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EXPLORING STUDENTS' EXPERIENCES OF STUDYING ENGINEERING IN HIGHER EDUCATION.

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A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements for the degree of MSc by Research.

The University of Huddersfield

January 2019

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Abstract

There is a paucity of literature in engineering education which examines students' experiences through the context in which they study. Previous literature tends to explore isolated concepts within students' experiences, be these attrition rates or the hostile climate of the discipline. However, this fails to gain a full understanding of student's experiences, their trajectories and the practices they negotiate in order to succeed in their studies. Much of the research in engineering education is also under theorised and draws upon a student deficit discourse. However, the following research makes the argument that we need to move away from a model which considers learning to reside within the individual and take a sociocultural stance in exploring teaching and learning. In order to explore individual's experiences in such way, data which captures the interaction of person, process and context needs to be gathered. The best method in order to gather data which explores experiences in such way is an ethnography. The following research utilised the ethnographic method to explore the experiences of taught engineering students in higher education. A sociocultural approach to teaching and learning was taken, drawing upon the work of Vygotsky, Lave and Wenger and Bronfenbrenner to understand the practices which influence students' experiences. The study explored and analysed student's trajectories to studying engineering, the practices they negotiated in engineering HE and the influence of macro system factors such as the masculine culture on the discipline. The data sources included observation, informal conversation and semi-structured interviews. Theoretical thematic analysis was undertaken. The analysis considers factors which both enable and disable successful participation and engagement in engineering education. The key findings indicate that student's identities must shift to conform to the monolithic identity which is set and perpetuated in the engineering education community of practice. A recommendation is made for critical examination of the proximal and distal processes, with a view of enabling successful participation, particularly increasing wider participation. I argue the culture of engineering and the way this is implemented into education needs to be addressed to enable inclusivity by addressing subject specialist support, shifting the competitive climate to be more collaborative and loosening the restrictive criteria which creates a structured tribe in the discipline.

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Chapter 1 - Introduction and Literature review

This study aims to explore the culture and context of studying engineering and how this impacts student's identity and participation in higher education. The literature review will provide a discussion of previous educational engineering research, exploring how this depicts the engineering culture and context, and what participation in the academic discipline entails. I will take a critical stance in discussing this research, in that I will be examining existing material in terms of issues that are connected to the following research and whether the solutions and discussions offered are agreeable. I will question the theoretical grounding of previous research and offer my own comparative analysis. This analysis will take the form of sociocultural perspectives. I make the argument that learning is a social enterprise and consider the work of Vygotsky (1978) to highlight the importance of learning relationships. I make use of Lave and Wenger's (1991) theory, which views learning as successful participation in the valued practices of a community. I will also use Bronfenbrenner's (1999) theory of development to consider the impact of wider societal influences beyond the academic community on learning. I will begin with a discussion of what engineering is, it's history and how this has consequently led to the formation of the masculine culture within the discipline. I will then go on to discuss the construction of an engineering identity and how this is shaped by the culture, context and practices of the field. Lastly, I will provide insight into research which explores engineering education, focusing on the different practices used and students' experiences of study.

1.1 - What is engineering?

The Oxford English Dictionary (2018) describes Engineering as a branch of science and technology concerned with the design, building, and use of engines, machines, and structures. The national research council (NRC) define engineering as *"business, government, academic or individual efforts in which knowledge of mathematics and/or natural science is employed in research, development, design, manufacturing, systems engineering, or technical operations with the objective of creating and/or delivering systems, products, processes, and/or services of a technical nature and content intended for use"* (NRC: pg 36). Davis (1996) provides an outline of how engineering become a discipline to educationally study and how this has shaped current educational practices. He states engineers were once males who simply operated engines or individuals who were in the army with job roles such as stone masons or carpenters. Engineering was, in other words, born an occupation of males. In the 18th century engineering was invented as a discipline and occupation, and a curriculum was developed for individuals to study. The

curriculum devised in the 18th century holds many similarities to what is taught today. Hartman and Hartman (2006) describe the curriculum as only differing in detail, with students still progressing from theory to application, placing heavy emphasis on physics and mathematics. The engineering discipline has a long history of development which has shaped the culture of the field, but also what engineering education is today and how it is taught. In using Lave and Wenger's (1991) communities of practice theory, we can explore how the discipline and its culture shape today's education, and the practices students partake in.

