymity was maintained when writing my findings. • All participants received a copy of the interview transcript to review.
Plausibility of products • I will make sure my research output reflects the voice of the participants. • I aim to disseminate my findings as widely as possible and have already published two papers based on the pilot study.
Transparency of process • I made sure to always explain my role as an internal researcher and answered any questions the participants had about my role and the research process.

Table 7 Ethical considerations for my research.

Another potential challenge in qualitative research is any assumptions and preconceptions the researcher may bring to the research, as no researcher can be wholly objective and detached from their own thoughts and experience. In this context I could see the value of "bracketing", "a method used by some researchers to mitigate the potential deleterious effects of unacknowledged preconceptions related to the research and thereby increase the rigor of the project" as Tufford and Newman suggest (2010, p.81). I found the practice of bracketing to be an interesting and introspective process; I set time aside to reflect on my own research questions and brainstormed any thoughts or preconceived ideas I had about them, tracing them back to their origins as far as possible. This exercise brought me closer to my data whilst highlighting how my own assumptions may affect my analysis.

3.7 Validity and reliability

The main role of validity and reliability in research is to establish its quality; validity seeks to establish if the reasoning and conclusions of the research are truthful, and reliability refers to replication and consistency of the research findings. In recent times, many scholars have discussed the need to review validity and reliability when applied to qualitative research (Atkinson, 2002; Bogdan and Taylor 1975; Goodson and Sikes, 2001) as these concepts are associated with a positivist view that can more easily be applied in quantitative research (Saunders, Lewis and Thornhill, 2016). Savin-Baden and Howell Major (2013, p.472) report on the growth of widely different approaches to validity and reliability over the last three decades, something that becomes particularly confusing for a novice researcher. As Morse et al. assert “the literature on validity has become muddled to the point of making it unrecognisable” (2002, p.4). Merriam and Tisdell (2016, p 237) suggest that “because qualitative research is based on assumptions about reality different from those of quantitative research, the standards for rigor in qualitative research necessarily differ from those of quantitative research”. Regardless of the nature of the research, research studies need to be conducted with rigour and to present coherent conclusions to its readers. As the main objective of this research is to increase understanding, the criteria for evaluating its quality are likely to differ from those applied to a quantitative project. Merriam and Tisdell (2016, p.238) suggest that the concepts of validity and reliability can be adapted to qualitative research so that, for instance, one can seek external validity by ensuring an appropriate sample that is representative of the phenomena under study. Internal validity can be interpreted as to what McAdams (2008, p 423) describes as “openness, credibility, differentiation, reconciliation, and generative integration” of the research. Tagg (1985) points out that there are few studies on the reliability of life story research, perhaps because life story research is seeking meaning and meaning is inherently subjective. Atkinson (2012, p.131) advocates that “The life story interview has its own standards of reliability and validity that are distinct from quantitative research methods.” Wolcott (1994, pp.348-354) offers a method that can help to preserve validity and reliability in this kind of research:

- ”Talk little, listen a lot”
- Record accurately
- Begin writing early
- Let readers "see" for themselves
- Report fully
- Be candid
- Seek feedback
- Try to achieve balance
- Write accurately.”

I found Wolcott’s advice particularly helpful as I explored how undergraduate students and apprentices developed their engineering identity in the life stories that they shared with me, and I sought to follow his advice at every stage of the research. To support the validity of these findings, data was obtained consistently using a semi-structured interview script that allowed students to talk freely whilst making sure that all the research questions were being addressed. As only one researcher was coding the data, I cannot provide intercoder reliability scores. However, I hope that the systematic approach followed based on well documented guidance, and the completion of four rounds of coding will provide some degree of confidence in the research findings. Although the students and apprentices who took part in this research were studying at very different institutions and for different engineering qualifications, the findings from both groups are quite consistent, providing what I hope is an accurate reflection of the topic under investigation. In terms of reliability, I hope that the careful management of the research process and the consistency of the findings across two different student populations provides assurances that, were the research to be expanded to other institutions, it would attain similar findings.

3.8 Limitations of design and trade-offs involved in methods chosen

There are a number of potential limitations to this research: the choice of identity theory as the theoretical framework may be questioned, as a different body of literature may provide different insights into the topic. The particular approach to narrative enquiry that I followed could also be called into question, as other authors advocate longer or multiple interviews with a smaller number of participants. Had this project not been limited by the time constraints of a DBA dissertation, I would have chosen a longitudinal study following the participants though the duration of their engineering education, as that would have provided much more data as to how their engineering identity develops over time, the challenges their engineering identity experience along the way and the people who play a key role in its development. White and Arzi (2005) advocate the use of longitudinal studies in educational settings and suggest returning to the research subjects at yearly intervals with a comparable interview script to reveal what change, if any, has occurred. Given the persistent lack of engineers in the UK, a longitudinal study following a cohort of undergraduate engineering students from enrolment to graduation and employment would provide valuable insights that higher education institutions may use to better support the development of an engineering identity in engineering education. Nevertheless, life story interviews have been found to be a very relevant method to study identity, particularly in the case of young adults, as Chaitin's own research with Jewish youths illustrates. She suggests that the use of life stories is advisable not only in the study of identity but also to research other complex social phenomena (Chaitin, 2004). Life stories enable us to listen to what students and apprentices have to say about their own experiences, as their individual voices would be lost in a quantitative study.

The sample for this project included engineering students at the start and the end of their engineering education, and I acknowledge that researching students and apprentices who abandoned their studies at different stages would have been valuable in order to understand the reasons that made them leave engineering education. Another potential limitation of this research is the fact that in qualitative research, the researcher is the primary instrument for data collection and analysis (Patton, 1990); as the primary researcher in this study, it was impossible to remove my own worldview from the research. Nevertheless, I trust that the practice of "bracketing" outlined earlier, has helped me to put aside my own beliefs as much as possible and to let the voice of the participants be heard. I found the fact that I am not an engineer helpful, as this enabled me to remain curious throughout the research process, whilst maintaining a helpful distance from the research subjects and the topic under study that may have been difficult to achieve had I been "one of them".

In the next chapter, I explore in detail the analysis from my research, making an extensive use of quotes from research interviews in order to let students speak for themselves, rather than providing my interpretation of what they said.

CHAPTER 4 DATA ANALYSIS AND FINDINGS

In this chapter, I outline the analysis of the interview data and findings from the Twenty Statement Test from both the initial pilot and from the main study. I share participants' views on what they think engineering is, the experiences that support or challenge the development of their engineering identity and the people who play a role in supporting or challenging the development of that identity. I also report on the identities students and apprentices claim for themselves and how they envision their future. The chapter includes some findings grouped by year of study, gender and ethnicity and a large number of interview quotes.

4.1 Introduction

The interviews that, together with TST responses, provide the data for this research project took place between March and July 2021 and included twelve students enrolled on an engineering degree at University and twelve apprentices enrolled on an engineering degree apprenticeship at a DA Provider. Data from an earlier pilot study undertaken with four students at the DA Provider was not included in the main research project but key findings from the pilot are reported in this chapter. The purpose of this research was to learn how engineering students and degree apprentices who have chosen different paths to becoming an engineer, develop an engineering identity during their studies. Whilst some comparisons between the two qualifications emerge from this research, the main focus is on the students' and apprentices' experience with regards to the development of their engineering identity rather than on making comparisons between the two degrees. In both institutions, the interviews included three male students/apprentices and three female students/apprentices in their first year, and three male and three female students/apprentices in their final year. All the participants selected for the study were British and six belonged to ethnic minorities. Two male students self-identified as gay although this was not a question I asked. Whilst the choices the participants made to go to university or to enrol on a degree apprenticeship were obviously different, participant profiles at both institutions were remarkably similar: most of the students and apprentices had a good experience in their schooling and achieved high grades, the majority had parents who were educated to degree level and, even when that was not the case, their parents had supported them throughout their education, often helping with homework. The majority of students and apprentices, although not all, had exposure to some engineering experiences through their schooling, but the level of exposure and range of activities varied widely. This section explores how the findings from this research may provide answers to the research questions outlined in Section 1.9.

4.2 Findings from the pilot study

Between 29th January 2021 and 10th February 2021, I conducted a pilot study with four students at the DA Provider: one male and one female in their first year and one male and one female in their final year. Data from the pilot study includes interview transcripts and responses to the Twenty Identity Test (TST). Three of the four apprentices identified themselves with engineering whilst one female apprentice in her fourth year did not. The apprentices with a strong engineering identity already had it at the time of starting their engineering education, whilst the fourth apprentice, who started her engineering education unsure about her future in engineering, remained unsure as she approached graduation. The three apprentices who identified themselves with engineering had different socioeconomic backgrounds, came from different parts of the country and had different interests. However, their stories had something in common: all three had built a trusted relationship with an adult during their schooling (a design and technology teacher, a physics teacher, and a scholarship mentor) who had encouraged them to consider a career in engineering before the students themselves had thought about it. A first-year apprentice 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."

A first-year apprentice said that it was a teacher who supported his emerging engineering identity: *“My D&T teacher… I spent an immense amount of time with him… and I started getting recognized within the classroom as the D&T guy that everybody came to for advice or … how to operate something, design ideas, checking people's work, and I felt ‘I'm actually good at this’”.*

A final year apprentice 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”.*

These adults encouraged the students to go beyond their boundaries, which resulted in all three having more or less formal teaching roles with their peers and in one particular case, older students at another college. Helping others to learn seems to have had a validating effect on the students’ identity; as more opportunities to test their identity came up, a positive feedback loop was established that led to greater trust and commitment to their engineering identity. By contrast, the female student with low identification with engineering would not define herself as an engineer despite being close to graduation; instead, she said: *“I know I can do engineering and I can be an engineer … it's just not necessarily where I see myself going 100%”.*

Three apprentices provided *“I am an engineer”* as one of their top four responses in the TST, even though two of them were only in the first year of their engineering studies, whilst the final year apprentice who did not identify herself with engineering wrote: *“I am an engineer by education”*. She was also the only apprentice to mention gender in her TST response *(“I am a woman”).*

4.3 Findings from the TST

In the main study, all participants completed the TST although not everyone provided twenty answers. The identities more often mentioned by students and apprentices were engineer, friend, family member, and student. Other identities mentioned by only one or two students included: animal lover, scout/guide, Christian, sportsman/woman, musician, British, gay, and apprentice.

Eight female and three male participants identified as engineers in their TST responses, whilst one male apprentice said: *"I am working to become an engineer".* Six participants defined themselves as "students", with two University students being more specific: "I am an engineering student" and "I am doing an engineering degree".

Being a family member was an identity mentioned by eleven participants, nearly twice as many females than males (seven vs. four). Eight female participants mentioned their gender in their responses by saying "I am a woman" or "I am a girl", and more second year female students did so. Two male participants responded: *"I am a male"* or *"I am a guy",* one in his first year and one in his final year.

The following word clouds show the words female and male participants used to describe themselves in the TST (both institutions, first and final year students and apprentices).

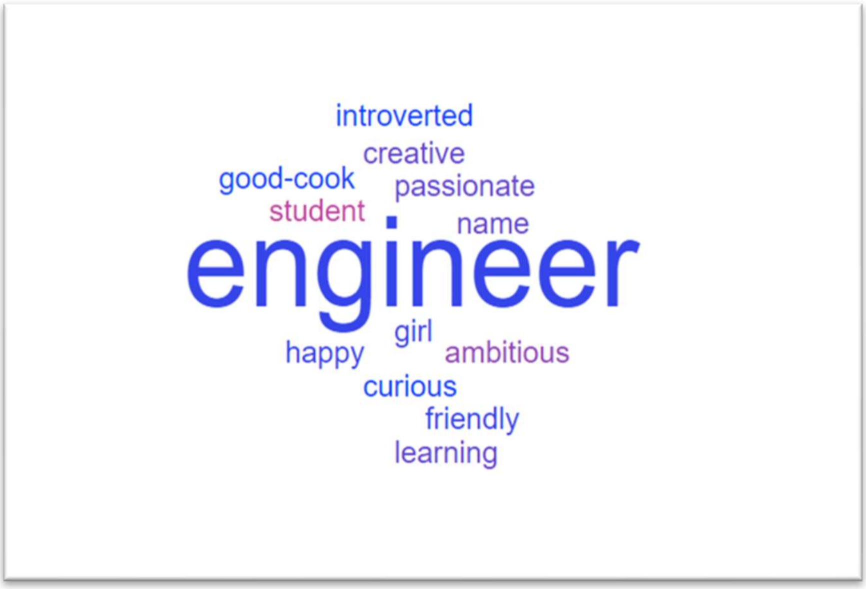


Figure 5 Word cloud showing female participants' descriptions.

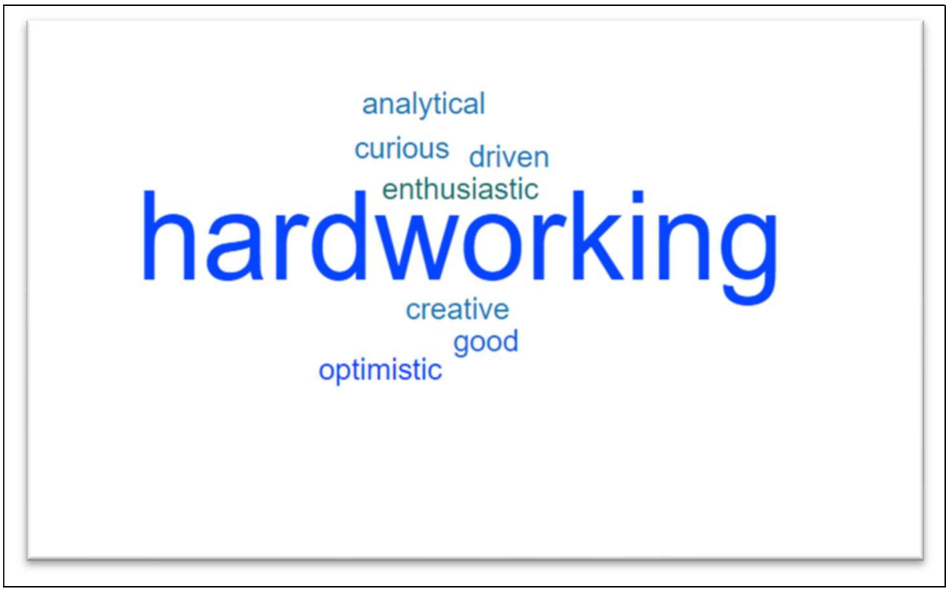


Figure 6 Word cloud showing male participants' descriptions.

The table below shows the identities more often reported by participants in the TST according to their gender, year of study and institution.

DA Provider – year one students							University – year one students						
		Gender	Friend	Family	Engineer	Student			Gender	Friend	Family	Engineer	Student
female	A		✓	✓	✓	✓	female	M	✓			✓	
	B							N		✓			✓
	C	✓		✓	✓			O	✓		✓		Eng. student
male	D						male	P					
	E							Q		✓			
	F				Working to become an Eng.	✓		R	✓		✓		Doing an Eng. degree

DA Provider - final year students							University - final year students						
		Gender	Friend	Family	Engineer	Student			Gender	Friend	Family	Engineer	Student
female	G						female	V	✓		✓	✓	
	H	✓		✓	✓			W	✓		✓	✓	
	I	✓		✓	✓			X	✓	✓		✓	
male	J	✓					male	S			✓	✓	✓
	K		✓	✓	✓			T					
	L			✓				U					

Table 8 Identities more often claimed by respondents in the TST.

Having coded participants' responses according to the procedure developed by McPartland (1965) and outlined in the previous chapter (Section 3.5.1), I found that the majority of the statements they provided fell into Category C, i.e., statements that describe moods, feelings, preferences, likes and dislikes. Examples of Category C statements provided by participants in this research include*: "creative", "passionate", "clever", "an introvert", "easy to work with in a team", "able to stay calm under pressure"* and "*very sociable and friendly"*. Female students provided twice as many Category A responses than their male classmates; examples include: *"a girl", "a 22 year old woman", "twenty three", "five foot six on a good day."* Female participants also provided more Category B responses than their male classmates, describing themselves more often in social roles than male participants. Examples of Category B statements include: *"a sister", "one of four children", "a family person", "an engineering student"* or *"a Christian"*. Only sixteen responses fell under Category D, with ten provided by male and six female participants. Examples of Category D statements include: *"I am going to change the world"* and *"I am merely a drop in the flow of time"*.

Figures 7 and 8 provide a graphic representation of participant responses grouped by category, institution, gender and year of study (where “U” stands for university and “DA” for DA Provider)

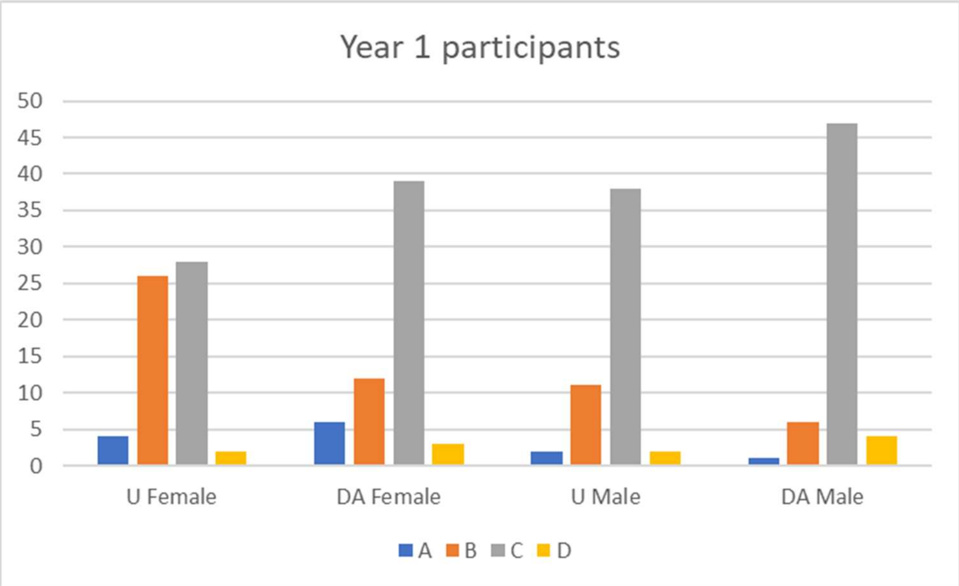


Figure 7 Type of responses from first year participants.

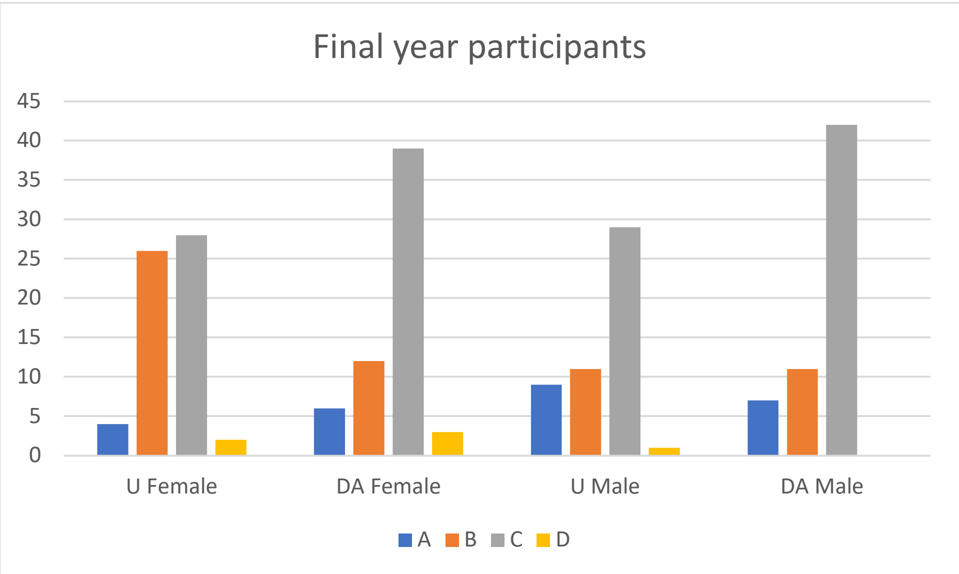


Figure 8 Type of responses from final year participants.

4.4 How do students and apprentices define engineering?

It is often said that one of the challenges of attracting recruits to the profession is that engineering is a difficult occupation to define, as it encompasses so many different activities and areas of specialism, a view shared by many of the students and apprentices interviewed for this research, as a first year apprentice, Apprentice F, said:

"…when you think about engineering in some ways, it's almost so broad and so multifaceted that it's hard to imagine any one thing. If you had asked me about maybe a year or two ago what engineering really, really was, I always thought of it as a very sort of hands-on thing."

Even final year students reported some degree of confusion: *"I guess even now, engineering is just so vague, and it covers such a wide variety of subjects that there are so many different types of engineers."* The fact that many students and apprentices had no exposure to engineering subjects during their schooling came up often during interviews, as several of them reported learning about engineering for the first time when they attended university open days, as was the case for Student T:

"I think that an additional challenge is that a lot of people have not had any exposure to engineering at school. I know some schools have things like D&T or other subjects that are more engineering led but if you've never had that, and if you don't have it at home, you don't really find out until you start (your degree)".

Ten participants had a parent who studied or worked in engineering and the majority of them chose to study a traditional engineering degree at the University. However, for those students who did not have an engineer in the family, lack of engineering role models was felt to be an issue. A small number of participants reported having to overcome a perception prevalent at their school that engineering was a lesser discipline when compared to maths or physics, as Apprentice F explained:

"…there was always …a perception at my school... that almost engineering was lesser in some way to physics … so maths is the most pure and then sort of physics is sort of second and then engineering they just kind of make it up as they go along kind of thing … I think somehow, I managed to internalize that quite a bit, and that almost dissuaded me from going into engineering."

Asked about what they understood by engineering, participants' responses focused primarily around three areas: solving problems, creating and improving things, and having a positive impact in society. Asked to define engineering, a first-year apprentice (Apprentice A) said: *"I would say engineering is taking the tools we have, such as maths, physics, etc. and using them to solve a problem."* Student M explained: *"…I would probably say it's the creation of new things. Things that you didn't know you needed until they've been made or, yeah, designing and building and innovating…"*; Student V, a final year student at the University, added: *"I'd say it was developing ideas, new techniques, new approaches that better technology to progress society."*

4.4.1 Traits participants associate with engineers

This section outlines participants' perceptions of engineers and the traits they associate with them. Although the interview script did not include any questions about engineering stereotypes, many participants shared their views and experiences of dealing with stereotypical engineers and these are included in the next section.