I will firstly depict the underpinning assumptions of the theory and then provide a discussion of its use in arguing for attention to be paid to the practices of the context and their impact upon learning. When considering learning, many theories, educators and researchers believe learning is something individuals do, that has a beginning and an end is the result of teaching and is separated from other activities. However, Lave and Wenger (1991) argue that learning is, in fact, a social process and occurs from our experience of participating in everyday life. They suggest learning involves a process of engagement in a community of practice. Communities of practice are formed by people who share a common concern or passion for something they do and who engage in a process of collective learning, to learn how to do it better (Wenger, 2007). As part of engaging in the pursuit of enterprises, or trying to improve on something as a group, individuals interact with one another and the world, and in turn, tune their relations with each other and with the world accordingly. This process would be described by Wenger (2007) as individuals learning. Over time, this collective learning results in practices that reflect both the pursuit of our enterprises and the attendant social relations. These practices are thus the property of a kind of community created over time by the sustained pursuit of a shared enterprise. The members of the community develop a shared repertoire of resources, such as; helpful tools, stories, experiences, ways of handling typical problems, routines etc. In other words, it involves practices or ways of doing/approaching things that are shared amongst members. These are termed 'reification' and reflect individuals shared experiences and shape participation. Therefore, learning (in the context of studying engineering) involves students actively participating in the practice of the social community (engineering degree in HE) to construct an identity (engineer) in relation to the community (Wenger, 1999). This involves a complex interplay between personal participation and reification to create meaning of what it is to become an engineer.

The theory clearly emphasises that learning is inseparable from the context. As Lave and Wenger (1991: 108-109) comment, 'the purpose is not to learn from talk as a substitute for

legitimate peripheral participation; it is to learn to talk as a key to legitimate peripheral participation'. This draws attention to the need to understand knowledge and learning in context. I therefore argue, in order to understand students' experiences of studying engineering and their participation in learning, we must consider the culture and context of the discipline. This is emphasised in communities of practice theory's concept of the regime of competence, whereby the history of the community of practice provides participants with a set of criteria and expectations by which they recognise membership.

In using Lave and Wenger's (1991) theory, we can explore how many of the practices formed when engineering was first founded as a discipline, still proceed into engineering education today. I believe it is important to draw attention to this, as through examining how current practices are shaped by historical influences, we can gain an understanding of why current practices exist as they do and how this has shaped the context and culture of engineering. For instance, in exploring the history of engineering, it is evident how and why the field became dominated by males. This enables us to draw attention to how the longstanding male dominance has shaped the culture of engineering, the practices it favours, and the students who are willing to participate in such context. In the following section, I will explore the culture of engineering in more detail and discuss how this has shaped the practices in engineering educational establishments and how it has left many students feeling inadequate or alienated from the discipline (Case, 2007).

1.2 - Engineering culture

I feel it is important to explore the culture of engineering in more depth as this appears to be a major underpinning influence on students' experiences of studying engineering. Following is a discussion of key themes in the literature exploring engineering culture. I will begin with a discussion of how engineers view themselves and the discipline, how these views then shape the culture of engineering and what is expected of new engineers entering the discipline. To conclude this section, I will provide a discussion of how the culture of engineering has impacted attrition rates and gender imbalances.

Dunsmore, Turns and Yellin (2011) describe engineering as a profession, stating *"engineers are leaders because of their competence in the world of theory, design, ideas and creativity"*. Engineers are involved in almost every physical object or construction within the world. They create medical instruments so that operations can take place, construct bridges so we can get from A to B and design household appliances to meet our everyday needs. This high-prestige profession is recognised by engineers themselves. Silva de Freitas,

Figueiredo and Iano (2013) argue that *"engineering is a field that attracts many students due to its prestige and its level of importance to the development of the country".* Vest (2008) suggests the engineering workforce will face the pressure of competing in the fast-paced changing economy, requiring individuals to be innovative and create the "best" solutions to meet human need. Engineering is not only about finding a solution but demonstrating why it is the best solution (Vest, 2008).

This notion of having the "best" solution and being the "best" is a theme I noticed throughout my literature search on engineering culture. Students attaining a high level of self-efficacy is something highlighted in the literature, suggesting without this, students will struggle to achieve in engineering. Mamaril, Usher, Li, Economy and Kennedy (2016) measured engineering undergraduate students' self-efficacy in relation to academic achievement. They used quantitative measures in the form of self-rating scales. Mamaril, Usher, Li, Economy and Kennedy (2016) concluded students with had high self-efficacy in their ability to achieve in engineering usually tended to strive to develop new skills and acquire knowledge. As students learn and master skills, their belief in their capabilities to complete similar tasks successfully becomes stronger. Therefore, as an engineering student, it is in their best interest to develop new skills and acquire knowledge which can be applied to the range of engineering problems they will face during their studies but also their professional careers. In students having such level of competence in engineering, they are able to strive to develop the best outcome or solution, this being a goal of professional engineers. Ponton, Edmister, Ukeiley and Seiner (2001) suggest teaching engineering is not just about imparting a formulation of knowledge but is teaching students to have self-efficacy in their abilities to achieve. If students do not have confidence in their ability to use the knowledge they have learned and to apply it to different situations to come up with their own ideas and solutions, they will not achieve in the discipline. As Dutta (2015) stated in her research, her participants began to understand when studying engineering…*"you have to speak up, you have to show that you know".*

The traits of high self-efficacy, mastery, confidence and competition in terms of being the best and developing the best ideas and solutions appear to stem from the masculine culture of the discipline. Fink, Ambrose and Wheeler (2005) suggest culture is typically defined as the common set of beliefs and values that create a shared interpretation and understanding of events and actions. Many research papers have described the engineering culture to be one of a masculine focus. In current HESA figures published in 2016/17 in the UK, 137,000 engineering and technology students were male and only 29,000 females. So, what is a masculine culture? Although a lot of research states engineering has a masculine culture,

many papers do not actually define what this is. As stated above, the engineering practices and what is expected of engineering students to achieve is fairly rigid, and this appears to be the same for its culture. Dutta (2015) states in her research that participants' experiences of studying engineering reveal the cultural and individual inclusion criteria in engineering education to be considered particularly important. She suggests engineering holds a unique nature of professionalism that exists in the field, and in order to succeed in this field, you must conform to its cultural values, norms, beliefs and rituals. Research exploring the masculine culture in engineering often takes the focus of gender differences in the discipline and how the culture impacts women and their beliefs of inclusion, rather than exploring a male perspective of the masculine culture, something which the following research does.

Faulkner (2007) used ethnographic methods to explore identities, particularly focusing on the gender imbalance in the discipline. She proposed such gender norms provide stability for the discipline, which already boasts many structural ideologies. Having such gender norms leads to normative pressures to view this as 'the way things are'. This, therefore, provides an explanation for the very traditional masculine views engineering holds.

"Masculinity stands for a society in which social gender roles are clearly distinct: Men are supposed to be assertive, tough, and focused on material success; women are supposed to be more modest, tender, and concerned with the quality of life." (Hofstede, 2001: 297).

Kim and McLean (2013) suggest the masculine culture focuses on achievement, performance and competitiveness. Engineering appeals to men as it demands a sense of mastery over something, where there is always a right answer. Men are also likely to focus on values such as money, success, and competition (Kim & McLean, 2013). Such masculine culture consist of a need for power, assertiveness and dominance. In addition, individuals within masculine cultures tend to be people who are likely to have stronger willingness to challenge at work, which relates to self-concept, and influences work performance, achievement, confidence and self-efficacy (Eraut, 2004; Lohman, 2006). Other research which has identified traits which hone in on the masculine culture includes Dutta (2015). She describes the engineering culture to be cold, unfriendly and of a chilly climate. These fit in with the masculine notion that you must be strong, independent learners.

As a consequence, this has impacted the practices in engineering education. Students feel they must be independent within their studies, a key theme running through all the traits mentioned above. This was noted by Meyer and Marx (2014) who suggested students felt

engineering lecturers were unapproachable when they required additional help. Dutta (2015) also noted in her research that students acknowledged that the culture of engineering educates students to believe that *"part of being a scientist or an engineer, is that you just got to be lonely".* Engineering students clearly have an understanding that when studying in the discipline, they must take the stance of it being a lone endeavour. However, factors outside the individual must be considered when exploring how the culture and context can impact learning trajectories. As the discipline is so rigid in what it expects from students, it does not account for the variation in backgrounds, experiences and knowledge of the students entering the discipline, but instead expects a rigid, uniformed, skilled engineer who complies with engineering practices. Therefore, when considering engineering education, we must account for the differences in students entering the discipline and how practices can be utilised to allow for such differences, rather than expecting the student to enter engineering in such a uniformed, set way.

This argument was supported by Tonso (2007) who carried out an ethnography exploring the enculturation of students' identities in the engineering discipline. When describing the culture she states

"individuals must fit into membership categories offered within engineering cultures; where some fail to meet the membership criteria in a vast array of engineering cultures that are nonetheless too narrow, too restrictive, and too greedy to accommodate many individuals" (Campbell, 2009: 130).