Every student/apprentice interviewed without exception had a positive view of engineers and attributed a plethora of positive traits to them. They described engineers as being creative, curious, analytical, persistent problem solvers and team players. Apprentice C went as far as to say *"… they are pretty nice people, mostly, I've not really met an engineer I don't like."* Nine participants associated problem solving with being an engineer; Apprentice C put it very succinctly: *"engineers are all about solving problems."*

Curiosity and creativity were the next traits participants used to describe engineers; Student N said: *"I think people underestimate how important creativity is in engineering because a lot of people think it's just maths, physics, kind of very academic, but … you* *are essentially coming up with new things the entire time …".* Her classmate, Student O, agreed: *"I'd say engineers are creative, which is something, as a STEM subject, creativity is not necessarily something you would expect."* Apprentice H added: *"I think somebody who's naturally curious and inquisitive and happy to challenge is a good engineer."*

Eight participants described engineers as being team players and talked about the importance of teamwork in engineering. Student P had a firm view: *"I think one of the most important things would be to be able to work in a team well because it's very rare that one engineer will be doing something alone and it's always as part of a team…"* Apprentice I concurred: *"you don't often see engineers who succeed by themselves, there's always a team of people supporting them."*

4.4.2 Stereotypes about engineers

Whilst all the students and apprentices interviewed had an overwhelmingly positive perception of engineers, the traditional stereotype of what engineers are like seemed to be very much alive in the minds of students and apprentices, particularly among females. Twelve participants spoke at length about the stereotypical engineer and eight of them were female. They described engineers as being *"quiet, reserved and less social"* (Apprentice B) and having *"a personality that's more like quiet, like the shy type"* (Student R). Apprentice I explained: *"I think the stereotypical engineer is quiet and sits at his desk all day and isn't very sociable and likes to do maths and, I don't know, in their spare time they also do engineering."* She added: *"When you think of an engineer, you typically think of a nerdy, white male typing away at some computer programming."* Only one male participant disagreed, if not very strongly: *"a stereotype is that the profession tends to attract more introverts and analytical people but I don't think that's always true"* (Apprentice L). Apprentice C confirmed the perception held by several female students across both institutions that *"there's still a sense that it's a job with male dominance and older, I guess because you have to be quite experienced to be an engineer."* In her first two workplace rotations her team members were all older men, and she was left wondering *"where are the girls? Where are the people my age?"* She expressed frustration because as a woman *"no one really expects you to be an engineer"* as she shared the story of her grandfather giving her a tool belt and saying to her *"maybe one of the boys can fix your car for you."* Her response was *"I'm an engineer! I can do it myself!"*

Several female participants spoke about the challenges of working with the stereotypical male, white and older engineers; after saying that working with those stereotypical engineers was easy, Apprentice I corrected herself: *"well, not always easy, still OK to get on with."* Student W shared the experience of one of her friends who, for her placement year, *"worked in an office full of those sorts of people and she did not enjoy it because, yeah, it just wasn't really nice for her"*. There seems to be a stereotype of *"the engineering boy"* too, as Student N explained: *"They are all into F1. They all have already like taken apart fifty engines, put them back together and yeah, they all have like A* math, physics, all this stuff"*.

An Asian University student talked in a similar way about his experience in the Zero Emissions Motorcycle Team: *"… the people working there are very passionate about all these mechanical things, batteries and what not. And you know, when I am there, that's kind of all they talk about and for me, that's sort of a definition of a typical engineer. They seem to just know everything about how to fix things, just everything you think is engineering, you know, like thermodynamics, mechanics, all these things…"*

A first year apprentice (Apprentice F), who self-identified as gay, reflected that while he was white and male and therefore fitted the stereotype, as an openly gay man he had *"a little bit of insight of what it means to be sort of in a minority... in engineering… it's definitely something that weights on my mind…"* Student W talked about comparing herself against the stereotype and not seeing herself reflected on it: *"the sort of stereotypical engineer is someone who specializes in one thing, older man specializing in one part … and they're really good at it and I just can't see myself falling into that category."* The old stereotype of engineers as being male, white, older, heterosexual, quiet and techy seems to be very much alive today in the minds of engineering students/apprentices at both institutions.

4.5 Participants' person identities

This section explores the traits participants attributed to themselves, as they can provide insights into how they perceive their own person identities and how those may relate to engineering traits. Many participants described themselves as practical learners who enjoyed the experiential activities their early schooling afforded them. They saw themselves as being smart as well as being good, hard-working students. Having many interests and talents was also a trait reported by participants. They talked at length about the importance of being confident and the challenges posed by lack of confidence.

4.5.1 Practical learners

Being a practical learner was the trait reported by the highest number of participants, thirteen out of twenty-four. They talked about enjoying their experience in primary school when learning was less formal and *"more experimental stuff, they were kind of teaching us for fun"* (Student N). They often described themselves as *"practical learners"* and talked about their preference for school experiences that enabled them to learn by doing and by solving problems rather than more traditional teaching styles, as Apprentice G explained: *"I guess my learning has always been more like hands on, like practice… I learn so much better like through problems and just practice"*. Participants recalled particular teachers who encouraged them to *"get stuck in"* and experience the world of science and became animated as they remembered some of the school projects and competitions they were involved with and what they were able to create.

Student Q shared an early memory:*"…I remember when I was in primary school, they used to have these kind of egg competitions and I used to love entering every year, but every time I entered, I'd want to make something move and I remember making like a lift with eggs inside and things like that. I think that was what really kind of interested me."*

4.5.2 Being smart/being a good student

Academic ability demonstrated by being in the top set at school, being part of a "gifted and talented" group or winning scholarships and securing places at selective schools was reported to be an important trait by eleven out of twenty-four respondents. Apprentice L said: *"I've always kind of held myself as … an exceptionally bright individual"*; he shared the story of accompanying his mother to take the MENSA test when he was eleven years old – his mother failed the test, but he was offered membership. Participants often described themselves as *"as quite smart"* and *"pretty capable",* whilst Apprentice I said about herself *"I actually have quite a smart brain in there".*

Two apprentices acknowledged that all their classmates were smart: "*I think we are quite sort of accomplished"* (Apprentice F), *"we were all the smartest at our schools, basically"* (Apprentice G). However, being smart was not a blessing for everyone; Student V had a difficult experience at school, as she *"was kind of picked on for being clever."*

Ten participants described themselves as being good students and eight of them also described themselves as being smart. Apprentice L explained what this meant to him: *"I enjoyed doing well at school and being good; there were other children who weren't very good … I took a lot of pride in… being a good student."* He went on to explain how doing well at school became such an important part of his identity that *"I relied even more on academic success… to measure my own self-worth."* Apprentice H explained how she enjoyed maths and physics more than other subjects *"because I can get good grades and that was a real ambition of mine"*. For these participants, achieving good grades became the driving force during their schooling, something that gave them recognition from peers and teachers; Apprentice I openly admitted: *"I liked to get on the teacher's good side…"* Student U reflected on how students are more likely to persevere at subjects they are good at: *"being good at something always encourages you to keep at it."* Whilst Apprentice K felt that *"you get pushed harder maybe a little bit more, if you come from an immigrant background or especially like Indian Asian culture."* Apprentice L explained to what extent doing well at school became part of his identity:

"I became reliant on doing well … because I didn't feel like I had much else and that was increased a bit more when I went to secondary school because I went to a school that was very sporty (I was not) … so I relied even more on academic success … to measure my own self-worth."

More than half of the participants who reported being a good student as an important trait acknowledged the role their families played in their early academic success; they shared stories of mothers who provided extra maths tuition so that their sons or daughters were always ahead of the content delivered at primary school, of summers spent doing revision and getting ready for the next academic year or doing Kumon from an early age.

4.5.3 Being hard-working

Seven participants described themselves as being hard working; by this they understood committing the time and effort needed to consistently achieve high grades during their schooling. Apprentice L said: *"I had the work ethic to try hard at everything to get the grades."* His classmate, Apprentice H also described herself as *"academically really hard working"* and talked about working hard at school to achieve high grades. Apprentice D expressed his view that *"hard work pays off"* whilst Student N felt that her experience of doing the International Baccalaureate had been good training for university, as she was *"quite used to high workloads."*

Several respondents talked about the struggles of maintaining the hard work ethic that had served them well at school as they moved to study at a higher level in a new environment. Reflecting on the start of her degree apprenticeship, Apprentice H commented on the challenges of wanting to do well on all fronts:

"I was working really hard in the team, working really hard at uni and not really taking time for myself … and you are in a new place, and you want to do really well socially and make new friends so you just kind of have it all going at once."

Student Q shared a similar experience: *"at first the workload seemed quite a lot so, you know, in the first semester I was working as much as I was kind of at the peak of my A level revision, but this was prolonged for the whole first semester… I like to do every bit of work that you get and there was a point when I realised that people don't do every bit of work that you get. That's why they've got so much free time! I was so confused!."*

4.5.4 Being an all-rounder

The idea of having many interests and being good at multiple subjects was expressed by eleven of the respondents, who saw it as a positive trait. Apprentice C said she "felt like quite an all-rounder." Participants reported that being good at many different academic subjects, and having many interests, made making choices difficult for them. Apprentice E explained the challenge:

"I really liked chemistry at school and physics… but I can't really make my mind up because I also like biology and maths and I just didn't know which one to do… so I was applying for natural sciences because … you do a bit of everything at the same time."

More than a third of participants who defined themselves as being all-rounders came from ethnic minority groups.

4.5.5 Being confident/lacking confidence

Research participants who felt confident in their own abilities felt able to deal with the demands of their course and conveyed a sense of feeling at ease in their environment. Nine participants, all of them white (four females and five males), expressed a sense of confidence in themselves and in what they were doing. Apprentice F said that he *"felt quite confident coming here … I'm quite a confident person."* His classmate, Apprentice D, added *"I think it's quite important to be able to …be confident in the stuff you don't know just as much as the kind of things you do know."* Several participants talked about how their confidence developed whilst at school, and the kinds of events that supported it; Student Q shared his experience of winning a national student competition in Year 12. Attracted by the £5,000 price money, he spent a whole night working on his poster and three weeks later received an email notifying him that he had won the competition, which lead to interviews with BBC Breakfast Television and other interesting opportunities. He explained the impact that experience had on him:

"…that competition really kind of boosted my confidence about my ability because, being in a maths school, it was quite selective and I felt like I was kind of, you know, lower third quintile, so to win something like that made me think that maybe I'm OK."

Apprentice I explained how her experience as a senior prefect at school had helped her to develop her confidence. For Apprentice D, being selected for an Arkwright Scholarship opened the door to multiple opportunities to learn more about engineering, develop useful skills and differentiate himself from his classmates "I was able to do stuff that set me apart from some of the other people in my Sixth Form." For student V, her placement year played a key role in developing her confidence in her own abilities as her work was recognised by her colleagues: *"I mean you get a lot of confidence over a year going – actually, I do know what I'm doing!"* However, school was not a confidence booster for all students; Apprentice G came out of a highly selective and competitive maths school with *"…very low self-confidence and self-worth"* and *"…a bit of an inferiority complex."*

Participants who had been confident at school talked about a lack of confidence in their abilities as they struggled to cope with some of the academic work in higher education. Six participants reported experiencing lack of confidence: four were female and two were male; one of the male students was gay and the other was Asian. The transition from school to university seemed to pose a challenge to the participants' self-confidence; two students in their first year at University, both with excellent academic records, talked about the challenges of studying at a higher level: *"…since coming to uni, when I thought I was good at math or science, it turns out … it's not really a talent at all and it's like everyone's at that level now"* (Student P). Student M described her struggles with her course: *"I look at the question then I just think I have no idea what I'm doing here. And I might look back at the notes and still think what is going on here?"* For those students and apprentices who lacked confidence, the difficulties they experience together with their perception that other students are brighter than they are, can lead them to question their own abilities:

"I… was quite a high achiever for most of like my education... I've just gotten things like snap instantly and so then, when I started it was actually like I was struggling with stuff, it sort of made me like question my abilities" (Student O), or to question their choice to study engineering, as Student M explains:

"Sometimes, when the lecturer is talking about something and someone puts their hand up and asks like a really, really, intelligent question, I literally have no clue what they're talking about at that point …Those are moments when I feel like I'm not suited to this kind of thing… I'm unsure whether I am suited to this uni, to this course."

Several female participants at both institutions commented that only male students asked questions in class, even when classes were conducted online during the Covid-19 pandemic. A final year apprentice (Apprentice G) explained her reluctance to speak up during her first year as *"I didn't want to say anything to come across as stupid or feel like less worthy."* Several apprentices felt their confidence was challenged by their workplace experience, as they joined real engineering teams at an engineering company from the start of their degree apprenticeship. Reflecting on his experience, Apprentice J said: *"the biggest challenge has been being confident to be able to go oh yeah, I have something to say, here you go." A* first-year apprentice who is deaf (Apprentice C), described her challenges:

"I think it made me more quiet for sure… as an apprentice, it's hard to tell like to what extent it's because I'm a female or to what extent it's because I'm an apprentice who doesn't know anything, or because I am quiet or because I'm deaf and can't hear through the masks. So, it's quite hard to tell, you know, which thing it is that's making me maybe miss out on something or not feel I fit in".

4.6 Experiences that support or challenge participants' engineering identity

This section reports participants' responses with regards to those experiences that support or challenge the development of their engineering identity, with a particular focus on experiences they had during their schooling as well as workplace experiences during their university or apprenticeship degrees. This section includes experiences that made students and apprentices feel recognised and their identities validated as they achieved a goal and gained recognition from others and by contrast, experiences that challenged them when they failed to reach a goal and their identities were not validated.

4.6.1 Experiences that validate participants' identities

Participants' identities are validated when they achieve their goals and are recognised for their achievements. Thirteen participants shared experiences of tackling a challenge, doing well at it, and gaining external recognition for it. Achieving consistently good grades at school, taking GCSE exams early, securing scholarships, winning student competitions, getting positive feedback from the workplace, securing a job offer, or being trusted by colleagues in the workplace are examples of activities through which students and apprentices gained recognition from their seniors and peers and achieved identity validation which, in turn, gave them encouragement to tackle other challenges and increase their confidence. Apprentice L talked proudly about “doing my GCSEs early …a lot earlier than everyone else in my school”. He also secured a scholarship for secondary school and gained MENSA membership. Apprentice D explained what securing an Arkwright scholarship meant to him at a point in time when he was unsure about pursuing an engineering education: “I don’t think I was 100% certain on saying I’m going into engineering, but the fact that someone else said you could do this… I thought actually, this is an opportunity that I can’t really turn down”. Student Q described how winning a national competition boosted his self-confidence whilst studying at a highly selective and competitive maths school. Student V’s confidence increased during her placement year, when she secured the respect of senior colleagues by coming up with an idea that solved a difficult problem.

4.6.2 Prior engineering experiences

By engineering experiences, I understand any contact with engineering organisations, engineers or any courses and activities with an engineering theme that students and apprentices were exposed to prior to enrolling on their engineering studies. Nineteen out of twenty-four participants reported having had some engineering experience, with the range of experiences varying widely. Schools were by far the biggest providers of engineering experiences; for the majority of students who reported multiple engineering experiences, most of those experiences had been provided by their schools. The range of experiences was quite broad: from formal courses such as D&T and Engineering, to different school projects, work experience, collaboration with local companies, company visits, national competitions, Arkwright Scholarships, F1 in Schools, engineering challenges, hackathons, STEM outreach, robotics competitions, masterclasses, Crest Awards, science clubs, collaborations with universities and engineering talks were mentioned. Family members were best able to help participants secure summer work placements and company visits.

Three University students attended Headstart courses, a week-long residential course providing an introduction to studying engineering at university, but this is not something that was available to all students, as Apprentice B said: *"… anything like going to Uni summer schools … you have to pay to do them and they just cost too much money so I didn't do it."* She expressed her frustration at hearing about the opportunities her degree apprenticeship classmates (particularly those who attended grammar or private schools) had, given that her own school didn't have much to offer. She was particularly jealous to hear about a robotics club *"I would have loved to do that when I was younger".* She tried to set up an engineering club at her school but failed; looking back she reflected that she probably could have found something in the local community *"but it's just harder to find, it's not like having that easy access within your own school".*

Seven participants studied D&T and all but one were committed to a future in engineering. Two of those respondents had also completed an engineering A level, an option that was not available to the majority of participants in this study. Apprentice C was upset when she found that her school was discontinuing the D&T course: *"it's really sad because my school actually stopped D&T and I was like no! lots of people signed petitions and stuff, but it's just the funding; it's awful."* D&T teachers were also reported to be the most influential by several students in this research (I explore their role in Section 4.7.1).

4.6.3 Workplace experience

Participants' exposure to the workplace is very different in the two programmes under study; at the University, students can choose to do a year-long placement on completion of their second academic year. All final year university students interviewed for this research had completed a placement. Fifteen participants in total talked about their workplace experience. At the time the interviews were conducted, it was too soon for first year university students to have secured a placement, although all of them intended to do one. Every final year student at the University talked positively about their placement experience, with three of them returning to the same company as graduates; two students secured graduate jobs in different companies within the same sector, and one moved into an altogether different field. While the year in industry had a positive impact on every student, it impacted them in different ways; for Student V the year in industry was key, as it helped her to develop her confidence:

"I remember one of the parts that I was working on with another guy who was like my mentor and really struggling to come up with an idea that would work, that meant that you could package all the bits together, actually be able to assemble it. I came up with an idea and they were like, oh my God, that's such a good idea! Yeah, it's pretty rewarding and I could feel quite smug."

For Student U, his placement experience helped him rekindle his interest in engineering *"after doing placement and seeing how different aspects of engineering can be applied, I felt really good about …studying engineering."* For Student T, whose focus during his first two years at university had been eminently academic, being exposed to a wider range of engineers and engineering experiences led him to appreciate the value of extra-curricular activities as a way of gaining a broader range of skills. Returning to university for his final year (he graduated with a BEng rather than an MEng) he made a concerted effort to get involved in extracurricular activities such as Formula Student. For Student S, who had a placement in a Formula One company, his experience confirmed his initial idea that he wanted a career in automotive so, returning to university for his final two years, he chose modules and projects that contributed to his specialisation and that later enabled him to get his dream graduate job in a Formula One team. For Students S, T and V, the year in industry was a milestone in their development as engineers that confirmed where their interests laid and what they wanted to do professionally. Student W felt very happy about her placement experience *"I think deciding to do a placement year I considered like one of the best decisions I've ever made and I have no regrets about doing, would do it one hundred times over"* but felt her placement role, to which she was going back as a graduate, was *"not super engineering … it's not really what we've learned at uni."* Student X defined her placement role along similar lines *"I wouldn't say (it is) like strictly engineering."*

As part of their degree apprenticeship, apprentices work for an engineering company three days per week. They join engineering teams from year one and change teams three times per year in their first two academic years. Once they chose an area of specialism in their third year, they remain in their teams until the end of their studies. Some apprentices were surprised by the level of responsibility they were given in the workplace; when Apprentice B's mother asked her if she spent her time making photocopies and coffee for her colleagues, her answer was: "*I do have a job here, basically I actually do engineering* *stuff."* Apprentice E shared the same feelings, and an anecdote of his early days in the workplace:

"It was different to how I expected, the responsibility that we were given was kind of surprising to me … one of my first days, I asked my line manager: can I go get a coffee? And he just looked at me like I was crazy! … I was just so used to being at school and like having to have permission to leave and stuff like that. I think that was … a moment where it kind of clicked and you realized I'm actually working, I'm part of the company, I'm not just here to observe."

His classmate, Apprentice A, commented on how much she enjoyed the workplace: *"I really enjoy the work … going to work and doing something that you know is real and like you can use in a job and is a job. It is really rewarding."* The workplace seemed to be students' favourite element of the degree apprenticeship, as Apprentice F explained: *"I think a lot of us would rather work five days a week… Work has always been the most enjoyable aspect here and surprisingly, the least stressful."*

Remembering her arrival at the engineering company, a final year apprentice recalled feeling overwhelmed by the technology she was exposed to: *"…I remember thinking … I don't know how to use any of this and I don't really know what a lot of it does because I've not had this exposure like, the company have basically state of the art of everything and if you've not kind of experienced that before it could be quite overwhelming."*

A female apprentice in her final year shared an uncomfortable experience that had taken place a couple of years earlier *"I was working on project X at the time and there was like a couple people who would just be quite weird at times like messaging me, being unprofessional and I dealt with that in the way that was appropriate at the time."* Working on a different project later, she felt her colleagues were focusing too much on her looks rather than on her capability, *"commenting on things that really should not be relevant in the workplace".* This became a very challenging time for her; however, she was relieved to find support from a senior colleague which resulted in the development of a training course on respect at work for the whole organisation.

Apprentice K talked about one of the highlights of his degree apprenticeship, when he was told that some work he had completed for an earlier team, had contributed to changes to a real product *"That's really cool, is knowing that like a bit of work that I did actually changed something."*

4.6.4 Facilitating other people's learning

Ten participants reported experiences of facilitating other people's learning during their schooling and eight of them were female. These experiences ranged from engaging with formal mentoring programmes organised by their school to seeking more informal opportunities to support friends or classmates, often with maths. Supporting classmates with their learning can be one of the ways in which students' and apprentices' identities are validated, as they gain recognition for their expertise from their peers and feel good about themselves. Apprentice L explained: *"I really like explaining things to people, trying to make it clear and helping them to learn"*. In some cases, these experiences were part of formal programmes put in place by their schools as was the case for Student V, who had Wednesday afternoons off to tutor middle school students at risk of failing maths, and Apprentice A, who helped run a Saturday Robotics group at a primary school. Student N started tutoring at school and then continued to do it for herself as a way of generating some income. For other participants, supporting people with their learning happened more informally; Apprentice I remembered: *"…maths lessons came quite easily to me so I would often be helping other people work through problems … prepare for exams"*.

Apprentice D talked about finishing his D&T project ahead of the deadline and being able to *"help around the workshop and kind of be a point of information or knowledge or help to people who might need it and that was really encouraging because I was able to do something that someone else was able to benefit from."*

Apprentice G talked about supporting classmates and friends in a more informal way*: "I had taken a role in the class where I was helping …the person or the two people sitting next to me …with their math… it was a very unofficial role."* Student W enjoyed the challenge of helping *"someone understand something."* However, not a single participant reported experiences of helping others to learn in higher education.

4.6.5 Fitting in – or not.

Respondents at both institutions shared experiences that made them feel that they fitted in their environment. Apprentice L talked about a moment at the start of his degree apprenticeship when he *"felt really … respected and cared for and part of the group."* Apprentice C said one of the highlights of her degree apprenticeship so far had been *"starting to feel like fitting into the workplace"* and added:

"…the team is really nice and you get to go out for lunch every day with the team and you get to the team's social and all that and it's starting to feel like, you know, if I did this for the rest of my life, I'd be very happy."