Tonso (2007) suggests this is one of the main issues with the engineering discipline, in that it assumes there is something so "monolithic, so uniform, and so powerful about engineering curricula in a wide variety of institutes as to produce "cookie-cutter" engineers". The structured, narrow practices in engineering education highly reinforce deficit discourse. The deficit model states students must develop the skills and values of the context or field they are immersed in. If students do not or cannot develop the skills required to participate, it is viewed as a deficit on their behalf. Students are expected to shift their identity and way of being to house the requirements of the engineering culture and context and to adapt to the learning practices. According to studies on learning in higher education (Halpern & Hakel 2002), it appears to be up to the student to take responsibility for their knowledge gaps. They consider learning in higher education as a learner's need for autonomy, self-motivation and responsibility, the need to be active participants in the act of studying and understand their learning. This enforces the idea in engineering culture that learning resides within the

individual and that they must fit into the mould which engineering culture and practices require.

As the culture is noted for being so rigid and reinforcing the deficit discourse, a large body of research has explored how such educational practices have impacted upon non-continuation rates in the discipline. HESA provides the most up-to-date details of student attrition rates from 2015-16 in engineering. The percentage of UK domiciled entrants on undergraduate engineering and technology degree courses who are no longer in higher education was 12.3% for young entrants and 13.7% for mature entrants. In comparison to non-continuation rates of other disciplines for mature entrants, this is 11.8% for social sciences, 6.7% for education and 11.8% for creative arts. For young entrants, there was 9% non-continuation rates for biological sciences and 7.6% for social sciences. In fact, for all the disciplines covered in the HESA report, engineering and technology have the second highest drop-out rate for young entrants and the sixth for mature entrants. This has consequently led to a large body of research exploring why the discipline has such high attrition rates. I will explore this in more detail because through understanding why students leave the discipline, we can gain insight into the culture, context and practices within the community which appears to disable their learning.

Nelson et al (2015) carried out a qualitative study exploring why undergraduate students leave engineering. They conducted interviews and a journey mapping exercise with students who had recently left their engineering studies. They categorised their literature review on engineering retention into two factors, individual factors and institutional factors. When looking at individual factors in regard to why students leave the discipline, they suggest the level of student preparedness for the rigours of a university engineering programme was vital in determining levels of success and attrition. In addition, a large decrease in student's motivation to study engineering after they submitted their first-year undergraduate coursework was also reported. They suggest this relates to students being disinterested or disappointed in the field, poor performance and loss of self-efficacy. The last major theme focusing on individual factors as a reason for low attrition rates in engineering was students' inadequate preparation. This was defined as the quality of maths and science provided to students in schools which instilled motivation and excitement for careers in science and engineering. Eris et al. (2010) describe confidence in maths and science skills to be the major difference between persisters and non-persisters in engineering. In looking at how institutional factors influence the discipline, research suggests students leave the discipline due to unapproachable faculty members and poor teaching and mentoring. They also describe an unwelcoming culture in engineering departments and discuss the student-

teacher relationship to be vital in promoting success in engineering but being unrecognised by lecturers themselves. The resistance from faculty causes tension between teaching quality and retention. Nelson et al's (2015) further discussed how students suggested feelings of responsibility for failure. They suggest the students had described a sense of being a member of a club as an engineer and described themselves as 'engineers', leading to a tremendous emotional effect when this ceased. The research also makes note of students' integration into the course, suggesting students' integration into the academic and social systems in universities were directly linked to the continuity of their studies. The research provides cause for students not being integrated due to a fault of their own. Be this unprepared for undergraduate engineering, a vague concept of engineering and the profession, or not being adequate for the efforts it takes to become an engineer. They suggest the implementation of induction courses can improve understanding of engineering but also motivate students to leave the discipline sooner to save time, money and emotional turmoil.

This research heavily focuses on student deficit as being the cause of drop-out in engineering education. When students did discuss engineering programs, they supported the rigidity of them, *"engineering programs need to be rigorous because of the importance of engineering work. If you build a bridge and you were wrong, people could die"* (Nelson et al, (2015). The research heavily emphasises deficits within the student, if they leave the discipline it is a fault on their part and not related to the practices, context or culture of engineering.