Apprentice B also felt that feeling integrated in her workplace team was a highlight of her experience so far: *"I've come such a long way since when I started in terms of confidence and in terms of feeling like I belong in a team. I think that's been particularly difficult at the start... but yeah, just being integrated into that team environment with lots of different ages and genders."*

Student V talked about feeling integrated into university life by getting involved in many extracurricular activities, although she acknowledged that finding time for such activities was a challenge. Student O spoke about the importance of having a good support system at university: *"I feel very lucky that I have been able to quickly and sort of easily build a support system at uni and I think for me like … having people around me that make me feel comfortable and safe and I'm really lucky that I've been able to find those people at uni … the uni overall … feels really supportive."*

Eleven participants shared experiences of feeling they didn't fit in at some point in their education, whether during their school life, at University or at the DA Provider. The majority of those participants were female, and the three male participants included an ethnic minority male and two white males who had self-identified as gay. Female students shared experiences of feeling *"alienated"* in maths lessons at school, being outnumbered by boys who didn't always behave well in class and missed having friends around. A gay male talked about his challenges at school as he *"found it very difficult to make social* *connections"* which left him *"quite closed off so socially isolated."* Some of those difficulties continued in higher education; Apprentice F acknowledged feeling the need to change how he dressed in an effort to blend in more: *"sometimes I do take my nail polish off and just wear less colourful clothes in the hope of blending."* A female ethnic minority student, Apprentice G, shared a similar experience:

*"I became self-conscious because I was like, I don't look like most of the people around me, like I'm not a man …I'm a girl …I don't look like all the other girls around me … I felt very out of place because aside from like myself and (another girl) were the only non-white girls in our course and so … it made me more self- conscious." F*or Apprentice H, the issue was *"having to deal with comments on your dress, … I was like I don't know how many of the boys experienced this. I just felt like a bit of a victim."*

4.6.6 Gender imbalance

Gender imbalance is another area that was not covered by the interview script but was discussed by twelve participants, eight of whom were female. In the context of this research, I understand gender imbalance to refer to the low percentage of females present in STEM education, both at school and in engineering degrees and degree apprenticeships. Female participants explained how having chosen male-dominated subjects, they became used to being in the minority at school: *"I was the only girl in it because I took mechanics and girls didn't do mechanics"* (Student W). Talking about her experience in Sixth Form, Student O said, *"there were loads of boys in my classes and they were all rowdy and obnoxious and confident and stuff."* Her experience of gender imbalance made her reconsider her choices, but she decided to stay:

"… I would rather put myself out of my comfort zone and be in a class with the people who are very different to me but know that I enjoy it and because I enjoy it, I'll do well rather than maybe doing a subject that I might walk into a classroom and see more people that look like me but I wouldn't enjoy being there."

At university, Student W had an uncomfortable experience that she struggled to explain:

"I am generally very comfortable with it, like it doesn't, it doesn't really bother me in that sense, but I think there are situations where I can recognize that other people would not necessarily be comfortable in that situation like last year we did group design and business projects like a whole semester, and I think they tried to put like two girls in groups together, but I was the only girl in my group and I don't actually know any other groups where there was only one girl so I think it was just how it worked out and my group had a lot of like, it was quite intense at times with the guys being guys and I can deal with that thing quite well, I think I I'm very pretty fairly comfortable with guys, but there was definitely like I know other girls who I know personally who would really not enjoy that situation. And there were times where I had to take myself out of it because it was a bit much."

Asked to clarify what the issue was, she added:

"…if you're in a situation where you're quite significantly outnumbered, then it tends to be more those conversations which can be quite a lot to deal with. It can be quite heavy as well but I don't have too much issue with that, but sometimes it can be a bit overwhelming."

Student X commented on the lack of female lecturers at university*: "in my first two years we had four times as many lecturers called Andrew as we did female lecturers."* Apprentice C had two work rotations in which she was the only female, as well as being the only female in her accommodation *"in my kitchen I am the only girl so that's sometimes a bit interesting, but yeah, I don't know. I think it's just something that you deal with…"* Student V counted the number of female students in her first year at university:

"It was 28 girls to like 330… I don't know what the proportion is now because people have … dropped out and I haven't seen everyone in the same room since first year, …but yeah it was like 10% ish."

Having been educated at an all-girl school, Student M found the transition challenging *"… I've been in a girl's school for so long and then suddenly it's like male dominated. It was crazy at first, but I've definitely got so used to it so now I barely notice."* She observed that *"every time that someone puts their hand up in lecture or write something in the chat in the lecture it's always a guy. It's very rarely a girl."* Before starting university, Student O, a first-generation university student, was concerned about what university life may be like:

"…starting university, I think I was really worried. You hear horror stories of like women going into male dominated subjects and then just being horribly disrespected and like their peers don't listen to them and like this, that and the other, and I've been quite lucky."

Having studied at an all-girl school that promoted women in STEM and provided a very supportive environment, she was left wondering if her choices would have been different had she gone to a mix-gender school: *"I do always wonder if that's maybe a reason why I've stuck towards doing like math and engineering, all those sort of subjects for so long because at my secondary school … there were no boys to like, you know, make the comments…"*

She shared that *"people always mention that engineers can be quite cold and not supportive of each other"* but found the women in her course to be a supportive group:

"…all the girls … we have a group chat and we go and meet up and we talk about …anything … why we chose engineering, why we chose to come to this uni and …if I'm struggling with something I can go to our group chat …and people will support you … it's been really nice having a group of other engineers that you know, if you're struggling, they'll help you…"

Seven female participants shared their perceptions of the challenges of being a woman in engineering. *"At the end of the day, I feel like it's still a man's world"* is how Apprentice H summarised it. Her classmate, Apprentice I, seemed to believe that having children was incompatible with an engineering career:

"I guess being a female in engineering, typically females are the ones that go and have children, so there's that to think about … I guess I'd be worried that if I went off to have children, the technical knowledge would disappear."

Apprentice E shared his views as to why women are underrepresented in engineering: *"…you don't really see any big female engineers … like Elon Musk like James Dyson. They are all male so yeah, it's not so surprising that women are choosing to go into other fields".* A male student who commented on gender imbalance at the University, overestimated the proportion of female students: *"I would say it's probably …like 70% male and yeah females only 30%. So yeah it's still a minority."*

4.6.7 Academic work

Poor academic results or simply not doing as well as expected may challenge students' and apprentices' identity standards and can lead to non-verification of their identities. Several participants talked about starting higher education believing they had a special talent for maths or physics only to struggle with the content of their course; Student M talked about her difficulties with her course and her sense that her classmates had a superior intellect *"They know everything straight away."* Student P found his first year at university more challenging than he was expecting: *"it's actually been more difficult and I didn't realise the workload would be like this much."*

Despite the differences in programme structure at both institutions and the fact that students at the University are full-time students whilst apprentices study part-time, both groups seemed to find the academic curriculum challenging and complained about heavy workloads. In his first year at university, Student P was unprepared for the workload:

"…it was a lot harder than I was expecting … I thought I'd have loads of time because …it's not like I'm in school all day…it's actually been more difficult, and I didn't realize the workload would be like this much".

Student M found her first semester exams challenging: *"I was feeling like the exams were so much harder than I expected they would be and I didn't prepare enough for them because I wasn't aware that they were going to be like that."*

An apprentice in his final year (Apprentice J), talked in general terms about *"…the loss of love for the subject"* of engineering as a result of an *"industrial"* approach to education. Given that there were just over thirty apprentices in his cohort, I understand that he was talking about a particular approach to teaching rather than teaching to large groups. This is what he had to say:

"I guess is slightly industrial education, when you're sort of trying to teach content to a wide range of personalities and learning styles, the teaching has to become quite formulaic and … it just sort of becomes a bit more factual and … actually loses the emotion, and so it's a very… effective way of learning a lot of content in a short amount of time, but I think people just lose the… love for it."

Student U, a final year student at the University, talked about having doubts about engineering before going on placement:

"…everything you learn in first and second year is quite fundamental stuff …so it's quite hard to … put it into …real life stuff…I think in second year in particular, … maybe because everything was crammed in … I think that's why I kind of started to doubt myself about engineering. But after doing placement and then seeing how different aspects of engineering can be applied, I felt really good about, you know, studying engineering and … got back into it".

Returning to university after her placement year, Student W struggled to strike a good balance between life and study: *"…working life … is a lot easier than uni …I worked until half five or whatever, and then I turn my computer off and I go home and I can ignore it the whole evening and do whatever I want and have fun and the same with the weekends …and then you come to uni and I tried really hard to maintain that structure but there are times where you just have too much work and you just have to work at the weekend and it kind of really sucks… by the end of placement year and I was feeling really good and then within like a month or two (my mental health) kind of went back down and so the pressure was a bit much. It is really hard here."*

4.7 People who support or challenge participants' engineering identity

This section explores the role played by individuals in supporting or challenging the development of an engineering identity, as reported by research participants. Respondents at both institutions talked mainly about the role played by their schoolteachers, university lecturers, their classmates and their parents.

4.7.1 Teachers

Participants talked extensively about the role played by teachers during their schooling. They talked about the quality of the teaching they received, the passion for the subject displayed by some of their teachers, the support provided by particular teachers and how a particular teacher might have guided them towards engineering. Seven participants talked about their D&T /Engineering teachers, five about their physics teachers and seven about their maths teachers. Apprentice A talked about her engineering teacher at GCSE and A level:

"My engineering teacher… was like amazing and he stayed after school until six for like weeks straight working for F1 in Schools … He was a good influence. He just like really cared… I think that kind of pushed me slightly more …not just doing well in engineering and like taking all these projects and doing well in projects. That's definitely helped me get in here and help me kind of realise my love for it".

Apprentice C also spoke highly of her D&T teacher who *"just loved the subject"* and *"was a really good teacher and he was the one that sort of showed me that engineering was an option by showing me the practical side and linking it with the maths which I already knew I liked."* Apprentice D was encouraged by his D&T teacher to apply for the Arkwright Scholarship

"… I had a lot of respect for him in the first place for offering me the opportunity to take the scholarship …so it was very much like, you gave me this opportunity and I want to prove

to you that, you know, you made the right decision in offering that to me. Yeah, it was really encouraging".

Student X thought highly of her physics teacher who, as well as being *"like the best teacher I have ever had"* pointed her towards engineering "I think it's just the fact I never thought of it before and then he suggested it and I looked into it and I though, oh, actually, this is something that I could do and I think I'd enjoy". For Student P, his physics teacher was also a favourite *"…he was like the most passionate when he taught… and just interesting because it made you want to actually find out why something is the way it is… and then, yeah, that would lead me to choose engineering."* Another participant reported a similar experience: *"my physics teacher in sixth form was really influential, as he taught beyond the syllabus and placed a large emphasis on problem solving skills which can be applied to any facet of engineering or science".*

Apprentice L talked at length about his maths teacher in sixth form *"… clearly very passionate about maths and teaching it and, yeah, she clearly cared a lot about it and put a lot of effort and time into delivering our lessons well".* Student R talked about a maths teacher who encouraged his students to apply their learning to real life issues: *"so, when we learn differential equations, he was like you can use this on airplanes just on a runway to calculate the distance of the runway… it's just applying stuff. That's another reason why I probably like engineering."* Apprentice K found himself having to choose from two offers: one from the University of Cambridge and one from the DA Provider. His maths teacher had studied engineering at Cambridge, so Apprentice K sought his advice. That one conversation was to have a great impact on his future; this is how the student recalled what his teacher told him:

"I did engineering, I tried for a year and I hated it because I was really good at hard maths but not (at) applying it, so it just depends on what you want; if you want to be good at hard maths … then go there. If you actually want to apply it maybe the degree apprenticeship is better for you" … so, yeah, that was quite a big conversation".

Describing their best teachers, participants did not simply focus on the quality of the teaching, how well prepared their lesson plans were or how engaging their teaching styles were but used emotional language to describe their teachers' *"passion"* and *"love"* for their subject.

4.7.2 Classmates

Failure to secure support or recognition from their peers is another way in which participants' identities may not be validated. Student P seemed quite hurt when he shared this experience: *"I've asked some people for help and they wouldn't really be willing to help … I'm not sure why."* Student V shared an experience of feeling excluded from teamwork: *"I remember once being on a lab with two guys and they were both quite arrogant and kind of not wanting to let you like do anything"* whilst Apprentice I seemed to fail to secure the recognition she was seeking from her peers:

"I think I get underestimated quite a lot. In our group there's a lot of very, very, very high achievers. So, like I'm a high achiever but it makes me more middle of the pack so like when it comes to group work, I am never the person that they go: "oh, work with Student I, she is amazing at that."

Apprentices generally found their classmates supportive as Apprentice A, in her first year of the degree apprenticeship, explained: *"it turns out that we can all get a first, we can all do really well and it's so much easier if we all just help each other, so it's actually got a really good sense of camaraderie."* This may be facilitated by the small class size and the fact that first year students live together onsite. However, Apprentice H reported feeling victimised by constant comments from her classmates on the way she dressed: *"light-hearted comments here and there about the dress I'm wearing or whatever … is fine, but when it's multiple people in the day it became really grating."*

University students reported finding their classmates less supportive, particularly in the first year. One Asian student felt his classmates were *"quite competitive"* and refused his request for help. A female Asian student complained about her male classmates' lack of motivation to complete a team assignment. A female student in her final year reported being in a lab with two male students who were *"quite arrogant and kind of not wanting to* *let you do anything."* However, a first-year female (Student O) commented on her female classmates being supportive, as I have reported in section 4.6.5.

4.7.3 University/DA lecturers

Four participants talked about the positive role played by university lecturers during their studies. Apprentice H was grateful for the support she received from her maths lecturer after she failed her first assignment in the first year of her degree apprenticeship:

"…that was a bit of a struggle and then I kind of questioned myself for a bit, but my maths lecturer sat down with me because he had seen me working in class and the way I approached problems, I remember he said to me: you could get a first, you could easily get a first, you are a really good student, he said, but this report just wasn't quite right and he sat down with me, he talked through it in quite a lot of detail and that was kind of a turning point for me and I really appreciated him taking the time to reassure me that I just had got this one a bit wrong, but it didn't mean that I was a failing student."

Student O felt well supported by her first-year tutor at university:

"…my tutor is like if you need help with anything, like anything, you can email me and we have tutor meetings where we don't even have to talk about engineering, we just chat about, you know how has your week been? Have you cooked any meals? which is nice."

However, she was not as enthusiastic about some of her lecturers: *"…some of my lecturers … who are engineers, they are what you would expect them to be; they are quite to the point, but not like in a rude way, to the point and then maybe not the most extroverted people in the world."*

Two female students shared negative experiences with lecturers at the University. Student V talked about *"one or two lecturers that are kind of quite obviously sexist but that's not the majority, that's only like a couple of arrogant people."* Student X found one of her supervisors particularly challenging *"… he is quite condescending, very so like picky …he just seemed quite difficult to work with him, I didn't feel at ease in meetings and I always had to like defend yourself and whatever you're doing."*

4.7.4 Parents

The majority of participants in this research reported having parents educated to degree level: ten respondents had a parent who studied engineering or worked in the engineering sector and three of those had siblings who were engineers or were studying engineering. Other professions held by participants' parents included doctors, biologists, computer scientists, academics, accountants, or businesspeople. Apprentice G, whose mother is an engineer, talked about her influence: *"I guess for me engineering was always in the cards because my mom pushed a lot of maths from a young age so we were like doing Kumon from as long as I can remember"*. Student N was also supported by her father:

"…my dad is also quite good at maths. He studied astrophysics and things like that so he's good at that and so yeah, he kind of supported me when I was younger doing kind of exam help and things like that."

She gained some engineering experience with him prior to studying engineering, as her father *"… moved into engineering now more. He's working with a wind turbine company… I've been helping him out a little bit … He asked me to do some CAD modelling and rendering this summer and I helped with some research because it's very similar to what I did my extended essay on the IB so I already knew quite a bit about it, so yeah, I helped him out a little bit there, which is nice".*

Student M, whose father is an engineer, talked about his influence*: "He definitely gave me a bit of a passion for science and maths. He was always helping me with my maths homework… he's definitely pleased that I'm going into engineering."*

Parents who were not engineers also played a key role in supporting students; Apprentice F talked about his parents' influence as follows:

"…both my parents are quite sort of analytical and smart. They both went to university so I think it was just a general sort of like ethos of the family … they definitely helped instil a passion for learning".

Apprentice L talked about how his father, who is not an engineer, introduced him to problem solving from an early age: *"…he generally would do little problem solving things with me. It's like puzzles. He would give me puzzles or things like that so I think, all throughout my childhood I've had a lot of problem solving … and got a lot of enjoyment from it."*

Apprentice A talked about her mother's influence: *"…my mom is very creative and like artsy and does a lot of craft. She taught early years so she got really into like teaching through play and all that kind of stuff so we were always building and making things".*

Apprentice H's mother encouraged her to understand how things worked: *"my mom was really good at …explaining something … and although she's not an engineer, she would always take the time to kind of explain how things worked or just point things out in a room and be like, do you know why that's done like that? and she would start to explain."*

For Student U, his mother was also a key influence as she taught him maths at home from an early age: *"I did have a pretty good start just because in primary school I think most of my friends just learned maths, you know, in school, but my mom made us do high, slightly more advanced maths just at home in the morning."*

Parents who were not educated to degree level were also supportive, as Student O shared:

"*…my parents didn't go to university so when I was like oh I want to go…they were really supportive and they helped me through all of it, and I think …it was nice having that sort of support."*

For Student W, her father's expectations seemed to weigh heavily on her mind: *"…my dad, I think he thinks I'm cleverer than I am and he's like, oh, you find it, you just get good grades, it's really easy, and I'm like it's not, I try really hard."*

4.8 Participants' identification with engineering.

Whilst some students/apprentices in the first year of their engineering studies referred to themselves and their classmates as engineers, four students/apprentices who were close to graduation would not describe themselves as such. During the interviews, eight participants readily identified themselves as engineers, including all three female first year students at the University. They did so when talking about their housing arrangements *"In my flat share … we are all engineers*" (Student N) or their means of communication with each other *"a group chat that we have for all the engineers*" (Student M). Apprentice C, in the first year of her degree apprenticeship, described her classmates along similar lines *"we are all engineers"* whilst her male classmate, Apprentice D, was a little more hesitant*: "I am given the responsibilities as if I am an engineer..."*

Three final year respondents identified themselves as engineers; Student T said: *"I certainly define myself as that (an engineer) and that's what I would say to other people"*. In the TST, Apprentice H said: *"I am an engineer at engineering company*" and talked about having "built confidence in myself as an engineer and kind of developed my engineering identity." Her classmate, Apprentice I, said: *"I am a woman in engineering*."

Out of five respondents who asserted that they would not define themselves as engineers; four of them were in their final year of studies and close to graduation. Apprentice L said: *"I don't really consider that (being an engineer) to be part of my identity, I guess. That's just the name of my role at the moment."* His classmate, Apprentice J, spoke along similar lines *"I wouldn't say I am an engineer."* He went on to explain he didn't study engineering because he wanted to become an engineer but because he *"was interested in engineering and it was something I wanted to learn more."* Apprentice E, a first-year apprentice, expressed his view that so far away from graduation, he had no right to call himself an engineer:

"… there's always going to be someone who's better at it than you so it just feels weird calling yourself like professional in that sense, when you're not one of those people who can do the job better than you… I don't know if that's the definition of professional there… Maybe when I've got the degree and I'm like qualified as an engineer, then you can call

yourself an engineer. But yeah, I don't think right now I have like any right to call myself an engineer.'

Student W, a final year student at the University, said: *"I don't see myself ever becoming like a serious engineer."* Her classmate, Student U, would not describe himself as an engineer: *"sure, I got an engineering qualification, but I know that a lot of the experiences I have are not like super engineering… a lot of the people I talk to seem way more engineering"*. He concluded *"I'm just qualified as a STEM subject person."*

Only two first year students at the DA Provider had some involvement with engineering organisations: a female student was involved with the Women in Engineering Society and a male student was planning to become an Engineering Technician member of The Institution of Engineering and Technology.

4.8.1 A future career in engineering?

All final year students at the DA Provider accepted a job offer to join an engineering company post-graduation, although two of the apprentices interviewed chose to defer their offer until September 2022 and at the time of writing this dissertation, it was not known whether they would join the company for sure. All final year students at the University had secured job offers:

- Three of them returning to the companies in which they had done their placements,
- Two going to different companies in the same sector and
- One going to a new company in a new sector.

Most of the final year participants interviewed for this research seem to see their future in engineering although not everyone was equally passionate about it and a couple of them were already considering other options outside engineering.

Having studied automotive engineering, Student T was very happy to be returning to his placement provider in F1:

"…I know I'm fortunate to have been offered a job from my placement provider… I've kind of had a quiet, relatively nice end to my university career and I haven't had this sort of anxiety of not knowing where I'm going, where I am going afterwards. So, yeah, I start work at the beginning of July... so I'm quite comfortable in the fact that I've already worked there for a year, I know all the people, I know kind of exactly what I'm going to do, and that is ultimately the career that I wanted to end up in, especially like having watched Formula One and for a lot of students …who study automotive engineering …motor sport and Formula One side is where they want to end up some obviously quite privilege to have gotten myself in that position."

Student V was also happy to be returning to her placement provider in F1 but had different aspirations for her future:

"I'd like to think that I'll be designing and doing engineering for things that will help people … progress technology. I'm not sure how long I see myself at Company F1. I really enjoyed my placement. It's really good place to build up skills and learn … but I'd say that the company is predominantly automotive and it's high end automotive. And I I'd rather design things that aren't going to sit in a rich guy's garage, I want to design things that are going to help people."

For Student S, his new job in F1 was a dream come true

"… that was probably the place that if you asked me, I don't know, 10 years ago, where do you want to work? That's where I would have said … It's where I grew up really and it's somewhere where I had always wanted to work at some point in my career … it's like a thing I always wanted to achieve."

Student W was happy to return to her placement provider as she had enjoyed her placement year but nevertheless, she was still considering an alternative career path she had been toying with for some time *"… it is in the back of my head about potentially going* *to PGCE and becoming a teacher… I think that being a teacher is something that I could pick up in five or ten years' time."*

Student X was starting a new job after graduation in a similar sector to her placement experience:

"…my placement was with an aluminium company and now I'm working with aluminium beverage brands so it's good; I like how aluminium is recyclable, you can recycle it…forever which is good. … That's where I have ended up now, may not stay in aluminium for ever."

Apprentice L, who specialised in software, seemed to have found his place:

"I'm just very fond of problem solving, and if all I'm doing all day is problem solving then I'll be quite happy and in software, particularly I enjoy it because all you're doing really while you are coding, is problem solving. You write a little bit and then run it and then there's a problem and you have to figure it out, and then there's another one, another problem. So, it's just problem solving constantly, which I find quite fun."

His classmate, Apprentice I, was not so clear about her future in engineering: *"I can see myself staying in the engineering field but not necessarily doing engineering… I would like to gain a better understanding of marketing or business or finance…"* It seems unlikely that Apprentice J, who would not describe himself as an engineer and is currently studying for a master's degree in applied psychology, will pursue a career in engineering.

The table below summarises the students' and apprentices' intention to pursue a career in engineering by institution and year of study, as expressed during the research. There is little difference in the intention of students at both institutions despite the different programme formats. Given the difference in programme formats, with apprentices working in engineering teams from day one, it is surprising to see that there is little difference in students' and apprentices' intentions to remain or leave engineering. There is also little difference between the intentions of first and final year students at both institutions, although two final year participants (one apprentice and one university student) indicated they were unlikely to join the profession after graduation. Given the importance of engineers to the country's industrial strategy as explored in the Introduction Chapter, engineering education does not seem to do enough to retain them.

DA Provider – year one apprentices					University – year one students				
Apprent.	Definitely	Probably	Unsure	Probably not	Student	Definitely	Probably	Unsure	Probably not
A	✓				M			✓	
B			✓		N	✓			
C	✓				O	✓			
D	✓				P			✓	
E			✓		Q			✓	
F		✓			R	✓			
DA Provider - final year apprentices					University - final year students				
G		✓			S	✓			
H	✓				T	✓			
I			✓		U				✓
J				✓	V	✓			
K		✓			W			✓	
L	✓				X		✓		

Table 9 Participants' intention to pursue a career in engineering.

About half of first-year participants expressed their passion for engineering and saw their future in the profession but the rest were unsure and seemed willing to consider other options such as finance or consulting. A first-year apprentice, Apprentice F, who had not had any exposure to software during his schooling, sounded non-committal despite having discovered a passion for it in his degree apprenticeship:

"…probably … leaning into more of a software engineering kind of vibe, which has become a sort of new passion, having found it here because …I didn't get computer science as an option (at school)… but it still remains to be seen… I think I'll lean into engineering if I can still sort of hold up the willpower to power through."

Student R's ambition was to secure an engineering job in Canada *"since the engineers are quite in high demand, specially from the UK."* For his classmate, Student Q, the dream was

"…to help in kind of renewable energy like hydroelectric or maybe solar, wind, tidal kind of places, in parts of the world that kind of really need it and don't have much access to that kind of energy because I'd like to travel but I would also like to help people as well…I would hate to spend my life working for … a firm that just makes cars or you know, like a defence firm…I don't think I'd get much out of that." although he also expressed a strong interest in finance.

Apprentice C, who described herself as an engineer throughout her interview and who wears a cochlear implant, was keen to explore biomedical engineering:

"…biomedical engineering is definitely the most interesting one and it's obviously had a direct impact on me with my implant. I would not be able to hear and I wouldn't even be able to go to normal school let alone University …so, I definitely do …kind of want to go into that and see if I can help other people. "

4.8.2 Keeping my options open

Eleven participants talked about having chosen engineering not necessarily to become practicing engineers but as a way of keeping their options open; as Student W said:

"…everyone said … if you do engineering you can do anything, like you don't have to be an engineer … you can go into finance and business and …you can do anything from it. So I was definitely going into it, partly because I didn't know what I wanted to do."

Apprentice L chose engineering as a way of delaying making a decision as to what he wanted to do:

"It was the most general subject that I could choose … one aspect of it was that I was trying to delay what I actually wanted to do, choose a subject that would allow me to go into anything afterwards so if I found out that I wanted to do finance or arts or whatever, I figured a degree in engineering would be a good thing to have."

For Student Q, who was very interested in finance and managed his own portfolio, choosing engineering was also a way of keeping his options open: *"… say you choose a finance degree, I can't go into engineering with that, but an engineering degree you've got so many options and I think that's why a lot of other people choose it as well."*

Student P shared his classmate's interest in finance: *"I have also had thoughts of not continuing to be an engineer. A part of me would like to go into finance, for example a trading role at an investment bank or hedge fund. This is because I am partially motivated by money and earning a large amount of money at a young age is exciting, as I would like (to) be able to be free from work at an earlier stage in my life."*

Apprentice E agreed that some roles outside engineering offered better financial rewards*: "if you have an engineering degree there are a lot of jobs that are out of engineering, not in engineering industry, but they have a much higher earning potential…"* Student W, a final year student, had been thinking about a different career path for some time: "something I've always thought about and actually probably one of the first careers I ever considered, was actually being a teacher … it is in the back of my head about potentially going to PGCE and becoming a teacher." No such doubts for Apprentice C, who, despite being only a first-year student, expressed her commitment to the profession: *"for me it is quite obvious what my future is, I know I really like being an engineer."*

4.9 Results by variable

This section explores the different findings across the two institutions under study, the DA Provider and the University, whether students were in the first or final year of their studies, by gender and by ethnicity. The profile of both groups of students is very similar in terms of age, school experience and socioeconomic background although students at the University, which has higher entry requirements, had achieved higher grades in secondary school. The research found several differences in the responses of students enrolled on the two different programmes, particularly around the traits participants assigned to engineers and to themselves.

4.9.1 Differences by programme of study

More apprentices described engineers as being curious, being team players and having to persevere to succeed. In terms of personal traits participants attributed to themselves, more apprentices described themselves as problem solvers, being smart and having many interests. More apprentices in the first year reported a lack of understanding as to what engineering is whilst more apprentices across the first and the final year of study reported experiences of not fitting in and shared stories that illustrated a lack of identity verification.

More university students understood engineering as creating or improving things and described engineers as being resilient; they expressed their love for maths, physics and science and reported gender imbalance and expressed having doubts about engineering. They found their classmates less supportive, particularly in the first year whilst more university degree students reported issues with lecturers, particularly final year students. They also reported keeping their options open and more so in their final year. More students who had a parent who was an engineer or worked in engineering chose to study a conventional engineering degree at the University. The programme of study did not seem to make a difference to how students envisioned their future; a similar number of students at both institutions saw their future in engineering or were unsure about the future, as Table 9 shows.

4.9.2 Differences by entry versus exit level participants

This section looks at differences and similarities in participants at the start of their engineering qualification as compared to participants in the final year of their studies at both institutions. More respondents in the first year of their engineering studies described themselves as having many interests and being practical learners, traits reported less often by students and apprentices in their final year. More entry level students and apprentices described themselves as being hard working and found the academic content challenging. More first year students and apprentices saw engineers as problem solvers. First year male students and apprentices reported having had more engineering experiences prior to studying for their degree than their female classmates and more first year students and apprentices reported experiences of identity validation.

The challenges of being a woman in engineering were felt more acutely by first year than final year participants. Family support was reported to be very important for participants at both institutions but more so for first year students and apprentices. Dealing with the stereotypical engineer was seeing as more of a challenge by first year participants, although it was also reported by final year students and apprentices.

4.9.3 Differences by gender

More male students and apprentices described engineers as being analytical and good with numbers whilst more female participants talked about the need for engineers to persevere in the face of difficult challenges; Apprentice G had this to say: *"…sometimes the problem is just a big problem. You got to have like the energy and the perseverance to just continue in your path through the frustrating days."* More female participants saw engineers as being creative and expressed their view of engineering as having a positive impact in society. More female respondents described themselves as being smart and being a good student although more female students in their first year reported struggling with the academic content of their programmes. Mainly female participants reported having experiences of facilitating other people's learning during their schooling and none of them reported them in higher education. Student N, who had several years of experience of tutoring younger students, explained her interest and her approach to helping others to learn:

"… I took psychology in sixth form so I quite enjoyed kind of getting to know how the students' brain works and how they understand things because I found that schools do teach one way of learning things and it doesn't work for everyone at all and often the students I had would just be like I just do not get it in school, my teachers don't teach it well to me… I would spend a session … trying to understand how they like to learn, what subject they like and why they like them, which would help me teach them the subjects they don't like as much."

More female participants reported experiences that made them feel they did not fit in, talked about the impact of gender imbalance and the stereotypical engineer. The importance of having family support was reported by more female than male students and apprentices.

More male than female participants described engineers as being analytical. More male participants expressed a love of science, maths and physics. More first-year female respondents talked about the important role played by D&T teachers in their path to engineering, whilst more first-year male respondents talked about the role played by their maths teachers. More male participants reported that they were keeping their options open when thinking about their future.

4.9.4 Differences by ethnicity

The sample included six participants from ethnic minorities, two males and one female at each institution. Ethnicity seemed to make a difference in terms of how students understood engineering; only eight white participants (male and female) defined engineering as problem solving whilst more female and ethnic minority participants than white males defined engineering as creating or improving things. An Asian student (Student U) explained that to him, engineering was *"… the creation of new things. Things that you didn't know you needed until they've been made or designing and building and innovating"*

Six participants thought engineers needed to have perseverance to succeed and all of them were either female or ethnic minority respondents. An Asian student in his first year at university had this to say:

"…perseverance because I don't think it's just a straightforward line to designing and making something, but more like there's loads of like things that sometimes you don't even expect that you have to encounter so being able to like push through with that as an engineer is quite important."

More female and ethnic minority participants had experience of supporting other people's learning; eight female students and apprentices reported some experience of formal tutoring. Only eight white participants (male and female) defined themselves as confident and, whilst thirteen respondents described themselves as practical learners, no male participants from ethnic minorities defined themselves as such. More ethnic minority males than white males commented on gender imbalance. Six participants expressed having doubts about engineering: one white male, three Asian males, one Asian female and a white female participant.

CHAPTER 5 DISCUSSION AND RECOMMENDATIONS

Following the analysis of the research data I shared in the previous section, this chapter describes the different identities students and apprentices who took part in this research claimed for themselves, the experiences that support the development of their engineering identity and the people who play a key role in that process. It includes some reflections drawn from looking at the engineering profession as a social structure and the symbolic importance of some of the behaviours exhibited by engineers. The chapter concludes by highlighting some of the limitations of this research and making recommendations for engineering educators to consider in order to better support the development of an engineering identity among their undergraduate students.

5.1 Participants' understanding of engineering identity

Many students arrive in higher education without a clear understanding of what engineering is and what engineers do, as they have little or no exposure to engineering during their schooling. Courses that can be a potential pathway into engineering, such as Design and Technology (D&T), have been in decline since D&T stopped being a compulsory subject in Key Stage 4 in England in 2000; according to a study by the Sutton Trust and the Bridge Group (2022, p.23), the number of students choosing to study this subject fell by forty two percent between 2010 and 2017. Most of the students who took part in this research had exposure to some engineering experiences during their schooling, although the number and range of experiences varied widely. Some had a parent who was an engineer, and this meant that they were more likely to have a better understanding of what engineering is and what engineers do. Research suggests that having a parent who is an engineer influences students' choices to study engineering, something supported by this study. Dorie et al. (2014) report on the different ways in which parents who are engineers promote what they call "engineering learning" in their children from an early age, as well as the role parents play in the development of their children's understanding of what engineering is and what engineers do.

Identity theory tells us that the self is not in place at birth, rather it develops through a process of socialisation and interaction (Mead, 1934) and therefore we can presume that people are not born engineers, they become engineers. As students and apprentices progress through their education, their behaviour is shaped by the meanings they attach to their interactions with others and by their own reflected appraisals of how others see them (Stets and Burke, 2014; Stets and Serpe, 2013). The first research question in this study sought to clarify what engineering students and apprentices understand by their professional engineering identity and a surprising finding is that white males, females and ethnic minority respondents seem to have a different understanding of what engineering is: whilst white male students and apprentices focused on engineering as problem solving, more ethnic minority and female students and apprentices defined engineering as the creation of new things and focused on engineering's positive impact in society. Although some of the participants in this study may have known little about engineering as they started their degrees or degree apprenticeships, they all had a very positive view of engineers, attributing to them a plethora of positive traits; they described engineers as being creative, curious, analytical, persistent problem solvers and team players. One participant went as far as to say that engineers were "pretty nice people" and that she had never met an engineer she did not like. This overwhelmingly positive perception stands in deep contrast to the traditional stereotype about engineers, something that seems very present in the minds of half of the students interviewed for this research and that I will explore in more detail in the next section.

5.1.1 Stereotypes about engineers

The traditional stereotype of engineers as being white heterosexual males, nerdy, techy and socially awkward posed a challenge for students and apprentices from minority groups (female, ethnic minority or gay students). If we revisit Mael and Ashforth's definition of professional identification (1992, p.106) as "the extent to which one defines him or herself in terms of the work he or she does, and the prototypical characteristics ascribed to individuals who do that work" we can understand why: some of the prototypical characteristics ascribed to engineers are being male, white, straight, techy. When students and apprentices who do not meet those characteristics compare themselves against the stereotype, they experience a lack of fit, that results in a negative reflected appraisal, triggering a negative emotion as the identity is not validated. Although participants talked about stereotypes, I would argue that they are actually referring to a prototype, defined by Hogg (2006) as the perceptions, feelings, attitudes and behaviours that convey the similarities within the group.. It is likely that some of the prototypical traits associated with engineers have become part of the students' and apprentices' own identity standard for their engineering identity, for instance engineers being male. This finding is supported by research by Cory and Rezaie (2008), who found that there is a definite male stereotype of the engineer in our society. Morelock (2017) also found that "the condition of being male was conducive to constructing an engineering identity". McIlwee and Robinson (1992, p.21) articulate it as follows "To be taken as an engineer is to look like an engineer, talk like an engineer, and act like an engineer. In most workplaces this means looking, talking, and acting male… Where engineers as a group are powerful, the workplace culture takes on a form strongly identified with the male gender role, emphasizing aggressive displays of technical self-confidence and hands-on ability as the criteria for success." In such an environment, female attributes are devalued and professional competence is defined in strictly masculine terms. Whilst their work focuses on women in engineering, it is likely that other minority groups would experience the same effects, and this is an area that would benefit from further research.

It is easy to understand why prototypical characteristics of engineers are so present in the minds of the students and apprentices who took part in this research: the engineering profession in the UK remains dominated by white males, so students need only look around to find the prototype confirmed. An EngineeringUK report on gender disparity in engineering found that "there is compelling evidence that gendered norms and stereotypes associated with engineering can have an effect on girls' self-efficacy and identity, which can in turn influence their subject and career choices" (EngineeringUK, 2018, p.9). It seems fair to say that the stereotypical view of the engineer held by society matches the reality of the engineering profession in the UK in 2022 and has become a prototype for the profession. Compared to other professions, engineering is conspicuous for its sex segregation as it continues to have the smallest proportion of women of all major professions; whilst women in the UK make up 52% of registered solicitors (Solicitors Regulation Authority, 2022) and just under 48% of all licensed doctors (General Medical Council, 2020) they account for only 16.5% of all engineers (EngineeringUK, 2022).

5.1.2 Findings from the TST

The purpose of using this tool was to elicit aspects of the students' identities that would complement what they shared during the interviews. Male and female students and apprentices used different words to describe their person identities: males described themselves as analytical, curious, driven, enthusiastic, creative, optimistic and good, whilst females saw themselves as introverted, creative, passionate, happy, curious, friendly and ambitious. Being a family member was mentioned by eleven participants, seven of whom were female. Other group identities mentioned by participants in the TST were being a friend, belonging to a church, a Scout or Guide group or a sports club, but my research did not provide sufficient data to explore them. In terms of role identities, more female than male participants described themselves as engineers in their TST responses. The student identity was the other main role identity mentioned by participants. With regards to social identities, eight female students mentioned their gender in their TST responses compared to only two male students. This finding is consistent with research by Rees and Nicholson (2011) who found gender to be a more salient identity for women in technical environments. Social class and ethnicity are also social identities, but my research did not gather sufficient data to explore those identities.

The majority of the statements provided by students and apprentices fell into Category C, i.e., statements that describe moods, feelings, preferences, likes and dislikes. This is consistent with research by Grace and Cramer (2002) who, reporting on the evolution of responses to the TST by university students in the USA over time, found that in the late 1960s and early 1970s, students responded with primarily type B statements, with only 31% of participants providing C type responses. However, by the late 1970s there was a shift, and students reported mainly C type statements (68% in the late 1970s and 88% in the early 1980s). They interpret this change as a shift in students' identities from being more attached to institutional roles to a self that focuses more on personal preferences and moods. My own findings seem to confirm that trend and are consistent with previous research into university students' identity (Grace and Cramer 2002; Babbitt and Burbach 1990).

TST findings show that gender is a salient identity for most of the female students who took part in this study, something that is confirmed by the interview data. Gender also colours the choice of words students and apprentices used to describe themselves, with male participants using words that express more confidence than females, something that is also found in the interviews.

5.2 Identities reported by respondents

Identity theory proposes that there are four types of identities: role, group, person and social identities (Burke and Stets, 2009; Stets and Serpe, 2013) and that the process of identity validation is the same for all of them (Burke, 2009; Cast and Burke, 2002). Traditionally, engineering identity has been studied primarily as a role identity (Lichtenstein et al., 2009; Pierrakos et al., 2009; Tonso 2006; Anderson, Snodgrass Rangel and Holly, 2021) or in the context of a social identity such as race (Henderson et al., 2021) or gender (Seron et al., 2016; Seron et al., 2018). In the following sections, I explore the different identities reported by the students and apprentices during their interviews.

5.2.1 Person identities

The literature tells us that a 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 and Stets 2009, p.124). Meanings associated with a person identity are both culturally defined and adapted by each individual. Those meanings are held in the identity standard against which individuals compare their reflected appraisals in the identity verification process; the verification of person identities generates feelings of authenticity, helping students and apprentices to feel at ease in their environment. Identity theory has studied a limited number of person identities, such as being more or less dominant (Stryker and Burke, 2000) or moral (Stets and Carter, 2006) for instance. Nevertheless, the identity verification process for person identities is the same as for other identities (Stets and Cast, 2007). During the interviews, students and apprentices described engineers as being curious, analytical and creative, for instance, and often used the same words to describe themselves in the TST; this can be interpreted as students having internalised the person identity traits they associate with engineers.

More students and apprentices at the start of their engineering education described themselves as having multiple interests and being good at many different subjects; this was an aspect of their identity that they valued and that had been supported through their schooling. However, by the time they were close to graduation, only three participants reported this characteristic and one of them was leaving engineering. It seems likely that, given the demands of engineering education, it does not support students and apprentices who wish to maintain a broad range of interests. Participants for whom this is an important identity may find validation difficult.

Facilitating other people's learning was an important person identity for two thirds of female participants during their schooling. However, this person identity did not seem to be available to them once they joined higher education. Given the positive feelings generated by the verification of this identity, its absence would be a significant loss to them. Being a hard worker was another identity participants talked about and one that seemed to support their student identity. Students and apprentices also talked about how much they enjoyed hands-on, practical learning early on in their education, an approach that seems to largely disappear as they progressed from primary into secondary school. The largely theoretical curricula at the DA Provider and the University means that both institutions make an extensive use of lectures and therefore students may struggle to experience the "hands-on" learning style they enjoyed, leaving them unable to validate their practical learner identity.

5.2.2 Role identities

Role identities are the meanings individuals associate with the various roles they occupy within the social structure, meanings that arise partly from the local culture and partly from the individual's personal interpretation of the role (Burke and Stets, 2009). The validation of role identities generates feelings of mastery and efficacy, as illustrated when students shared stories of achieving high grades, winning competitions or securing places at selective schools. White participants reported feeling more confident than their ethnic minority classmates and this may be due to the more frequent validation of their role identities. During the interviews, students and apprentices talked mainly about two role identities: student and employee. Students and apprentices had experience of the student identity whilst only apprentices and final year university students had experienced an employee identity in an engineering environment. The role identity of being a friend was reported in the TST findings, but my research did not gather sufficient evidence to explore it further.

5.2.2.1 Student identity

According to identity theory, every identity has four basic components: an input, an identity standard, a comparator and an output (Burke and Stets, 2009, p.62). The identity standard is the set of meanings that defines that particular identity, including “one’s values, beliefs, and ideals” (Stets and Harrod, 2004, p.158). Research by Cast and Burke (2002) found that the self-verification of role identities cannot be achieved independently but requires verification from others in the group. Cast and Burke (2002) also posit that when two people interact, the identity verification process of one has an impact on the identity verification process of the other, as Figure 3 illustrates (Cast and Burke, 2002, p.1045). Imagine two engineering students, one male and one female. Both may have a similar identity standard for their engineering student identity; their standard may contain some of the characteristics participants in this research assigned to engineers, such as being hardworking and curious, for instance. The expectation that engineers are male was reported by the majority of female participants in this study (ten out of twelve) and it is therefore likely to be part of their identity standard. When the male student compares his own identity to his standard, he is likely to find that his identity meets the standard and hence it is validated, leading him to display behaviours that exude a sense of confidence and belonging. When the female student compares her identity to her standard, she is likely to find that she meets some of the characteristics but not others, such as being male, an experience shared by some of the female participants interviewed for this project. At the same time, the confidence displayed by her male classmate may convey a symbolic meaning that may appear intimidating to the female student. The behaviour displayed by the male student/apprentice in this example provides information to the female student/apprentice in terms of a reflected appraisal, impacting her own identity verification process and making her feel that she does not belong to the same extent that he does. A male student who believes it is normal for women to choose other professions as they do not succeed in engineering in the way that Elon Musk or James Dyson have done, may not contribute to the engineering identity validation of his female classmates. The identity validation of minority students is also impacted by their perceived lower status, which means that they are less likely to secure the positive reflected appraisals from their peers that they need to validate their identities. The experience of the identity verification process would be the same for other underrepresented students/apprentices (ethnic minorities, gay, non-binary) who consciously or unconsciously may be comparing themselves against a white, male, heterosexual identity standard. If we apply this idea more broadly to the engineering profession, it may help explain why minorities continue to be underrepresented in engineering to this day, as their identities are less likely to be validated than those of the dominant group due to the two reasons I have just explored: their identity standard is likely to include characteristics they do not meet, such as being white or male, and the process of identity verification of the dominant group may actually hamper identity verification for the minority.

During the research several participants lamented the loss of their “good student” identity as they started their degrees. They felt challenged by their perception that many students were “better” than they were and had to come to terms with the idea that they were “nothing special.” Students and apprentices conveyed a real sense of loss and bewilderment as behaviours that had served them well at school were not working for them in higher education. Lack of verification of their “good student” identity and the associated distress that they felt were making them wonder if they had made the right choice, if engineering was for them.

5.2.2.2 Employee identity

Apprentices perform two different roles leading to two different role identities: they are students two days per week and employees at an engineering company three days per week. Given that they are employed as “undergraduate engineers” and work in engineering teams for the four years of their degree apprenticeship, it would be reasonable to expect their engineering identity to be stronger than that of the university students who took part in this research, whose workplace experience is limited to a placement year halfway through their degree. However, the findings from this research do not support that view.

Every final year university student interviewed for this research had completed a placement year and talked positively about their experience. They shared stories of experiencing identity validation when their colleagues or seniors acknowledged their work and, having completed two years of their engineering degree before going on placement, they felt they had some level of expertise and knowledge to contribute. They talked about their placement experience as a “confidence boost”. It was clear from the interviews that the identity validation derived not only from the internal satisfaction of a job well done but from the external recognition received as a result, something that is consistent with Cast and Burke's findings (2002) that self-esteem is an outcome of identity validation and that it cannot be achieved in isolation. The employee experience of apprentices differed according to the year of study; apprentices at the beginning of their education found the workplace challenging; as the youngest and least qualified person in their teams they rarely experienced opportunities to have their engineering identities validated. Whilst some final year apprentices still struggled with finding their voice and feeling confident in the workplace, others related positive stories of the impact their work had made to a particular project and of gaining recognition from their managers. Nevertheless, more apprentices across the first and the final year of study reported experiences of not fitting in and shared stories that illustrated a lack of identity verification.

5.2.3 Group identities

Group identities refer to the meanings associated with belonging to a particular group in a society such as a family, a club or a church, for instance (Serpe et al., 2020). Validation of group identities generates feelings of increased self-esteem and belonging, whilst lack of validation can leave individuals feeling that they do not belong in their environment. Students and apprentices made references to their families and to the importance of family ties during their interviews, particularly first year students. For apprentices, a salient group identity was that of being members of their cohort, as they study in small year groups of around forty learners per intake. During the first year of their degree apprenticeship, they live together onsite in the small town where their employer is based and have few opportunities to socialise with people their age outside their cohort. Living, studying and socialising together means that cohorts become close-knit communities. A student or apprentice who is not enjoying his engineering degree may find it harder to drop out if he is deeply connected to his cohort, making his commitment to that identity stronger given the number of relationships involved (Stets and Burke, 2014), whilst a student who has few friends among his classmates may not feel the same level of commitment.