Other research which has explored dropout rates in engineering undergraduate study is Hartman and Hartman (2006). They make reference to "the hard "weeding-out" classes rather than a nurturing environment, a lack of social and ethical perspective surrounding the academic work, a strong emphasis on individual competition and a lack of warm and close interpersonal relationships with faculty and peers as all contributing to low attrition rates. Although this was identified initially in their article, their results section heavily ignores cultural and contextual factors and rely on student deficit. They discuss how students who enter engineering with lower high school achievements in maths and science were more vulnerable to drop-out. They also suggest students who integrated themselves into the program, such as partaking in study activities and academic enrichment were more likely to persist in the discipline as they felt a sense of community and integration. Again, I highlight the emphasis of the results on students having to shift their identity to fit in with the culture and contextual practices of engineering favours, as opposed to shifting the disabling practices of the weed-out culture, which should be addressed in order to lessen attrition rates. For instance, in Hartman and Hartman's (2006) research it was suggested

the engineering student must go out and explore activities which would enable them to feel more integrated into the course and a sense of community and belonging. This was also noted by Koenig, Schen, Edwards and Bao (2012) who suggest incoming STEM majors are unprepared in content and cognitive abilities and struggle through introductory courses.

Although the research exploring attrition rates in engineering is ample, an argument has been made for attention to be given to the role of social context in attrition. Litzler and Young, 2012) explored students' risk of attrition and persistence in undergraduate engineering. They make the argument that it is not student grades or academic performance which causes students to make the decision to leave the field but experiences in and out of the classroom. They emphasise the importance of a sense of community, suggesting the quality of teaching, interaction with peers and professors, degree of competition among students and social acceptance are all factors which influence persistence in the discipline. The results from their survey reveal that the undesirable educational climate of engineering leads to student attrition. They suggest factors such as work/life balance, feelings of value from professors, increasing confidence and creating a sense of community can all aid student persistence in the discipline. This research is useful as it considers factors outside individual ability and control. It calls for attention to be paid to contextual factors and how they can impact the student experience. They look at shifting the disabling practices within the engineering discipline, rather than individuals shifting to fit in with practices. Although this research is useful in exploring which practices in the engineering community shape students learning, they fail to explore the practices in depth, something my research explores closely. The research touches on student-teacher interactions or membership of a community but fails to provide theoretical depth to their argument.

I will now provide a discussion of how the culture and context of the engineering education community of practice shapes the trajectory of incoming students' identities.

1.3 - Engineering identity

I have previously discussed Lave and Wenger's (1991) theory in relation to the culture and practices surrounding engineering studies. I will now use the theory to explore the role of identity in the learning process.

The concept of a community of practice cannot be considered in isolation. It is the perspective that locates learning not within an individual or outside them, but in the relationship between themselves and the social world. Lave and Wenger (1991) focus on the notion that learning involves a deepening process of participation in a community of practice, arguing that the formation of knowledge is situated in the social meanings of the community. Students engage directly in personal participation in the community of practice but also forms of physical and conceptual artefacts or reification (tools, methods, stories, concepts and words), which reflect shared experiences from participation (Wenger, 2010). However, participation and reification are not always connected. At each moment, an individual's engagement in the world requires bringing them together to negotiate and renegotiate the meaning of their experience (Wenger, 2010). Therefore, participation within the community and reification characterise two strands of memory, which, over time create a social history of learning for the community by combining individual and collective aspects. This history enables a community to be formed, as its participants outline a regime of competence, a set of criteria and expectations by which members of recognised. This includes:

"

- Understanding what matters to the community, what its enterprise is and how it proceeds a perspective in the world.
- Having the competence to engage productively with other members in the community.
- Making use of the repertoire of resources the community has collected through the history of learning. "

(Wenger, 2010: 2).

Emphasis is placed on the individual as a social participant within the community of practice, they are viewed as a meaning-making entity, where the social world is a resource for their construction of identity. The process of meaning-making is not just a cognitive function but involves the whole person, be this their relationships, aspirations and other human experiences, which are all involved in the negotiation of meaning (Wenger, 2010). Therefore, learning is not just the acquisition of skills and knowledge but is becoming a certain person – a competent individual within the context where what must be learnt to be a knower is negotiated with the regime of competence of the community.

Participants of a community hold their own experiences of practice which could or could not reflect the regime of competence. The process of their learning entails realignment, where the newcomer to the community is usually being encouraged by competence until the

learner's competence reflects the competence accepted of the community (Wenger, 2010). Each moment of learning is a step towards competence in the community. This process can lead to hopeful identification with the community. Lave and Wenger (1991) discuss identification to involve modulation, in that some individuals identify with a community more than others, feel a greater need to belong to it and therefore see a stronger need to be accountable to its regime of competence. Through the process of identification and modulation of and within the community, the individual's relationship with the practices and the community become part of their identity (Wenger, 2010). Therefore, identity reflects the complex relationship between the social and the personal world. Making the argument that learning is a social becoming and that identity plays a key role in this process.