The university students interviewed for this research study in much larger groups and did not convey the same sense of becoming a close-knit community, with the exception of female students, who reported having formed female-only groups that were very supportive and valued. An ethnic minority student in his first year reported feeling confused when his request for help from his classmates was turned down. Group members are expected to be supportive towards each other and this lack of support is likely to have made him feel excluded from the group and dented his self-esteem (Burke and Stets, 2009, p.121). Some students at both institutions mentioned their involvement in student clubs although this was not something I explored in detail in this research.

It was surprising to find that professional engineering organisations do not seem to play a role in the professional development of the engineering students who took part in this research. Only two first year apprentices had some involvement with engineering organisations: a female student was involved with the Women in Engineering Society and a male student was planning to become an Engineering Technician member of The Institution of Engineering and Technology. Given the importance of professional bodies in engineering, I would have expected a higher degree of exposure to engineering organisations, particularly for students coming to the end of their engineering education, as such involvement could contribute to a greater sense of belonging in the profession.

5.2.4 Social identities

Social identities are linked to the meanings related to the social categories we occupy in society and mainly refer to ascribed characteristics such as gender and ethnicity (Stets and Burke, 2000). Social identities reflect the attitudes and values that society attributes to particular categories. The verification of social identities generates feelings of self-worth and belongingness. The only social identity identified in this research is gender, which seemed to be particularly important for female students. This finding is consistent with research by Rees and Nicholson (2011), who found gender to be a more salient identity for women in technical environments. Social class and ethnicity are also social identities, but my research did not gather sufficient data to explore those identities.

5.3 Engineering identity as a person, role and group identity

I understand engineering identity to be the extent to which students and apprentices identify themselves as engineers, something that "involves more than just gaining technical knowledge and skills; it involves the personal and social process of identifying with the profession" (Liptow et al., 2016) a definition that is consistent with the findings from this study. Students' and apprentices' identity, who they think they are, matters because it influences what they see themselves capable of achieving as well as where and with whom they think they belong (Han et al., 2018). My research indicates that for an engineering identity to develop, students and apprentices need more than the technical knowledge and skills gained in their studies; they need to develop the person, role and group identity of an engineer. This may explain why an engineering identity does not come easily. When participants reported that their engineering identities were validated, they expressed feelings associated with every type of identity: confidence (role identity), self-esteem (group identity), person (feeling true to themselves) and the opposite is also true: when their engineering identity was not validated, they expressed lack of confidence, low self-esteem and questioned their place in their course.

This finding is consistent with work by Caza and Creary (2016), who proposed that professional identities involve all three types of identities. I have adapted Burke's identity model (1991) to incorporate Caza and Creary's ideas (2016), as shown in Figure 9. The result is an identity model with three different standards, one for each type of identity (person, role and group). The implication is that an engineering identity can only develop when all three standards are met. An engineering student may believe that to be an engineer, he needs to have an eye for detail, work hard and be persistent (person identity), be a good problem solver and highly competent at technical tasks (role identity) as well as being a good team player and a respected member of the profession (group identity). Meeting so many high demands is likely to be challenging, particularly for engineering students and new graduates, who lack the experience to display the level of competence they expect to have. It may also be harder for engineering students from underrepresented groups to secure the respect of their peers. Failure to validate any of the three standards would mean that an engineering identity cannot be achieved.

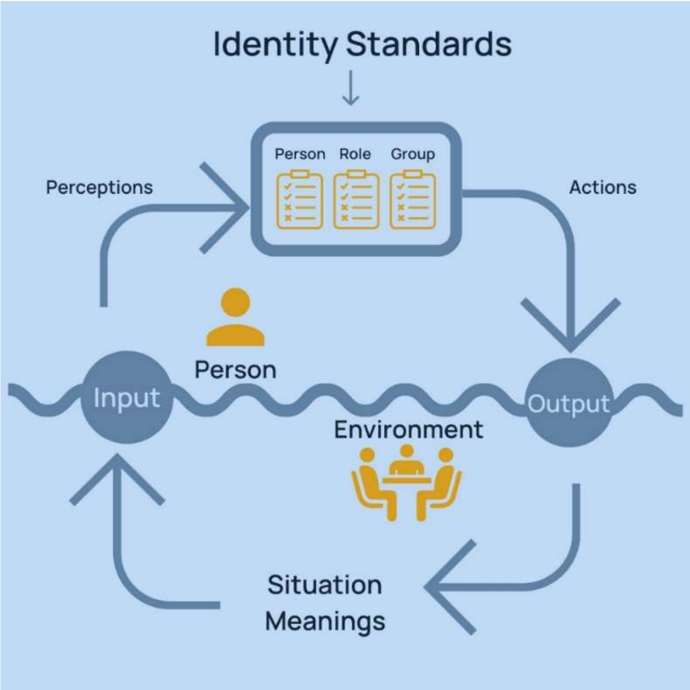


Figure 9 Proposed model of identity validation for an engineering identity.

Carter (2014) suggests that those identities that are activated across different situations are “diffuse identities”. Whilst his work focused on gender, my findings suggest that engineering may also be a diffuse identity as it requires person, role, and group identities to be activated.

5.4 The role of status in identity validation

Identity theory understands status to be our position in a social structure. Status matters because it is that position that shapes who we interact with, the nature of the interaction and the resources available to us (Serpe et al., 2020, p.11). Research into the role of status in identity verification has shown that higher status individuals are more likely to have their identities verified (Burke, 2008) and that their evaluations of others are more influential than those of lower-status individuals (Cast, Stets and Burke, 1999). There is a symbolic tradition in engineering that associates masculinity with technology in what Faulkner (2000, p.761) calls the “durable equation” that has persisted to this day. The women in this study reported being ignored or excluded by their classmates or occasionally their lecturers in a way that is consistent with a lower status group and that alone would mean that they are less likely to have their identities validated. Stets and

Burke (1996, p.195) tell us that “gender… invokes cultural assumptions that men are competent and valuable and that women are incapable and not to be taken seriously; thus, women are placed at a disadvantage.” This cultural assumption may explain the many examples shared by female students of being treated less favourably by their male classmates or some of their male lecturers. This finding is supported by research by Stets and Harrod (2004) who found that higher status individuals such as males (vs females) are better able to achieve identity verification across multiple identities. Stets and Harrod found that status had the same effect in other underrepresented groups, such as whites versus non-whites. Turning down a request for assistance from an ethnic minority student may be a way of signalling his lower status in the group, but my research has not gathered sufficient data to support that suggestion.

5.5 Stress as an outcome of identity non-verification

We tend to think of stress as an imbalance between our resources and the demands placed upon us; we feel stressed when we have too much to do and not enough time to do it in, but identity theory offers a different perspective: Burke (1991,1996) proposes that stress arises when identities are not verified. It is interesting to note that in this research, only minority students (female, ethnic minority and gay men) who may find it more difficult to have their identities validated by virtue of being a minority, reported struggling with the academic work involved in their degree. Although they rarely used the word “stress”, they talked about feeling overwhelmed, struggling to cope with their academic work and with the multiple demands placed upon them by exams, group projects, etc. According to Burke (1991,1996), stress may arise from the interruption in the verification loop of an identity; for first year students and apprentices, moving away from home leaving family and friends behind would create such an interruption as their identities as sons/daughters, siblings, friends, members of their local church or guides group would be disrupted. Lack of opportunities to validate identities that had been important to participants during their schooling, such as helping people to learn or having multiple interests, may also generate stress. A second type of interruption is caused by interference with other identities; for apprentices, having to cope with being students two days per week and employees three days per week may cause interference between those identities. Burke suggests a third type of interruption caused by a tightly controlled identity such as being a high performing student. Many students talked about having high standards for themselves in the context of academic performance; having spent their schooling as high achievers with top grades, they often reported struggling to maintain the same standards of academic achievement in higher education, something that seemed to cause them stress as they fought to maintain their top student identity. The fourth type of interruption according to Burke is caused by the “episodic performance of a role” (Burke, 1991, p.844). One could argue that some of the participants’ identities become episodic as they moved away from home and had fewer opportunities to validate some of the identities associated with their home life.

Findings from this research project suggest that students and apprentices from underrepresented groups (females, ethnic minorities, gay men) are less likely to have their identities validated in engineering education and this may leave them feeling stressed, even though they may not understand what the root cause of that stress is. More research is needed in this area to better support the wellbeing of minority students.

5.6 Experiences that impact the development of an engineering identity

In this section, I report on the experiences shared by students and apprentices that seem to support or challenge the development of their engineering identity. Participants talked at length about the importance of having exposure to engineering experiences ahead of higher education, their experiences in the workplace and in their academic studies, the impact of gender imbalance (particularly felt by female students), and the stereotypical engineer.

5.6.1 Prior engineering experience

Participants commented on the importance of having some degree of exposure to engineering during their schooling, with those students and apprentices who had fewer opportunities to explore the profession before arriving in higher education reporting that they felt they had missed out. Formal courses, such as D&T and Engineering A level provided the clearest path to the engineering profession and seemed to be effective in generating engineering identities in their students: all but one student who reported having done D&T expressed their passion for engineering and envisioned their future in the profession. D&T teachers were also reported to be the most influential, providing validation to their students' engineering identity. I will explore the role of teachers more fully in Section 5.7.2.

5.6.2 *Workplace experience*

The placement year students complete as part of their university degree is an experience that was highly valued by every student. Every final year university student interviewed for this research had completed a placement year and every first-year student intended to do one. The timing of the placement year, following completion of the second academic year and before choosing an area of specialism, seemed to work well for students, as they could apply what they had learned about engineering and about themselves to their year in industry, enabling them to make choices that better suited them and their future careers upon their return to university. For the majority of the students interviewed for this research, the placement year served to confirm their interests and their identities as engineers. However, those students whose placements were not perceived to be "super engineering" may have missed an opportunity to connect more fully with their engineering identity.

Apprentices join the workplace from the start of their degree apprenticeship and hence their workplace experience is very different to that of university students. Whilst most apprentices reported that their work at an engineering company was their favourite part of the degree apprenticeship, the workplace provided ample opportunities for their engineering identities not to be validated. Being the youngest and the only non-qualified person in an engineering team is a daunting experience and something that minority students (female, ethnic minority, gay) felt even more acutely, as there is typically nobody else in their team who looks like them. This could leave apprentices feeling they did not fit in their workplace, something that if it persisted over time, may make them question their place in the engineering profession.

5.6.3 The Degree

Respondents in both engineering programmes researched for this study found their degree demanding despite the obvious differences in their mode of study, as apprentices study part-time whilst university students are enrolled on a full-time degree, with all but one student completing a five year MEng. The challenges posed by the academic curriculum did not seem to abate as students and apprentices progressed through their degree, with final year participants reporting being challenged by it just as much as first year participants. Interestingly, the students and apprentices who talked about struggling with programme content were from groups underrepresented in engineering education: females, ethnic minority students and a gay man.

A comparison of engineering curricula provided in Appendix A shows a remarkable similarity of programme content and structure across different providers in England, showing a consistent emphasis on “hard” technical knowledge to the detriment of everything else. In their report for the Royal Academy of Engineering, Lucas, Hanson and Claxton (2014) quote Ferguson’s assertion that: “the real ‘problem’ of engineering education is the implicit acceptance of the notion that high-status analytic courses are superior to those that encourage the student to develop an intuitive ‘feel’ for the incalculable complexity of engineering practice in the real world” (Ferguson, 1977), an idea that remains current more than four decades later. Respondents at both institutions found the first two years of their degree particularly arid and removed from real-life application. In their longitudinal study of a female engineering student, Godwin, Potvin and Hazari (2014) report how the content of engineering courses is “often tied to understanding complex equations, abstract theories, and getting the right answer” rather than emphasizing the practical and societal importance of engineering knowledge” (p.454). This is something that can discourage female and ethnic minority students, who in this research reported to seek the wider societal implications of engineering work, whilst their white, male classmates seemed to focus more on the technical aspects of engineering. In their study of what constitutes an effective engineer, Newport and Elms (1997) question the tacit assumption shared by engineering education that technical knowledge and numerical ability make effective engineers. They quote Millar (1990), who illustrates the difference between knowing and doing:

"… It is not what a person knows, thinks, believes, or feels that gets wanted results but rather what s/he does and how it is done. The medical practitioner, who faints at the sight of a particular gruesome accident, will be ineffective regardless of his/her technical competence"

Their research shows that "while it is nearly impossible to obtain an engineering degree without being technically competent, numerically skilled, etc., the possession of these qualities does not guarantee success or effectiveness." They go on to acknowledge that "outstanding academic achievement does not necessarily lead to greater effectiveness" in engineering (Newport and Elms, 1997, p.330). This is a realisation shared by several university students returning to university after their year in industry. It is interesting to note that whilst many participants at both institutions felt unhappy about the demands of their degree, none of them made any suggestions as to how their programmes could be improved; they all seemed to assume that engineering degrees have to be the way they are, possibly as a result of the prescriptive and normative role of prototypes in encouraging group members to behave normatively.. My findings support earlier research by Sheppard et al. (2008) in the USA who concluded that engineering education needs to focus on the development of students' engineering identity.

5.6.4 Gender imbalance

Female students and apprentices interviewed for this research shared the challenges they experienced during their schooling, having chosen to study male-dominated subjects such as maths or physics. Whilst they did well academically, they talked about feeling alienated and lonely being the only female in the class or one of a very small minority and having to put up with their classmates' often disruptive behaviour. Burke and Stets (2009, p.115) tell us that "identities acquire meaning through the reactions of others "; when the identity meanings are not shared, individuals may seek validation elsewhere or settle on a compromise as to the meaning of a role identity and the behaviours associated with it. In this case, female students would have their role identities as good and smart students validated by the academic results they achieved and the positive feedback from their teachers; however, some aspect of their role identity would not have been validated as they clearly felt excluded from the social side of their courses, leaving them to seek validation from other groups such as guides, the school's orchestra or their friendship group.

Their experience did not improve once they arrived at university; most female participants reported multiple incidents, more often with male classmates and occasionally with male lecturers, that made them feel disrespected, mistreated or ignored and yet every single one insisted that it was not a problem and that it did not bother them. This behaviour seemed puzzling; why do female students put up with such behaviours without complaining? Research by Seron et al. (2018) with engineering students in the USA may throw some light; they followed four cohorts of engineering students from their first year through to graduation at four engineering schools: MIT, UMass, Smith (a women only programme) and Olin. Their research found that "engineering education successfully reproduces the profession's working culture through processes of socialization that mimic and anticipate the gender bias of the workplace" (Seron et al., 2018, p.133). According to Seron et al. (2018), women respond by adopting the norms of the majority group, therefore contributing to the self-perpetuation of male dominance in the engineering profession. My research findings support Seron et al.'s (2018) as by normalising their experiences of not being treated equally in engineering education, female students are adopting the norms of the majority group and contributing to the self-perpetuation of male dominance. This finding is also consistent with Bourdieu and Passeron's assertion (1990) that social structures have a tendency to reproduce themselves, as I will explore further in Section 5.9. Four times more female participants than males mentioned their gender in their TST responses signalling that gender was a more salient identity for them. This finding is consistent with research by Rees and Nicholson (2000) who found gender to be a salient identity for women in technical environments. Female participants also provided more Category B (social roles) responses than male students, describing themselves more often in social roles than their male classmates. This finding is consistent with research by Babbitt and Burbach (1990), who studied college students in the late 1980s in the USA and found that female students tended to use more Category B responses in their TST.

5.7 Engineering identity supporters or challengers

This section explores who plays a role in supporting or challenging the development of students' and apprentices' engineering identity. It reports on the role played by parents, schoolteachers, lecturers and classmates.

5.7.1 Parents

Research shows that having a parent who is an engineer can strongly influence a young person's choice to study engineering. Work by Godwin, Potvin and Hazari (2014) found that engineering fathers are more likely to have a strong influence on their children choosing engineering, although they do acknowledge that this may be due to the low numbers of mothers in engineering roles. This finding is supported by my own research: nine participants reported that their father was an engineer whilst only one of the mothers was an engineer. Godwin and colleague's study (2014) found no gender differences amongst students whose parents were an engineer; in my own research there is not enough data to draw any conclusions, other than noting that seven female and three male participants had a parent who was an engineer. Having a parent who is an engineer can provide first-hand information about what engineering is and what engineers do, something that is quite hard to find elsewhere. They can organise visits to their workplace and involve their children in helping them with their own work, making engineering more accessible. Seeing someone they respect succeeding as an engineer may support students' beliefs that they can succeed as engineers too. In my research, parents who were not engineers also played an important role in encouraging the identity development of their children as they supported them with their schoolwork and encouraged them to learn and to achieve.

5.7.2 Teachers

Participants in this research talked at length about the role played by certain school teachers in their path towards engineering. Whilst a few participants commented on the teaching style of individual teachers, the one thing most of them remembered was the teacher’s passion for the subject and the fact that they “really cared.” From their descriptions of their relationships with their teachers, it seems clear that they were based on mutual trust and generated a positive feedback loop in which the teachers validated the student’s identity by helping them with projects and providing positive feedback, whilst the students validated the teacher’s identity by engaging in their lessons, completing their assignments and responding to their teachers with respect. The students’ accounts show that their relationships with those teachers went beyond a purely transactional classroom experience based on a rational calculation (I will do this because I want to get a good grade) but instead invoked an emotional response (I will do this because I care about what you think of me and I do not want to let you down). This idea is consistent with research by Burke and Stets (1999) who found that when a person verifies our identity, we develop trust in that person. As a result of the trust and emotional connection of those relationships between the students and their teachers, advice given by the teachers was taken on board, even when the student had initially resisted it. Several participants reported that it was a teacher who first suggested they considered engineering as a career path. This finding is consistent with work by Burke and Stets (1999) who found that identity verification generates positive emotions and trust which contribute to the development of committed relationships and emotional attachment.

5.7.3 Classmates

Students and apprentices can verify each other’s engineering identity when they are supportive and recognise their classmates as engineers. However, when that doesn’t happen, they can hinder the verification of their classmates’ engineering identity. As we have already seen when we looked at student identity in this chapter, overconfident male students may make it more difficult for their female classmates to validate their identities, as a number of female students reported in this study. In a similar way, male students constantly commenting on the appearance of a female classmate, signalling that they see her as a woman rather than as an engineer, would make it difficult for her to validate her engineering identity.

5.7.4 Lecturers

Whilst participants talked at length about some of their schoolteachers, they generally had little to say about their university or degree apprenticeship lecturers. This may be due to the fact that, as a result of Covid-19 restrictions, first year students were limited to online teaching for the best part of their academic year, with face-to-face teaching starting only in their final term. Final year students had a similar experience during the pandemic, although they would have had more time to develop relationships with their lecturers in their previous years at their university or degree apprenticeship. What seems clear from the findings is that lecturers in engineering degree programmes do not seem to develop the same kind of deep and trusting relationships that schoolteachers do, and this would have an impact on the extent to which they are able to influence their students' views and guide their career choices. I can speculate that large class sizes may make it difficult for lecturers at the university under study to get to know their students well, although that constraint would not apply to the DA Provider, where class size is typically around forty apprentices per intake. When engineering lecturers appreciate the participants' work and provide positive feedback, they contribute to verifying the engineering identity of their students and apprentices. However, when they are perceived as being overly critical, sexist or prejudiced, they would not be supporting the development of an engineering identity in some of their students and apprentices.

5.8 Engineering identity and a career in engineering – is there a link?

Engineering students arrive in higher education with an overwhelmingly favourable idea of what engineers are like, a perception that clashes with the prevalent stereotype of engineers as being older, white and techy males with limited interpersonal skills, as described by participants in this research. Students and apprentices who do not fit the prototypical characteristics are likely to find it more challenging to have their engineering identities validated, something that may eventually lead them to abandoning the profession.

Almost half of the respondents admitted that they had chosen to study engineering as a way of keeping their career options open and therefore were not committed to a future in the profession. This represents both an opportunity and a threat: engineering educators need to do more to engage those students with the profession during their studies or risk training future financiers and management consultants rather than practising engineers. My research suggests that there is a link between having an engineering identity and seeing your professional future in engineering, as indicated by those students/apprentices who identified themselves as engineers. However, it is impossible to predict if those students and apprentices will indeed develop their careers in engineering in the future.

The findings from this study suggest that an engineering degree or a degree apprenticeship does not make an engineer and that engineering students do not necessarily develop an engineering identity as they progress through their studies, as indicated by the fact that a similar number of students in their first and final year saw their future in engineering. Whilst other authors have researched the outcome of engineering degrees (see Lichtenstein et al., 2009 for instance), given the novelty of degree apprenticeships as a qualification in England this may well be one of the first studies to look at their effectiveness in developing engineers who will persist in the profession. A surprising finding from this study is that the degree apprenticeship format used by the DA Provider, in which apprentices spend three days in the workplace and two days studying for their degree, does not appear to be any more effective than a traditional engineering degree in developing the engineering identity of their apprentices. It was equally surprising to find that some first-year participants had a strong engineering identity, whilst some final year participants close to graduating with an engineering degree or degree apprenticeship, would not identify themselves as engineers. My research shows that, whilst not all students and apprentices start their engineering education aiming to become an engineer, their programmes of study do not succeed in engaging them with the profession. Their initial perception of engineering as a multifaceted field of study that provides opportunities for creativity and hands-on experience is challenged by an arduous academic curriculum far removed from practical application.

5.9 The engineering profession as a social structure

Bourdieu and Passeron (1990) tell us that social structures have a tendency to reproduce themselves, maintaining existing hierarchies, power structures and inequity, and the engineering profession is no exception. The profession determines who is an engineer and who is not according to established norms; some of the norms are explicit and some are codified in symbolic behaviours; a symbolic tradition in engineering is that males are better at technology than females (Faulkner, 2000 p.761), a belief held by many to this day. Over the years, different organisations in the UK have put in place policies to attract more women and ethnic minorities to engineering with limited success. Those policies are trying to change behaviours but Burke and Reitzes (1981) tell us that it is not the behaviours themselves that matter but rather the symbolic meaning given to those behaviours. An example may serve to illustrate this idea: if when I see a woman engineer, I label her as a "female engineer" and associate a meaning to that label that says, "not very good technically", it is likely that I will exclude her from highly technical projects; in my mind I am choosing the best person for the job. To change my behaviour, I need to reassess the meaning I have attached to the label I assigned to my female colleague (Redmond, 2015) so that when I see the label "female engineer" the meaning associated with it becomes "technically competent" for instance. Technical prowess is a symbolic behaviour that becomes a powerful form of exclusion, as McIlwee and Robinson assert: "To be taken as an engineer is to look like an engineer, talk like an engineer, and act like an engineer. To engage in using tools, tearing apart machinery, and building things: A fascination with and desire to talk at length about these activities is part of the interactional display of the culture of engineering" (1992, p.21).

The findings from my research are consistent with research by Seron and colleagues (2018) with engineering students in the USA who found that, whilst training students for the profession, engineering education supports established tacit patterns of gender inequality in engineering. The students in their research shared experiences of sexism just as they did in mine and yet none of the students complained about them; something I found surprising. Seron et al. suggest that students justify those experiences based on "two values central to engineering cultures: meritocracy and individualism" (2018, p.131). They go on to say that "The unquestioned presumption of meritocracy and the invisibility of its muting effects on critiques resembles … a hegemony of meritocratic ideology" and this is how the culture of engineering endures by turning "potential critics into agents of cultural reproduction" (2018, p.132).

I conclude this section with a quote from Sullivan et al. (2007, p.4): "Professional schools are not only where expert knowledge and judgment are communicated from advanced practitioner to beginner; they are also the place where the profession puts its defining values and exemplars on display, where future practitioners can begin to both assume and critically examine their future identities." Engineering education is not just the place students come to learn the theorical underpinnings of the profession; during their engineering education, students learn what behaviours are expected of engineers and who has the most value. It is the responsibility of engineering educators to ensure they are conveying the values and behaviours future engineers need to succeed rather than transmitting dated and unfair conventions. Engineering educators need to acknowledge and address the symbolic aspects of training for the profession instead of focusing mainly on technical content.

5.10 Limitations of this research

My research studied first and final year students and apprentices on their path to engineering qualification, providing useful insights into the different perceptions held by them at different stages of their engineering education. However, it is not possible to predict how a motivated first year student or apprentice with a strong engineering identity may fare three or four years into her engineering education, or whether an unmotivated first year student or apprentice could develop an engineering identity later in his degree or degree apprenticeship. It is equally impossible to predict from this study the future career path of students or apprentices with or without a strong engineering identity. A longitudinal study following a cohort of students and apprentices from application to graduation and beyond would provide much more data to study this fascinating topic.

An obvious limitation of this research is that it did not include students who abandoned their engineering studies, both at the University and the DA provider. Their insights and experiences would have been very interesting to help us understand why they chose to study engineering in the first place, what made them reconsider their choices and at what stage of their education they took the decision to leave. Exploring the differences between students and apprentices who abandon engineering and those who persevere may enable us to see if their identities differed.

In choosing a purposeful sampling technique, I focused on recruiting British nationals from different genders and ethnic backgrounds as well as different perceived levels of engineering identity. Whilst it was fortunate that the sample included three students from ethnic minorities at each institution, one female and two males in each case, it would have been useful to have had a larger sample of minority participants to work with as they may have provided more insights into their experience in engineering education. It would also be interesting to conduct a larger study with students from both types of institutions, as a larger sample would ensure we had a cross section of participants. An additional potential limitation of my research is that, whilst asking University Tutors and the Apprentice Support Team for their assistance to select students and apprentices was helpful, they may have inadvertently selected or excluded particular types of students from their selection. Finally, it is impossible to assess the impact of the Covid-19 pandemic on research participants, as they experienced limited in-person teaching in their first or their final academic year. Their interactions with lecturers and classmates were significantly limited during successive lockdowns as all teaching was delivered online and it was not possible to access labs.

5.11 Recommendations

Identity theory brings good news to engineering educators: if engineers are made rather than born, everyone has the potential to become an engineer provided they are given the right opportunities to develop their engineering identity. It is often said that it is difficult to attract young people to engineering because of the challenges of conveying what engineers do as their work is so varied, but this could be a strength if the profession takes the view that there is something in engineering for everyone, whatever their strengths and interests. Moving away from the traditional stereotype and prototype of engineers as being male, white, heterosexual, and techy is vital to widen the profession's appeal and to enable engineers who do not fit that profile to validate their engineering identities. My findings support previous research (Pierrakos et al., 2009; Eliot and Turns, 2011; Cook et al., 2018; Godwin, 2016; Beam et al., 2009; Cech et al., 2011, Matusovich, Streveler and Miller, 2010) suggesting that the development of an engineering identity is key to persistence in the engineering profession. However, my research suggests that it is actually the established majority (white males) who need to change to create a more supportive environment in which minority engineers can validate their engineering identities and therefore chose to remain in the engineering profession.

Based on findings from my research, I propose the following initiatives to support the development of an engineering identity in engineering education:

1 To make the development of an engineering identity an explicit objective of engineering education.

As explored in this dissertation, engineering education assumes that the personal and professional attributes required to become an engineer will be developed somehow during the course of the degree; however, where or how this is to happen is never explicit. I propose that developing an engineering identity becomes a formal learning objective of engineering degrees and degree apprenticeships and as such is supported throughout the programme, perhaps via a module that runs along their technical training, with progress evaluated at different stages. Students/apprentices could take the TST during their induction week at the start of their degree in a session exploring their identity: what it is, what types of identities they have and how the process of identity validation works. Such a session would be of great value to students' personal and professional development, at a time in their lives in which they embark on a period of intense growth. Later in their degree, as they explore different engineering specialisms, sessions would include opportunities to network with engineers from those different areas as well as company visits to get a clearer sense of what the roles involve. Important aspects of professional engineering practice such as ethics or communication skills, for instance, would be included in the module and evaluated, to signal to students that these are not "soft" subjects but rather important topics. Some of these sessions could be delivered by professional engineering bodies, helping to establish early links between them and budding engineers. It is important to include time for reflection into the module, so that students can charter their own personal progress and consider what supports or hinders them in their search for their engineering identity.

Although I propose the development of a module focusing on engineering identity, I do not suggest that such a module is the only place in which engineering identity is explored and would expect all engineering lecturers to have an understanding of engineering identity that they can apply in their teaching, so that they can support the development of such an identity in their students.

2 Faculty development

Research by Steinert et al. (2007) in medical education in the USA has showed that faculty development is an essential tool to support the development of a professional identity among students. Engineering faculty need to understand the process of identity validation so that they can better support their students. This will require some level of formal training and a willingness to touch upon engineering identity in their own teaching to make the links between engineering theory and professional practice more explicit. It would be helpful for engineering faculty to have the opportunity to get to know their students well and to develop trusting relationships, something that may be challenging when teaching large groups in lecture theatres. The lack of diversity of engineering faculty needs to be addressed and inappropriate behaviours eradicated.

3 Welcoming newcomers to the community

It would be helpful for engineering students to establish links beyond those of their own cohort and to be introduced to a more diverse set of role models and mentors. Connecting with other engineers from different specialisms as well as different backgrounds (age, gender, ethnicity, nationality) would be of benefit to engineering students as they embark on their path to becoming engineers. A broader and more diverse network would also support students to challenge traditional stereotypes about engineers.

4 Identifying the best workplace opportunities.

The placement year offered by the University in this study has a positive impact in the development of an engineering identity for the majority of students. However, better care could be taken to identify the best placement opportunity for each student, this is to say, the kind of role that will better support the student’s engineering identity. For degree apprentices, the workplace is an opportunity to engage with real engineering work in engineering teams but, given the apprentices’ young age and lack of experience, it is also an opportunity for their engineering identities not to be validated as they struggle to make a contribution, particularly in their earlier work assignments. DA providers would do well to ensure first year students work on engineering projects that are suitable for their level of experience, creating opportunities for them to validate their engineering identities. They should also ensure that apprentices from minority groups have teammates who are similar to them, so that they do not feel isolated. In order to better support apprentices' engineering identities, their teams should focus on giving frequent positive feedback to the apprentices, something that would contribute to validate their identities and give them a sense of belonging in their teams and the profession. This is particularly important for minority students, who can be left feeling very isolated when there is no one who looks like them in their environment.

5 Replacing old symbolic traditions with new ones

Many of the symbolic traditions embedded in engineering practice that I explored earlier in this chapter are outdated and do not support diversity, such as men's superiority with technology and the value of technical prowess over collaboration, for instance. The first step is to make the symbolic aspects of engineering practice explicit so that they can be challenged, and unhelpful practices replaced with better ones. This will require substantial work to change the hearts and minds of engineers so that they can change the meanings they assign to certain labels, such as "female engineer" or "minority engineer". The profession needs to replace the old prototype with a better one and engineering educators are ideally placed to lead this change.

6 Recommendations for policy makers

If the British government is serious about addressing the shortage of engineers, they should restate D&T as a compulsory subject in Key Stage 4 as there is evidence of a clear link between students taking up D&T and progressing onto engineering. Links could be established between schools and the engineering departments of universities/degree apprenticeships to find ways of creating an interest in engineering at a younger age, and opportunities for schoolteachers and university lecturers to collaborate. Companies could also get involved by providing engineering challenges to be incorporated into the curriculum.

Engineers are key to the UK's Industrial Strategy; to deliver the government's ambitious plans the country needs more engineers than is currently producing and closer collaboration between engineering educators, government and industry is required. Despite excellent career prospects, engineering degrees do not attract sufficient numbers of candidates. High fees may be a deterrent, although that would not be the case for engineering apprentices, which have no fees. The high academic grades required to access engineering education may be a barrier to attracting potential engineering talent. It is too early to say if the recent introduction of T Levels in England in September 2022, with their focus on vocational skills and developed by employers and businesses, will contribute to addressing the country's long-standing engineering skills gap.

CHAPTER 6 CONCLUSION

This chapter summarises the key research findings in relation to the research questions, exploring the value and contribution of this research to the wider engineering identity literature. It proposes recommendations for further research so that engineering educators can better support the development of an engineering identity in their undergraduate students and apprentices and informed by identity theory, makes a suggestion as to an approach that can be taken to address the lack of diversity in the engineering profession in the UK. The chapter concludes with some personal reflections on my experience as a part-time doctoral researcher.

6.1 Contribution to the literature

The initial idea for this research originated after reading a report by EngineeringUK (2019) that said that around 35% of women and BME engineering and technology graduates were found to be working in non-engineering roles six months after graduation. Given that engineering in the UK is still a profession dominated by white males, I wondered it that dominance had something to do with the fact that so many women and ethnic minority graduates were leaving the profession. As the project took shape, my aim became to gain new insights into the process of engineering identity development in undergraduate engineering students pursuing two different paths to qualification: a traditional engineering degree and a degree apprenticeship. In my search for answers to the research questions outlined in Chapter 1 (Section 1.9), I found that the development of an engineering identity in undergraduate students is not straightforward and that, whilst some students already have it at the start of their studies, others failed to develop it by the time they graduated. Some of the research participants developed an engineering identity and were committed to a future in the profession; however, for those who did not develop an engineering identity, the engineering profession was simply one of many career options open to them and therefore their future in the profession is not guaranteed. My research confirms the view that an engineering qualification does not make an engineer, a view supported by previous research in this field (Lichtenstein et al., 2009).

Identity theory proved to be a useful framework for the study of engineering identity in undergraduate students and apprentices; rooted in the work of Mead (1934) and Cooley (1902), identity theory posits that our sense of who we are (our identity) is the result of a social process; the identity theory literature provides a detailed explanation of how identities work and the different types of identities available to us that together define how we behave and interact with each other. It was surprising to find that a key concept in identity theory, Powers' perceptual control theory (1973), is based on an engineering notion: Weiner's cybernetic control model (1948), a conceptual framework describing how systems manipulate their environment to achieve desired states. Powers' compelling insight was that when it comes to human beings, the system works by modifying the outputs (behaviours) rather than the inputs (perceptions). Just as our identities develop in social interaction, they cannot be validated in isolation; we depend on interaction with others to generate the reflective appraisals that lead to validation or non-validation of our identities. This idea is important in the context of higher education, where a male student's confident stance may have a negative impact on the identity verification of a less confident female classmate, for instance. Whilst it may well not be the male student's intention to make it more difficult for his female classmate to validate her engineering identity, my research suggests that this is often the outcome. Not everyone has the same opportunities to validate their identities; research shows that higher status individuals are more likely to have their identities validated (Burke, 2008; Stets and Harrod, 2004), the reflective appraisals they provide to others are more influential and they have access to more resources (Cast, Stets and Burke 1999), which means that they are more likely to successfully validate multiple identities (Stets and Harrod, 2004). In line with previous findings from engineering identity research (Fleming et al., 2013; Tonso, 2006; Liptow et al., 2016), this study supports the idea that it is more difficult for minority students to develop an engineering identity as, by virtue of being a minority, they have lower status and are therefore less likely to secure identity validation from their peers and also because their engineering identity standard is likely to include some characteristics they do not meet, such as being white or male.

Identity theory offers insights into the various types of identities students and apprentices claim for themselves. My research suggests that the development of an engineering identity involves all three types of identities, as proposed by Caza and Creary (2016), as it affects the way in which people interact across all three types of identities and hence requires the development of a person, role and group identity. This may explain why it can be harder to develop an engineering identity and more so for minority groups, as outlined above. Whilst other professions in the UK have reached gender parity or are close to it, engineering is conspicuous for its sex segregation, as I highlighted in the previous chapter (Section 5.1.1). Multiple government initiatives, educational institutions and professional bodies have worked to increase the diversity of the engineering profession for decades with limited success. Increasing the number of minority students who choose to study engineering will not address the profession's lack of diversity if a quarter of those students chose roles outside engineering upon graduation. It is perhaps time to recognise that an approach to increasing diversity that focuses primarily on recruitment and attraction has not worked; whilst there has been an increase in female participation in the engineering workforce from 10.5% in 2010 to 16.5% in 2021, a recent report by EngineeringUK (2022) acknowledges that "women were more likely to be in related – rather than core – engineering roles and working in industries outside of what is traditionally deemed to be 'engineering.'" Blackand minority ethnic (BME) talent is also underrepresented in engineering; the Association for Black and Minority Ethnic Engineers (AFBE-UK) reports that only 9% of practicing engineers are from a BME background (AFBE-UK, 2020). Identity theory provides an explanation as to why this approach has not worked, as students from minority groups are less likely to be able to verify their engineering identities than their white classmates. As highlighted above and according to the literature, minority students face a dual challenge: on the one hand they cannot verify their engineering identities without support from their peers and on the other, they are less likely to verify their identities because their condition as a minority renders them as lower status. Their white, male colleagues (classmates, teachers, co-workers) hold the key to their identity validation and consciously or unconsciously, have kept the engineering profession in the UK largely white and male. As I explored in Chapter 2 (Section 2.4.4) it is the meanings we give to the labels we assign to people in interaction that influences our behaviour. To change behaviour, we must reassess those meanings and change the labels accordingly, as illustrated by the example of the male manager who associates women with being less technically competent than men (Section 2.4.4). What is needed to truly bring diversity to the engineering profession is a mindset change of the white male majority so that they can better understand and support the identity validation of their minority colleagues.

A surprising finding from this research is the impact of traditional stereotypes about engineers in the development of students' and apprentices' engineering identity; my research suggests that some of the characteristics of stereotypical engineers have become part of the students' and apprentices' own engineering identity standard. If a student believes engineers are meant to be male, white and highly technical introverts and she doesn't meet some of those characteristics, she will be unable to validate her engineering identity. Failure to validate an engineering identity over time will most likely result in the student leaving the profession, as she seeks to enact behaviours that are consistent with her view of herself (Pierrakos et al. 2009). Eradicating this deeply rooted stereotype is part of the mindset change required to bring diversity to engineering education and the engineering profession.

My research also suggests that different students/apprentices are attracted to engineering for different reasons; whilst white students/apprentices are attracted by the problem-solving nature of engineering, more females and ethnic minority students see engineering as a means of creating new things and making a contribution to society.

Engineering education in England largely overlooks the development of an engineering identity in their students and apprentices, leaving it to chance whether they do indeed develop an engineering identity or not. This need not be so; engineering educators can incorporate interventions into their programmes that support the development of an engineering identity in their students. This idea has been explored in the USA by Liptow and colleagues (2016), who developed an introductory engineering course for first generation and underrepresented students during their first term in engineering education that was found to have a positive impact in the development of an engineering identity and a sense of belonging in their students. Han and colleagues (2018) have studied a wide-ranging culture change programme at a USA university that included developing a shared vision, strengthening academic interaction with industry, reviewing the curriculum and pedagogy and ensuring that organisational policies are supportive of the change process. It would be great to see similar schemes taking shape in England. My recommendations build on those from previous authors, as I suggest that we make the development of an engineering identity a formal learning goal in engineering education, involving engineering faculty, engineering bodies and the profession more broadly in developing a welcoming culture that nurtures budding engineers from diverse backgrounds.

For any initiative that supports the development of an engineering identity in higher education to succeed, the dominant group (white males) need to play their role in verifying the engineering identities of those engineers in the making who are different to them. This requires a level of awareness that I have not yet found. If in the past most of the work to address the lack of diversity in the engineering profession focused on attracting greater numbers of minority students to the profession; my research suggests that it is the white, male majority who needs to understand their role as gate keepers and change their behaviour to support the engineering identity verification of their minority colleagues. Engineering educators also need to acknowledge that different students are attracted to engineering for different reasons; if, as this study suggests, white students are attracted by the problem-solving nature of engineering whilst more females and ethnic minority students are attracted by the idea of creating new things and making a contribution to society, engineering can satisfy those diverse expectations. All that is needed is to recognise the differences and create opportunities to meet the needs of diverse students during their education. It is often said that engineering is such a wide discipline encompassing so many different areas that it makes it hard to explain what it is. This could also be engineering's saving grace as with such a wide array of options, it can offer something of interest to everyone no matter what students are seeking in engineering; whether it is to push the boundaries of artificial intelligence, to find solutions to climate change, to protect us from cyberattacks, to improve the sustainability of manufacturing techniques, to upgrade the country's aging infrastructures or to improve the lives of people with disabilities, engineering can help.

The traditional stereotype of engineers as being white, older, techy men was found to be very much alive in the minds of engineering students and apprentices and is something that can interfere with their engineering identity validation, as some of those characteristics seem to have unconsciously become part of their own engineering identity standard. This poses a real challenge to the development of an engineering identity for students and apprentices who do not fit the stereotype. The profession needs to take an active stance against this stereotype by promoting the work of underrepresented groups, giving them greater visibility, both in academia and in the workplace. It is important to ensure greater diversity in engineering education, where white males still make up the vast majority of engineering faculty at most institutions and hence contribute to supporting the old stereotype in the minds of their students and apprentices.

As explored in Chapter I, degree apprenticeships are expected to become a successful path to engineering qualification by virtue of the professional experience apprentices gain while they qualify and yet, this research suggests that they are no more successful at developing an engineering identity in their students than a traditional engineering degree. The apprentices' exposure to the workplace at such a young age is likely to make them more vulnerable to negative behaviours exhibited by their colleagues (such as sexist behaviours) perpetuating old stereotypes and having a negative impact on the engineering identity verification of women engineers. Joining an engineering team as an eighteen-year-old school leaver they have little to contribute to the workplace, at least initially, something that seems to create ample opportunities for their engineering identities to be challenged rather than validated. Degree apprenticeship providers and employers would do well to look at their programmes and identify opportunities for apprentices to have their identities validated from the outset. This could be done by identifying suitable projects apprentices can get involved with as well as providing mentoring and peer feedback. Employers must ensure that apprentices are not exposed to sexual harassment or any form of discrimination, by creating a supportive culture and implementing a zero-tolerance policy of such behaviours.

Engineering educators could do more to bring engineering to life in the first two academic years of the qualification, when the focus is very much on hard science and far removed from engineering application. Student projects, guest speakers, company visits, etc. can provide a way of keeping the students' interest and focus on the longer-term goal of qualification. Professional engineering bodies do not seem to have a presence in the lives of most engineering students in England other than by accrediting their degrees. There is scope for greater involvement of professional organisations in engaging with engineering students to support the development of their engineering identities through outreach activities and opportunities to promote diversity in the engineering profession.

Some of the engineering students and apprentices who took part in this research, particularly female and ethnic minority students, shared that they felt overwhelmed in their engineering education, regardless of whether they were studying full time or part time. They complained about heavy workloads and reported to struggle to achieve a good work/life balance, something that had a negative impact on their mental health. Student wellbeing has become a major concern for higher education providers in the UK, who struggle to meet an ever-increasing demand for student support services. Identity theory suggest that stress may be an outcome of students' identities not being validated; if students understood more about their identities, what happens when there is a conflict between different identities and how identities can be successfully validated, they may feel more empowered to make choices that support their identities and improve their wellbeing.

6.2 Future directions for research

Identity theory has an important contribution to make to the study of professional identity development in general and engineering identity development in particular. Using identity theory as a framework for the empirical study of person, role and group identity in engineering students and apprentices provides much needed information on how to support the development of an engineering identity in students and apprentices with diverse backgrounds, something that would benefit the engineering profession by virtue of attracting more diverse points of view and greater innovation as well as ensuring that the country can train and retain the number of engineers it needs. Traditionally, identity theory has focused on the study of role identities and therefore more research is needed to study person, group and social identities and how they interact. Identity theory could also guide further research into possible links between engineering identity, stress and the mental health of engineering students and apprentices, a topic of great concern at higher education providers in the UK.

Further qualitative research could provide more insights into the experience of underrepresented groups in engineering education such as females or ethnic minorities but also disabled students or those with learning differences. Additional research could also explore the impact of intersectionality of gender and race in engineering education. A quantitative study could explore if the findings from this qualitative research apply to larger populations of engineering students in the UK and internationally.

Another area that warrants further research is the finding that students with different profiles (males vs. females, white vs. non-whites) have a different expectations of what it means to be an engineer, something that has not been widely explored in the engineering identity literature or indeed in the broader identity literature, and an area that may provide clues as to how to better attract a more diverse student body to engineering.

New thinking is required to address the shortage of engineers and therefore it would be wise to research alternative paths into an engineering career. Research could explore whether the North American model of graduate education required to access some professions, such as medicine or law, could be extended to engineering, or whether alternative paths for more mature learners could be an option. Engineering educators may also like to examine how engineering degrees are promoted and whether a greater focus on engineering as a vocation rather than engineering as training for other professions may better support the development of an engineering identity and encourage persistence in the profession.

6.3 Reflections and closing thoughts

Embarking on a doctorate whilst working full time was always going to be a challenging proposition; the DBA team did warn me that it would involve a great deal of work, I just had no appreciation as to how much! Despite the vast number of hours involved, I have thoroughly enjoyed my doctorate. I was very lucky to fall in love with the topic I was researching even if at times this posed additional challenges: I simply found everything so interesting that I could easily spend weeks reading articles of little relevance to my research. I had to learn to be more focused and to put aside papers that, whilst interesting, had little to do with the work in hand. I sorely missed my classmates and the intense modules that made up the first couple of years of the DBA programme. As we completed the taught element, everyone seemed to move at different speeds and it became harder to stay in touch with each other. It was lonely work and, as an extrovert, I was surprised by how much I enjoyed the many hours spent doing research and writing. Having said that, it was never easy; a number of times over the years I wondered if I had made a terrible mistake and should simply cut my losses and do something else; I often felt lost, overwhelmed and had doubts as to the direction I was following. My innate lack of confidence posed a major challenge that my supervisors' support and encouragement kept at bay. Perhaps my saving grace was perseverance: I never stopped working.

Before embarking on this journey, I knew little about identity theory and the process of identity validation but somehow identity theory resonated with me. The more I learnt about it, the better I understood some of my own experiences, such as the stress I felt earlier on in my career as a mother to two young daughters in a demanding professional role. Those challenging years put my mental and physical resilience to the test; I wish I had understood then that I was dealing with two conflicting identities: my identity as a mother and my identity as a professional woman in a male-dominated environment. Immersing myself in the literature whilst doing my research meant that I came to see every situation through an identity theory lens: if the relationship with my husband worked it was because we validated each other's spouse identity; if one of my students was stressed, he was experiencing an identity clash; when a member of my team struggled at work it was due to her person identity not aligning with the institution's identity. Identity theory seemed to provide the answer to so many questions that I wondered how I had not heard of it before. Looking at some of the most challenging issues faced by higher education through an identity theory lens provides a totally different point of view and a novel approach to finding a solution; widening participation, for instance, becomes a problem that the majority (rather than the minority) needs to fix and therefore something to requires a substantial culture change rather than simply better outreach.

The engineering profession in the UK remains to this day a bastion of male dominance. Other professions such as law or medicine have reached (or are close to reaching) gender parity if not gender equality, as men still dominate the higher echelons of those professions. Nevertheless, engineering's performance in terms of gender balance or ethnic diversity remains dismal. Engineers are great at fixing complex problems, how come they have not found a solution to this one yet? I would humbly suggest that they have been looking at the wrong problem. White, male engineers are very good at verifying the identities of white, male engineers. It comes naturally to them; they do not even realise they are doing it. However, when it comes to people who are different to themselves, they simply do not know how to do it. This is what needs to change, and higher education can help by developing the vision and facilitating the discussion towards a shift in mindset. I am not suggesting that it will be easy; cultures are notoriously hard to change, but I do believe it is the right approach.

THE APPENDICES

APPENDIX A Course content and structure of eight engineering degrees in England

Table of Contents

This appendix outlines the course content and structure of engineering programmes available at six established universities in England who offer either a mechanical engineering degree or a general engineering degree and two new institutions who opened their doors to their first cohorts in September 2021: New Model Institute for Technology and Engineering (NMITE) and The Engineering & Design Institute London (TEDI-London). The focus of every degree is eminently technical, with only the University of Warwick and TEDI-London offering one non-technical unit each:

- Warwick's Introduction to Engineering: Professionalism & Practice is a five-credit unit designed to help students decide which engineering discipline they wish to focus on, to provide essential tools such as communication skills, professionalism and ethics, and to prepare them for internships and future employment. The unit introduces students to the UK Standard for Professional Engineering Competence and to continuing professional development.
- TEDI-London's Advanced professional skills & portfolio module offers students the opportunity to start to develop their personal and professional portfolio using the Engineering Council's framework to path their progress towards becoming a professional engineer.

The courses outlined here and provided by the six established universities were mentioned by the students in this research as part of their UCAS choices and are all highly ranked. The information contained here refers to 2023 entry.

1. University of Cambridge

Degree: MEng Mechanical Engineering. Entry requirements: A*A*A

Year 1 Mechanical Engineering: mechanics, mechanical vibrations & thermofluid mechanics Structures & Materials Electrical & Information Engineering: Physical principles of electronics & electromagnetics, linear analysis of circuits & devices and digital circuits & information processing Mathematical Methods	coursework activities and projects, on topics including structural design, product design, presentation skills, drawing, laboratory experiments and computer programming.
Year 2 Mechanics Structures Materials Thermofluid Mechanics Electrical Engineering: linear circuits & devices, electrical power & electromagnetic fields & waves Information Engineering: linear systems & control, communications and Fourier transforms 7 signal & data analysis Mathematical Methods: vector calculus, linear algebra and probability The engineer in business	+ options to choose from: Aerothermal engineering Mechanical engineering Civil and structural engineering Bioengineering Manufacturing & management Information engineering Electrical engineering Option of a language programme for engineers
Year 3 Students choose options towards their area of specialisation: Mechanical engineering Energy, sustainability & the environment Aerospace & aerothermal engineering Civil, structural & environmental engineering Electrical & electronic engineering Information & computer engineering Electrical & information sciences Instrumentation & control Bioengineering	
Year 4 The range of modules available is similar to that in year three (though studied at a more advanced level), but also includes additional modules in topics of cross-disciplinary interest such as Sustainable Development, Nuclear Energy, Engineering Mathematics & foreign languages & modules in relevant topics from other courses within the University.	Students choose to specialist in a particular engineering area or to qualify in General Engineering

Available from: https://www.admissions.eng.cam.ac.uk/course/fourthyear

Accessed 18 March 2022

2. University of Oxford

Degree: MEng in Engineering Science. Entry requirements: A*A*A

All Engineering students study core topics in the first two years which are relevant to all major engineering specialisms. Students can then choose to specialise in one of the eight branches of Engineering Science: Biomedical, Chemical & process, Civil & offshore, Control, Electrical & opto-electronic, Information, Solid materials & mechanics and Thermofluids & turbomachinery.

<table>
<tr><td>Year 1
Mathematics
Electronic & Information Engineering
Structures & Mechanics
Energy
Engineering Coursework</td><td rowspan="2">All Engineering students study core topics in the first two years which are relevant to all major engineering specialisms.</td></tr>
<tr><td>Year 2
Mathematics
Electronic & Information Engineering
Structures, Materials & Dynamics
Energy Systems
Engineering Practical Work</td></tr>
<tr><td>Year 3
Papers (choose 5 options)
Engineering Computation
Engineering in Society
Group Design Project (3rd Year Project)
Engineering Practical Work</td><td rowspan="2">In the third and fourth years, students are able to specialise in one of six areas of engineering: Biomedical, Chemical, Civil, Electrical, Information and Mechanical. An exclusive pathway in Entrepreneurship and Innovation is also available for engineers who have entrepreneurial ambition.</td></tr>
<tr><td>Year 4
Papers (choose 6 options)
4th Year Project</td></tr>
</table>

Available from: https://eng.ox.ac.uk/study/undergraduate/your-degree/

Accessed: 18 March 2022

3. University of Bristol

Degree: MEng Mechanical Engineering. Entry requirements: A*AA

Year 1 Engineering mathematics 1 Engineering science Engineering y investigation Principles of mechanical engineering	Year 2 Engineering mathematics 2 Thermofluids Dynamics & control Materials engineering Engineering practice
Year 3 - Optional placement year	
Year 4 Individual research project Behaviour of dynamic systems Applied solid mechanics Engineering management Fluid mechanics & heat transfer	(No optional modules)
Year 5 Group industrial project plus either: Advanced topics in mechanical engineering or Advanced topics in mechanical engineering Computer based modelling	Optional modules Control & robotics Product & production systems Structural integrity & non-destructive evaluation Probability & statistics for seismology & structural reliability Innovation, entrepreneurship & enterprise

Available from: https://www.bris.ac.uk/unit-programme-catalogue/RouteStructureCohort.jsa?byCohort=Y&cohort=Y&routeLevelCode=4&ayrCode=23%2F24&modeOfStudyCode=Full+Time&programmeCode=4MECH008U

Accessed: 18 March 2022

4. University of Warwick

Degree: Mechanical Engineering MEng. Entry requirements: A*AA

Year 1 Dynamics & Thermodynamics Electrical & Electronic Circuits Engineering Design Engineering Mathematics Introduction to Engineering Business Management Introduction to Engineering: Professionalism & Practice (*) Materials for Engineering Statics & Structures Systems Modelling, Simulation & Computation	Optional extra modules: A modern foreign language (*) This module provides an introduction to the various engineering disciplines and career pathways. It also includes content on ethics, health & safety, communication, institutional membership and various skills.
Year 2 Dynamics & Fluid Mechanics Electromechanical System Design Engineering Mathematics & Data Analytics Technical Operations Management Core modules from one of the engineering disciplines	Optional modules from the same engineering discipline
Year 3 Dynamics of vibrating systems Engines & heat pumps Fundamental fluid mechanics for mechanical engineers Finite element methods Advanced mechanical engineering design Precision, measurement & control Individual project	Year 4 Group project

Available from:

https://warwick.ac.uk/study/undergraduate/courses/mechanicalengineeringmeng/

Accessed: 18 March 2022

5. University of Leeds

Degree: Mechanical Engineering MEng. Entry requirements: A*AA

Year 1 Computers in engineering analysis Design & manufacture 1 Thermofluids 1 Solid mechanics Engineering materials Engineering mathematics	Students study compulsory modules in years one and two to establish the core mechanical engineering projects.
Year 2 Engineering mechanics Vibration & control Design & manufacture 2 Economics & management Mechatronics & measurement systems Thermofluids	
Year 3 Thermofluids 3 Additive manufacturing Individual engineering project Finite element methods of analysis	Optional modules Biomedical engineering design Vehicle design & analysis
Year 4 Team project	Optional modules Design optimisation Electric & hybrid drivetrain engineering Automotive chassis engineering Engineering computational methods Energy systems, policy & economics for engineers Tribology & surface engineering Biomaterials Functional joint replacement technology' Aerospace structures Rotary wing aircraft Vehicle systems engineering Computational fluid dynamics analysis

Available from: https://eps.leeds.ac.uk/courses/UG/F411/mechanical-engineering

Accessed: 18 March 2022

6. University of Exeter

Degree: MEng General Engineering. Entry requirements: AAA

Year 1 Engineering mathematics & scientific computing Multi-disciplinary group challenge project fundamentals of mechanics, materials & electronics entrepreneurship 1	Year 2 Sustainable design challenge project# Solid mechanics Introduction to fluid dynamics Modelling engineering systems Entrepreneurship 2 Industry 4.0 Structural behaviour
Year 3 - optional placement year	
Year 4 – core Control engineering Materials manufacturing Mechanical design & build: part 1 – research Structural dynamics Thermodynamics & heat transfer Mechanical design & build: part 2 – development Structures & finite elements analysis	Year 4 – optional modules Fluid dynamics & CFD Mechatronics Operations management Energy & the environment
Year 5 – core MEng individual investigative project	Year 5 – optional modules Advanced finite element analysis Composite materials Sustainable manufacturing Additive manufacturing Metamaterials Design, innovation & entrepreneurship Advanced CFD Advanced finite element analysis Multivariable state-space control Sustainable manufacturing Nonlinear control Robotics & automation Data-centric engineering

Available from:

http://www.exeter.ac.uk/undergraduate/courses/engineering/mechanicalmeng/#course-content

Accessed: 18 March 2022

7. New Model Institute for Technology and Engineering (NMITE)

Awarding institution: The Open University. Entry requirements: BBB at A level or equivalent.

Degree: MEng Integrated Engineering (3 years)

First intake: September 2021

This course is a challenge-based programme organised around a series of 3.5 week-long modules during which the five main pillars of engineering are covered:

- Integrated systems,
- Electrical & electronic engineering,
- Flow, heat & energy,
- materials & processes and
- Statics & dynamics.

Level 4 Certainty Engineering materials & processes Introduction to electrical & electronic engineering statics & structures Programming Making it happen Integrated systems Introduction to flow, heat & energy dynamics	Level 6 Advanced materials & processes Advanced solid mechanics Past, present & future Community based challenge: concept 2 Community based challenge: prototype 2 Integrated electronic engineering Thermal fluids Advanced control systems Independent development project
Level 5 Community based challenge: prototype 1 Electromagnetics in engineering Structural materials & their innovation Information Control systems Energy systems Manufacturing systems optimisation Creativity in a team	Level 7 Advanced integrated engineering – infrastructure Advanced integrated engineering – energy Advanced integrated engineering – health Advanced integrated engineering – security Master's engineering project

Available from: https://nmite.ac.uk/meng-integrated-engineering/course

Accessed: 18 March 2022

8. The Engineering & Design Institute (TEDI) - London

Degree: MEng Integrated Master of Engineering. Entry requirements: BBB at A level or equivalent.

First intake: September 2021

TEDI-London's degree is a project-based programme comprising core modules (no options are available). It is an interdisciplinary degree and therefore it does not offer specialisations.

Year 1 Introduction to engineering design Reverse engineering for design Prototyping Modelling & simulation in engineering Designing for smart cities 1 Applied professional skills & portfolio (*)	Year 3 Design for advanced manufacturing Global design engineering individual project Innovation & entrepreneurship in design Professional & personal portfolio (*)
Year 2 Design for manufacture User-centred product design The living lab Ecological design Designing for smart cities 2 Advanced professional skills & portfolio (*)	Year 4 User-centred global design Professional & personal portfolio (*) Global engineering design masters individual project

(*) In this module students develop their personal and professional portfolio, using the Engineering Council's framework to show progress towards becoming a professional engineer.

Available from: https://tedi-london.ac.uk/learn/global-design-engineering/

Accessed: 18 March 2022

APPENDIX B Research documentation

PARTICIPANT INFORMATION SHEET

Research Project: Exploring the development of engineering identity in an apprenticeship degree and a university degree

Researcher: Maria Elena Liquete Cotera
melc21@bath.ac.uk

Supervisors: Prof. Gina Wisker
gw647@bath.ac.uk

Dr. Elies Dekoninck
ensead@bath.ac.uk

This information sheet forms part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. Please read this information sheet carefully and ask one of the researchers named above if you are not clear about any details of the project.

1. What is the purpose of the project?

Every year, around 30% of engineering graduates (mainly female and ethnic minority graduates) choose roles outside engineering. Given that engineering as a profession struggles to attract recruits, this represents a significant loss of qualified talent the profession can ill afford. A possible reason why engineers choose not to practice after qualifying may be that they have not developed a professional engineering identity during their engineering education. Engineering education focuses on technical knowledge and skills and does not necessarily facilitate the development of an engineering identity. If we knew more about the process of professional identity formation in engineering education and the impact of educators in validating it, we could design interventions to support the development of engineering identity in our students.

2. Why have I been selected to take part? Who can be a participant?

You have been selected for this study because you are currently a first or a fourth year student of mechanical engineering at a University or a first or forth year student at a DA Provider and are a British national.

3. Do I have to take part?

Participation in this research project is entirely voluntary. It is up to you to decide if you would like to take part. Before you decide to take part, I will describe the project and go through this information sheet with you. If you agree to take part, I will ask you to sign a consent form. However, if at any time you decide you no longer wish to take part in the project, you are free to withdraw, without giving a reason.

4. What will I be asked to do?

You will be asked to take part in an interview which will take place using Microsoft Teams. The interview will be recorded and may last between one to two hours. After the interview, I may come back to you and ask you to clarify some points that perhaps were not clear, or I may ask you to take part on a follow up interview. Two weeks after the interview has taken place, I will produce a transcript as a Word file the video recorded will be deleted. The Word file will not contain your name, participants will be referred to as “student1” “student2” and so on.

5. What are the exclusion criteria? (are there reasons why I should not take part)?

I am only interviewing British students because different cultures understand identity differently and my study will focus on just one culture (British nationals).

6. What are the possible benefits of taking part?

There are no obvious direct benefits of taking part in this project. However, you may find that reflecting on the choices that you have made in your life that brought you to your current programme of study and reflecting on your identity may give you new insights or clarify your thinking about your future.

7. What are the possible disadvantages and risks of taking part?

There are no obvious disadvantages to you for taking part in this research project. If I ask you any questions that you would rather not answer for any reason, you can choose not to answer.

8. Will my participation involve any discomfort or embarrassment?

I don’t expect you to feel discomfort or embarrassment from taking part in my research. If however you feel uncomfortable at any time during the interview or appear upset, I will stop the interview straight away and will direct you to approach an appropriate student support service.

9. Who will have access to the information that I provide?

Only the research team will have access to the information you provide (that is myself and my supervisors). All the information you provide will be treated as confidential.

10. What will happen to the data collected and results of the project?

I am conducting this research as part of the requirements of the Doctor in Business Administration programme at the University of Bath School of Management. All data collected during the project including personal, identifiable data, will be treated as confidential and saved on a password protected file on the University of Bath´s secure server (X drive). The storage of data will be done in accordance with GDPR. Your name or other identifying information will not be disclosed in any presentation or publication of the research.

After the project has finished, I will provide participants with a summary of my findings if they would like that. This summary will not include any identifiable information and will show the overall findings of the project.

11. Who has reviewed the project?

This project has been given a favourable opinion by the University of Bath, Social Science Research Ethics Committee (SSREC).

12. How can I withdraw from the project?

You can withdraw from the project at any point without providing reasons for doing so and without consequence for yourself. Please contact me by email if you wish to stop participating before completing all parts of the project.

If, for any reason, you wish to withdraw your data please contact me within two weeks of your participation. After this date, it may not be possible to withdraw your data as it would have been anonymised and amalgamated with other research data and cannot then be excluded. However, your individual contribution will not be identifiable in any way in any presentation or publication.

13. University of Bath privacy notice

The University of Bath privacy notice can be found here:

https://www.bath.ac.uk/corporate-information/university-of-bath-privacy-notice-for-research-participants/

14. What happens if there is a problem?

If you have a concern about any aspect of the project please speak to me in the first instance, or my supervisors, and we will do our best to answer any questions you may have. If we are unable to resolve your concern, or you wish to make a complaint regarding the project, please contact the Chair of Social Sciences Research Ethics Committee (SSREC) at ssrec@bath.ac.uk.

15. If I require further information who should I contact and how?

Please don't hesitate to contact me or my supervisors for any further information you may require. Our email addresses are provided at the top of this form.

Thank you for expressing an interest in participating in this project. Please do not hesitate to get in touch with myself or my supervisor if you would like additional information. Our email addresses are at the top of this form.

PARTICIPANT CONSENT FORM

Research Project: Exploring the development of engineering identity in an apprenticeship degree and a university degree

Researcher: Maria Elena Liquete Cotera
melc21@bath.ac.uk

Supervisors: Prof. Gina Wisker
gw647@bath.ac.uk
Dr. Elies Dekoninck
ensead@bath.ac.uk

Please initial box if you agree with the statement

1	I have been provided with information explaining what participation in this project involves.	
2	I have had an opportunity to ask questions and discuss this project.	
3	I have received satisfactory answers to all questions I have asked.	
4	I have received enough information about the project to make a decision about my participation.	
5	I understand that I am free to withdraw my consent to participate in the project at any time without having to give a reason for withdrawing.	
6	I understand that I am free to withdraw my data within two weeks of my participation.	
7	I understand the nature and purpose of the procedures involved in this project. These have been communicated to me on the information sheet accompanying this form.	
8	I understand and acknowledge that the investigation is designed to promote scientific knowledge and that the University of Bath will use the data I provide only for the purpose(s) set out in the information sheet.	
9	I understand the data I provide will be treated as confidential, and that on completion of the project my name or other identifying information will not be disclosed in any presentation or publication of the research.	
10	I understand that my consent to use the data I provide is conditional upon the University complying with its duties and obligations under the Data Protection Act.	
11	I understand that after signing this form, I will be given a copy for my records.	
12	I hereby fully and freely consent to my participation in this project.	

Participant's signature: ______________________________ Date: ________________

Participant name in BLOCK Letters: _______________________________________

Researcher's signature: ______________________________ Date: ________________

Researcher name in BLOCK Letters: _____________________________________

If you have any concerns or complaints related to your participation in this project, please direct them to the DREO, Dr. Tahiru Lieodng, T.A.Liedong@bath.ac.uk

PARTICIPANT DEBRIEFING INFORMATION

Research Project: Exploring the development of engineering identity in an apprenticeship degree and a university degree

Researcher: Maria Elena Liquete Cotera
melc21@bath.ac.uk

Supervisors: Prof. Gina Wisker
gw647@bath.ac.uk

Dr. Elies Dekoninck
ensead@bath.ac.uk

Thank you for taking part in this project which has been investigating the development of engineering identity in students enrolled on an Integrated Design Engineering programme at a University and a degree apprenticeship at DA Provider. Your contribution is very much appreciated.

May I remind you that the data you have provided remains confidential, and that your name or other identifying information will not be disclosed in any presentation or publication of the research.

When my findings become available, I will send you a summary of my research in case it is of interest. I will also be happy to have a follow up meeting with you to explore the results further.

Thank you again for participating in my research. If you would like to speak to us about the project, please get in touch.

APPENDIX C Twenty Statement Test

Kuhn and McPartland (1954)

Who am I?

1. I am…
2. I am…
3. I am…
4. I am…
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18. I am…
19. I am…
20. I am…

APPENDIX D Pilot interview script

Adapted from McAdams, 2008.

Introduction

This is an interview about the story of your life and the path that took you here, to your engineering degree/degree apprenticeship. As a social scientist, I am interested in hearing your story, including parts of the past as you remember them and the future as you imagine it. The story is selective; it does not include everything that has ever happened to you. Instead, I will ask you to focus on a few key things in your life that brought you to your engineering degree/degree apprenticeship – a few key scenes, characters, and ideas. There are no right or wrong answers to my questions. Instead, your task is simply to tell me about some of the most important things that have happened in your life and how you imagine your life developing in the future. I will guide you through the interview so that we finish it all in no more than ninety minutes.

Please know that my purpose in doing this interview is not to figure out what is wrong with you or to do some kind of deep clinical analysis! Nor should you think of this interview as a "therapy session" of some kind. The interview is for research purposes only, and its main goal is simply to hear your story. Everything you say is voluntary, anonymous, and confidential.

I think you will enjoy the interview. Do you have any questions?

Interview Script

1. About Engineering

Engineering is a broad discipline; I am interested to hear what engineering means to you. What do engineers do? Please explain what attracted you to studying engineering and to your choice of a degree/degree apprenticeship. What other options did you consider?

2. The chapters of your life

Please begin by thinking about your life and the path you followed to get to where you are now as if it were a book or novel. Imagine that the book has a table of contents containing the titles of the main chapters in the story. To begin here, please describe very briefly what the main chapters in the book might be. Please give each chapter a title, tell me just a little bit about what each chapter is about, and say a word or two about how we get from one chapter to the next. please keep your descriptions of the chapters relatively brief.

[Note to interviewer: The interviewer should feel free to ask questions of clarification and elaboration throughout the interview, but especially in this first part. This first section of the interview should run between 15 and 30 minutes.]

3. Key Scenes in your Life Story

Now that you have described the overall plot outline for the journey that you followed to get here, I would like you to focus in on a few key scenes that stand out in the story as particularly relevant to your choice of an engineering degree. A key scene would be an event or specific incident that took place at a particular time and place. Consider a key scene to be a moment in your life story that stands out for a particular reason – perhaps because it was especially good or bad, particularly vivid, important, or memorable. For each of the key events we will consider, I ask that you describe in detail what happened, when and where it happened, who was involved, and what you were thinking and feeling in the event. In addition, I ask that you tell me why you think this particular scene is important or significant in your choice of engineering. What does the scene say about you as a person? What does it say about you as an engineer? Please be specific.

3.1 High Point

Please describe a scene, episode, or moment in your path to engineering that stands out as an especially positive experience. Please describe this high point scene in detail. What happened, when and where, who was involved, and what were you thinking and feeling? Also, please say a word or two about why you think this particular moment was so good and what the scene may say about who you are as a person and as an engineer.

3.2 Low Point

The second scene is the opposite of the first. Thinking back over your entire life, please identify a scene that stands out as a low point in your path to engineering. Even though this event may be unpleasant, I would appreciate your providing as much detail as you can about it. What happened in the event, where and when, who was involved, and what were you thinking and feeling? Also, please say a word or two about why you think this particular moment was so bad and what the scene may say about you as a person and as an engineer.

[Interviewer note: If the participant has difficulty with this, tell him or her that the event does not really have to be the lowest point in the story but merely a very bad experience of some kind.]

3.3 Turning Point

In looking back over your life, it may be possible to identify certain key moments that stand out as turning points in your path to an engineering career -- episodes that marked the direction of travel or gave you new insights. . Please identify a particular episode in your life story that you now see as a turning point in your path to studying engineering. If you cannot identify a key turning point that stands out clearly, please describe some event in your life wherein you went through an important change of some kind. Again, for this event please describe what happened, where and when, who was involved, and what you were thinking and feeling. Also, please say a word or two about what you think this event says about you as a person or about your life.

3.4 Positive Childhood Memory linked to engineering

Think about an early memory – from childhood or your teen-aged years – that stands out as especially positive in some way on your path to engineering. This would be a very positive, happy memory from your early years. Please describe this good memory in detail. What happened, where and when, who was involved, and what were you thinking and feeling? Also, what does this memory say about you or about your life? If you can't think of a scene that is connected to engineering, think about a positive childhood memory.

3.5 Negative Childhood Memory connected to engineering

Think about an early memory connected to engineering – from childhood or your teen-aged years – that stands out as especially negative in some way. This would be a very negative, unhappy memory from your early years, perhaps entailing sadness, fear, or some other very negative emotional experience somehow connected to your engineering path. Please describe this bad memory in detail. What happened, where and when, who was involved, and what were you thinking and feeling? Also, what does this memory say about you or your life? If you can't think of a scene that is connected to engineering, think about a negative childhood memory.

3.6 Vivid Adult Memory linked to engineering

Moving ahead to your adult years, please identify one scene that you have not already described in this section (in other words, do not repeat your high point, low point, or turning point scene) that stands out as especially vivid or meaningful in your path to engineering). This would be an especially memorable, vivid, or important scene, positive or negative, from your adult years that connects you to engineering. Please describe this scene in detail, tell me what happened, when and where, who was involved, and what you were thinking and feeling. Also, what does this memory say about you or your life?

Now, we're going to talk about the future.

4. Future Script

4.1 The Next Chapter

Your life story includes key chapters and scenes from your past, as you have described them, and it also includes how you see or imagine your future. Please describe what you see to be the next chapter in your life. What happens after graduation? What is going to come next in your life story?

4.2 Dreams, Hopes, and Plans for the Future

Please describe your plans, dreams, or hopes for the future. What do you hope to accomplish in the future in your life story?

4.3 Life Project

Do you have a project in life? A life project is something that you have been thinking about and plan to work on in the future chapters of your life story. The project might involve your family or your work life, it may have to do with engineering, or it might be a hobby or pastime. Please describe any project that you are currently thinking about or plan to work on in the future. Tell me what the project is, how you got involved in the project or will get involved in the project, how the project might develop, and why you think this project is important for you and/or for other people.

5. Challenges

This next section considers the various challenges, struggles, and problems you have encountered in your life. I will begin with a general challenge, and then I will focus in on some particular areas or issues where many people experience challenges, problems, or crises.

5.1 Life Challenge

Looking back over your entire life, please identify and describe what you now consider to be the greatest single challenge you have faced in your life. What is or was the challenge or problem? How did the challenge or problem develop? How did you address or deal with this challenge or problem? What is the significance of this challenge or problem in your own life story?

5.2 Health

Looking back over your entire life, please identify and describe a scene or period in your life, including the present time, wherein you or a close family member confronted a major health problem, challenge, or crisis. Please describe in detail what the health problem is or was and how it developed. If relevant, please discuss any experience you had with the health-care system regarding this crisis or problem. In addition, please talk about how you coped with the problem and what impact this health crisis, problem, or challenge has had on you and your overall life story.

5.3 Loss

As we go through life, we all suffer losses of one kind or another. By loss I am referring here to the loss of important people in your life, perhaps through death or separation. These are interpersonal losses – the loss of a person. Looking back over your entire life, please identify and describe the greatest interpersonal loss you have experienced. This could be a loss you experienced at any time in your life, going back to childhood and up to the present day. Please describe this loss and the process of the loss. How have you coped with the loss? What effect has this loss had on you and your life story?

5.4 Failure, Regret

Everybody experiences failure and regrets in life, even for the happiest and luckiest lives. Looking back over your entire life, please identify and describe the greatest failure or regret you have experienced. The failure or regret can occur in any area of your life – work, family, friendships, or any other area. Please describe the failure or regret and the way in which the failure or regret came to be. How have you coped with this failure or regret? What effect has this failure or regret had on you and your life story?

6. Personal Ideology

Now, I would like to ask a few questions about your fundamental beliefs and values and about questions of meaning and morality in your life. Please give some thought to each of these questions.

6.1 Religious/Ethical Values

Consider for a moment the religious or spiritual aspects of your life. Please describe in a nutshell your religious beliefs and values, if indeed these are important to you. Whether you are religious or not, please describe your overall ethical or moral approach to life.

6.2 Political/Social Values

How do you approach political or social issues? Do you have a particular political point of view? Are there particular social issues or causes about which you feel strongly? Please explain.

6.3 Engineering values

What are your values as an engineer? What do you see as the purpose of engineering? Please explain.

6.4 Change, Development of Religious and Political Views

Please tell the story of how your religious, moral, and/or political views and values have developed over time. Have they changed in any important ways? Please explain.

6.5 Single Value

What is the most important value in human living? Please explain.

6.6 Other

What else can you tell me that would help me understand your overall philosophy of life?

7. Life Theme

Looking back over your entire life story with all its chapters, scenes, and challenges, and extending back into the past and ahead into the future, do you discern a central theme, message, or idea that runs throughout the story? What is the major theme in your life story? What is the role of engineering in your life? Please explain.

8. Reflection

Thank you for this interview. I have just one more question for you. Many of the stories you have told me are about experiences that stand out from the day-to-day. For example, we talked about a high point, a turning point, etc. Given that most people don't share their life stories in this way on a regular basis, I'm wondering if you might reflect for one last moment about what this interview, here today, has been like for you. What were your thoughts and feelings during the interview? How do you think this interview has affected you? Do you have any other comments about the interview process?

APPENDIX E Main study interview script

Adapted from McAdams, 2008

Introduction

Thank you for making the time to have this interview with me. I am researching identity development in engineering students and am interested in the path that took you here, to your engineering degree/degree apprenticeship. I am interested in hearing your story, including parts of the past as you remember them and the future as you imagine it. The story is selective; it does not include everything that has ever happened to you. Instead, I will ask you to focus on a few key things in your life that brought you to your engineering degree/degree apprenticeship – a few key scenes, characters, and ideas. There are no right or wrong answers to my questions. Instead, what I ask you to do is simply to tell me about some of the most important things that have happened in your life that are relevant to your choice to study an engineering degree and how you imagine your life developing in the future. I will guide you through the interview so that we finish it all in no more than ninety minutes.

Please know that my purpose in doing this interview is not to do some kind of deep clinical analysis! Nor should you think of this interview as a "therapy session" of some kind. The interview is for research purposes only, and its main goal is simply to hear your story. Everything you say is voluntary, anonymous, and confidential. I think you will enjoy the interview. Do you have any questions?

Interview Script

1. Your story

Tell me the story of how you got to where you are today, to your engineering degree/engineering degree apprenticeship. You can go back as far as you think is relevant.

What made you choose this particular programme? What other programmes did you consider/apply to? Is there anyone who played a role in your choice? Are there any engineers in your family? Were you inspired by any famous engineers?

2.First impressions on arrival to University/Degree Apprenticeship

What were your first impressions when you arrived at university/DA Provider? What were your hopes and fears? How did you find studying for the degree? How did you find the workplace (for apprentices only)? What was is like to move away from home? What about the social aspects of the experience? How comfortable do you feel here? Tell me about what makes you feel comfortable/uncomfortable here.

You have now been doing your degree for XX months/years. How do you see things now? Please tell me about your experience in the various aspects of being at university/DA Provider: academics, workplace, social, wellbeing. What has been the high point of your experience so far? Please describe in as much detail as possible. What about the low point? Again, please describe in as much detail as possible. Is there anything missing in your engineering training, in your path to engineering? Is there anything you wish you could do more of? Is there anything you wish you could do less of?

3. Your biggest life challenge

Looking back over your entire life, please identify and describe what you now consider to be the greatest single challenge you have faced in your life. What is or was the challenge or problem? How did the challenge or problem develop? How did you address or deal with this challenge or problem?

4. Future Script

Now, we're going to talk about your hopes and plans for the future.

4.1 The Next Chapter

Please describe what you see in the next chapter in your life. What happens after graduation? What is going to come next in your life story?

5. I would now like to focus on identity. If I ask you who you are, how would you describe yourself?

5.1 Please take a moment to complete the Twenty Statements Test. Now, please rank the top five of your statements.

5.2 Do you think you will make a good engineer? Please explain why.

5.3 Explore links between the top statements and engineering.

5.4 What do engineers do? What do they need to do? What are their personal characteristics?

6. Reflection

Thank you for this interview. I have just one more question for you. Many of the stories you have told me are about experiences that stand out from the day-to-day. For example, we talked about a high point, a turning point, etc. Given that most people don't share their life stories in this way on a regular basis, I'm wondering if you might reflect for one last moment about what this interview, here today, has been like for you. What were your thoughts and feelings during the interview? How do you think this interview has affected you? Do you have any other comments about the interview process?

APPENDIX F Codebook

Research questions:

RQ1. What do engineering students understand as their professional engineering identity?

RQ2. What experiences support/challenge the development of undergraduates' engineering identity?

RQ3. Who plays a role in supporting/challenging that identity?

RQ4. How does the students' engineering identity impact their choice of a future career?

Theme: Engineering identity (RQ1)				
Category: Identities reported by students				
Code	Empirical indicator source	Code description	Count	Cases
All-rounder	"…I felt like quite an all-rounder…" (C, line 36)	This code captures participants describing themselves as being good at different subjects and having many different interests.	16	11
Smart	"… I always knew I was sort of quite smart…" (F, line 149)	This code captures participants describing themselves as high achievers in an academic setting, being smart.	23	11
A good student	"…I enjoyed doing well at school and being good, there were other children who weren't very good and they sometimes get told off or they wouldn't do very well at school in their results, or they wouldn't do their homework or something and I took a lot of pride in doing all of that and being good, at being a good student…" (L, lines 212-215)	This code captures students/apprentices describing themselves as a good students	14	10

	Hard working	"…I had the work ethic to try hard at everything to get the get the grades…" (L, line 17-18)	This code captures participants defining themselves as hard working.	13	7
	Fascinated by how things work	"being able to learn about stuff like around me and around us and being able to understand how things work as well. It was more interesting than like anything else that I'd be learning at the time". (E, lines 25-27)	This code captures the participant's interest in finding how things work from an early age.	5	4
	Confidence	"… I think it's quite important to be able to ... be confident in the stuff you don't know just as much as the kind of things you do know…". (D, Lines 317-218)	This code records participants referring to being confident even when you don't know much.	12	9
	Lack of confidence	"...the biggest challenge has been being confident to be able to go Oh yeah, I have something to say, here you go." (J, lines 265-266)	This code records participants expressing a lack of confidence in what they are doing.	16	6
	I am an engineer	"…I know I really like being an engineer…" (C, lines 470-471)	This code captures the participant referring to herself/himself and/or their classmates as engineers.	14	9
	I am not an engineer	" I'm just qualified as a STEM subject person." (U, lines 441-442)	This code captures participants not feeling that they can call themselves an engineer.	12	5
	Creative	"I've always been quite creative. I quite like drawing or like when I was younger like colouring or something that involves a creative	This code captures participants t describing themselves as being creative and enjoying creative pursuits.	12	6

		mind as well". (P, Lines 65-66)			
	Curious	"… I was always like really curious, asking questions …" (K, line 8)	This code captures participants describing themselves as curious.	4	4
	A problem solver	"… that's what I wanted to do. You know, solving problems…" (T, line 65)	This code captures the participant describing himself/herself as enjoying problem solving from a young age.	18	9
	A practical learner	"I guess my learning has always been more like hands, on like practice." (G, line 123)	This code captures the participants describing themselves as enjoying a practical style of learning.	28	13
	I want to have a positive impact	"… that's something that I was like strongly looking for in my career, like having an impact on people and sort of making the world a better place." (G, lines 39-40)	This code captures the participant's wish to make a positive contribution to society.	20	8
	Category: Engineering traits (RQ1)				
	Code	Empirical indicator source	Code description	Count	Cases
	Engineers as problem solvers	"I think that a good engineer possess good problem-solving skills" (P, line 314)	This code describes the participants understanding of engineers as having problem solving skills.	13	9
	Engineers as team players	"…I think one of the most important things would be to be able to work in a team well, because it's very rare that one engineer will be doing something alone and it's always as part of a team…" (P, 285-285)	This code captures the importance in the participant's view of engineers as team players.	12	8

	Engineers are creative	"…people underestimate how important creativity is in engineering because a lot people think it's just maths, physics, kind of very academic, but ... you are essentially coming up with things the entire time." (N, lines 287-288)	This code captures the student's view of engineers as being creative.	13	8
	Engineers are curious	"Engineers are curious. Engineers like playing with things. Yeah, they're curious, they want to know more about the world", (K, lines 357-358)	This code captures the participant's view that engineers are curious.	17	8
	Engineers are resilient	"… you need to have that level of resilience to understand that as much as you might want to have something done to a deadline, sometimes things you know don't go to plan and you have to re-evaluate…" (T, lines 251-253)	This code captures the participants describing engineers as being resilient.	7	3
	Engineers persevere	"… I think perseverance as well because, Jesus, sometimes the problem is just a big problem. You got to have like the energy and the perseverance to just continue in your path through the frustrating days." (G, lines 439-441)	This code captures the participants' view that engineers need to persevere in order to succeed.	7	6
	Engineers are analytical	"... that would be quite important when you're an engineer, being	This code captures the participants' perception that engineers are analytical.	8	6

	Code	Empirical indicator source	Code description	Count	Cases
		analytical, good with numbers." (Q, lines 216-217)			
	Category: Definition of engineering (RQ1)				
	Code	Empirical indicator source	Code description	Count	Cases
	Engineering as problem solving	"I would say engineering is taking the tools we have, such as maths, physics, etc and using them to solve a problem" (A, Line 137)	This code captures the participants' definition of engineering as problem solving.	12	8
	Engineering as creating/improving things	"…I would probably say it's the creation of new things. Things that you didn't know you needed until they've been made or, Yeah, designing and building, an innovating…" (M, lines 167-168)	This code captures the participant's definition of engineering as creating/improving things.	12	10
	Positive impact of engineering	"I'd say it was developing ideas, new techniques, new approaches that better technology to progress society." (V, lines 193-194)	This code captures the participant's view of engineering as having a positive impact on society.	8	5
Theme: Experiences that support/challenge engineering identity (RQ2)					
	Category: Experiences that support engineering identity (RQ2)				
	Code	Empirical indicator source	Code description	Count	Cases
	Prior engineering experience	"I did an engineering day with a local company … that's definitely like the first thing I can remember that like made me interested in engineering" (C, lines 38-41)	This code describes participant's involvement in any practical experience with an engineering slant prior to university: company visits, work experience, summer schools, school projects, scholarships, etc.	68	19

	Workplace experience	"…starting to feel like fitting into the workplace, because that kind of is both social and workplace … And like the fact that it's interesting, it actually engages and then when the team is really nice and you get to go out for lunch every day with the team and you get to team's social and all that and it's starting to feel like, you know, if I did this for the rest of my life, I'd be very happy…" (C, lines 302-307)	This code captures the participants' experience in the workplace as part of the degree apprenticeship/placem ent year.	38	15
	Facilitating other people's learning	"…I did quite a lot with local primary schools in robotics mainly, so we did like Saturday Robotics master classes and like small F1 schools competitions where they make the cars out of paper and things like that with primary schools." (A, lines 42-43)	This code captures participants' experience of supporting student learning through tutoring, clubs and outreach activities. This could be more or less formalised.	21	10
	Fitting in	"…I guess so like respected and cared for and uh, and part of the group… " (L, lines 132)	This code captures a sense of belonging to the group.	15	11
	Identity validation	"... I remember one of the parts that I was working on that I was working on it with another guy who was like my mentor and really struggling to come up with an idea that would work, that meant that you could package all the bits together, actually be able to assemble it. I came up with an idea and they were like,	This code captures participants describing an experience that validates/supports their identity as they achieved a goal and gained recognition from their peers and/or superiors.	43	13

		oh my God, that's such a good idea. Yeah. It's pretty rewarding and I could feel quite smug." (V, lines 45-48)			
	Category: Experiences that challenge engineering identity (RQ2)				
	Code	Empirical indicator source	Code description	Count	Cases
	Gender imbalance	"... if you're in a situation where you're quite significantly outnumbered, then it tends to be more those conversations which can be quite a lot to deal with. It can be quite heavy as well but I don't have too much issue with that, but sometimes it can be a bit overwhelming." (W, lines 441-442)	This code captures participants' comments about noticing gender imbalance in their education.	51	12
	Academic work	"… I found the academic stuff quite hard…" (C, line 326)	This code describes participants talking about finding academic work hard.	21	10
	Being a woman in Eng./STEM	"I was working on X at the time and there was like a couple people who would just be quite weird at times like messaging me, being unprofessional and I dealt with that in the way that was appropriate at the time…" (H, lines 239-241)	This code captures the participant's perceived challenges posed by being a woman in engineering.	29	7

	Not fitting in	"…it made me more quiet for sure… I think it's also something that I kind of accept as part of the workplace, you know, the other thing is that I'm still an undergraduate, so, you know, as an undergraduate it's hard to tell like to what extent it's because I'm a female or to what extent it's because I'm an undergraduate who doesn't know anything, or because it's quiet or because I'm deaf and can't hear through the masks. So, it's quite hard to tell, you know which thing it is that's making me maybe miss out on something or not feel I fit in…" (C, lines 494-499)	This code captures a sense of not quite fitting into the environment.	32	11
	Having doubts	"…there's moments where I think I should, I'm doing the wrong course, I've messed it up. I should stop and start again. And I'm unsure whether I am suited to this uni, to this course…" (M, lines 234-236)	This code captures the participant having doubts about the course they are doing and whether they are suited to it.	12	6
	Lack of identity validation	"…The first thing that comes to mind was not making the offer to study here last year. I think that was it. That was really challenging for me to deal with because I was having like a really good run in terms of the opportunities and	This code records the participant's account of experiencing non verification of an identity.	10	6

		everything that was being brought to me like. I suppose it lured me into a bit of a false sense of security and I kind of felt a bit almost kind of unstoppable. I seemed to be doing well in in Sixth form and I got like one or two or the job offers and but like I was able to kind of. But this was the place that stood out to me at the time and not making that offer mate It was like a very, very tough reality check…" (D, lines 225-231)			
	Category: My favourite subjects at school were				
	Code	Empirical indicator source	Code description	Count	Cases
	Maths	"I just always loved math as a child and I was very good at it…" (EC, line 5)	This code describes the student talking about enjoying maths/being good at maths from a young age.	43	20
	Physics	"… out of all the scientists, physics was my favourite." (BF, line 116)	This code describes the student talking about enjoying physics/being good at maths from a young age.	13	8
	Science	"…I've always liked STEM stuff but I was more interested in science…" (SSD1, line 7)	This code describes the student's enjoyment of science over other subjects	20	10
	D&T	"…I really enjoyed like D&T when I was at secondary school and then going into A level I enjoyed it so much more…" (AM, lines 11-12)	This code captures the student's enjoyment of DT	5	3
Theme: Who plays a role (RQ3)					

Category: Engineering identity supporters (RQ3)				
Code	Empirical indicator source	Code description	Count	Cases
D&T/Engineering teacher	"... He was always willing to put in extra time if I wanted to pursue an engineering project outside the curriculum. He also took us on some incredible school trips like visiting the Ducati and Pagani factories in Italy or travelling across the country for VEX Robotics competitions." (E, lines 36-38)	This code captures the encouragement and guidance towards engineering provided by DT teacher or engineering teacher.	14	7
Physics teacher	"…I really liked my physics teacher, he was my favourite teacher because he was like the most passionate when he taught and it wasn't like reading off slides, but the way he taught was just interesting because it made you want to like actually want to find out why something is the way it is. And I found that style of teaching way better and I think that's what caused me to enjoy physics the most. And then yeah, that would lead me to choose engineering." (P, lines 26-30)	This code captures the impact a physics teacher had in the student's experience and his choosing engineering.	8	5
Maths teacher	"...she was really good, amazing teacher. She was very good at explaining stuff and very supportive.... she definitely made me feel a lot better and I think helped me	This code captures the participant talking about a maths teacher who had a particular impact.	17	7

		unlock my potential in maths" (B, lines 92-96)			
	Family support	"my dad is also quite good at maths. He studied astrophysics and things like that. So he's good at that and so yeah, he kind of supported me when I was younger doing kind of exam help and things like that…" (N, lines 19-20)	This code captures participants talking about the kind of support they have had from their family.	14	12
	University lecturer	"... I think in terms of the academics. P sticks out because I wouldn't have got through the electronics modules had it not been for him like helped me out at times." (H, lines 411-413)	This code captures participants' positive comments about a particular lecturer at university who has made an impact.	8	4
	Category: Engineering identity challengers (RQ3)				
	Code	Empirical indicator source	Code description	Count	Cases
	Stereotypical engineer	"…there's still a sense that it's a job with male dominance and older, I guess because you have to be quite experienced to be an engineer…" (C, lines 452-453))	This code captures the student's perception of what a stereotypical engineer is.	25	12
	University lecturer	"... I mean we've had like, one or two lecturers that are kind of quite obviously sexist but that's not the majority, that's only like a couple of arrogant people" (V, lines 77-79)	This code captures the student's negative comments about university lecturers.	4	4

	Code	Empirical indicator source	Code description	Count	Cases
	Classmates	"I remember once being in a lab with two guys and they're both quite arrogant and kind of not wanting to let you like do anything…" (V, lines 76-77)	This code captures the student's negative perceptions of some classmates.	10	4
	Lack of understanding of what engineering is	"it wasn't really anything that we did at school; no electronics, no computing, no programming" (I, lines 23-24)	This code describes the student's lack of understanding/exposure to engineering before university.	13	5
Theme: Future career (RA4)					
	Category: Future career (RQ4)				
	Code	Empirical indicator source	Code description	Count	Cases
	Initial thoughts on future career	"my young ambition was originally to become a doctor" (R, lines 13-14)	This code captures the participant's initial thoughts about a future career.	31	17
	Keeping my options open	"…I knew I wanted to do again a degree that like, if I did it, could still go into other things and not have to go into engineering if I ended up changing my mind…" (B, lines 57-60)	This code captures the participant's view of engineering as a path to other opportunities outside engineering in case they change their mind in the future.	28	11
	Future in engineering	" I've never really seriously like considered anything else as sort of a primary profession."(T, line 348)	This code captures the participants seeing their future in engineering.	59	21
Theme: Covid impact					
	Code	Empirical indicator source	Code description	Count	Cases

	Social impact	"it's been hard because of COVID and hasn't really been much going on, but it's been really nice, like being able to like meet people and like now that everything is starting to open up more, you can feel that everybody is happier now". (P, lines 175-177)	This code captures the participants talking about the impact Covid had on their lives	13	8
	Academic impact	"Actually, last semester was pretty good because my course is practical so we got kits to be able to do practical work at home and we were pretty early for being able to go back and do some things. This semester we've not really had any contact at all. It's kind of just been like. Go on now, you know what you're doing. So, it's been it's been a mix." (V, lines 225-228)	This code captures the academic impact of covid, either at A level or at university	17	5

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