Nespor (1994) accepted Lave and Wenger's (1991) theory of learning and identity formation but highlighted the importance of exploring wider scale communities of practice, such as the global features of disciplines, be this politics, history and economy, which is ignored by Lave and Wenger. His research looked at how physicists from one time or location share many features with physicists from different campuses, different counties and even those educated at different times. From his observations, he suggested students are prescribed into discipline-appropriate ways of belonging that constrain who can belong and what belonging entails. Nespor (1994) contended that physics students developed an identity that remained primarily aligned with academic practices such as dedicating oneself tirelessly to academic endeavours, while partaking in practices encouraged by the school, such as affiliations out of school. Nespor (1994) argued

"communities aren't just situated in space and time, they are ways of producing and organising space and time and setting up patterns of movement across space-time: they are networks of power. People don't simply move into these networks in an apprenticeship mode, they are defined, enrolled and mobilised along particular trajectories that move them across places in the network and allow them to move other parts of the work into that network."

His research demonstrated that the discipline of physics moulds students into discipline-appropriate ways of acting, and promotes learning the kinds of disciplinary knowledge, both academic and social, that is valued by practitioners. These findings were extended to engineering education by Tonso (2007). She suggests communities of practice encompass a set of shared cultural knowledge that provides meaning to who members are, what they must do to become members, and how they must be within the community. The meanings that's members acquire must be learned; this not only incorporates propositional knowledge and the day to day undertakings of putting such knowledge to work, but also includes how

students think about themselves to be someone who fits in and belongs, in other terms, developing practitioner identities.

So, what does an engineering identity encompass? Godwin's (2016) research provides a framework for understanding engineering identity, focusing on students' self-beliefs of what this encompasses. Previous research exploring engineering identity in education tends to focus on the qualities students need to be an engineer or the discourse students use to develop and identify as engineers in practice. However, past research has failed to explore internal states and student's self-perceptions of attaining an engineering identity. I felt this was important to consider, as not only is my research centred around exploring experiences of studying engineering from the student's perspective but also as students are the individuals subject to developing such identities, it made sense to explore this experience from the people going through such trajectory. This was the focus of Godwin's (2016) research, who suggests identifying as an engineer matters for students' academic and personal development, retention and incorporation into the larger engineering community. His results suggest the construct of engineering identity can be broken down into three dimensions of students' beliefs; perception/competence, the recognition they receive from others and their interest in engineering. Godwin's (2016) research is however limited to only capturing a subject related identity within engineering, whereby my research does capture engineering identity in the workplace. Godwin's (2016) research also ignores factors previously highlighted in engineering identity research, such as students identifying with subjects like maths and physics in college, as she believes they do not measure student's direct perception of their engineering identity. I believe that although it is essential to consider students experiences of their current engineering identities, we must account for this in conjunction with their past experiences and identification with previous related disciplines which will have an impact on their incoming trajectories, this is something my research considers which has previously been ignored.

Although Godwin (2016) only explores the direct identity of engineering studies, I feel her research provides insightful dimensions of which to consider the construction of identity in engineering. I will now use her research to expand on the three dimensions of engineering identity which she proposed, through discussion of previous literature in relation to each. Godwin (2016) defined recognition as how others views of an individual can impact the view they have of themselves. Competence is students' beliefs about their ability to perform in the practices of their discipline and understand the concept. Do they see themselves as someone who can legitimately participate in these areas? Interest was the students desire

or curiosity to think about and do well in engineering. This plays a role in whether or not the student wants to take on the identity of an engineer.

Recognition

Rover (2008) makes note that even students who persisted through graduation did not identify themselves as engineers, but that this identity was influenced by the recognition of others. Tonso (2007) argues that in order to have an engineering identity, it is not enough to just recognise oneself as an engineer, but one must be recognised by others. She carried out an ethnographic study exploring engineering programs and uncovered that although some women displayed greater skills in engineering, because they were not recognised as the gender associated with engineering, their performance was overlooked by peers and instructors, leading to the women having a weaker engineering identity and feeling like they did not belong to the culture of engineering. She argues students must recognise themselves as someone who could achieve in such a discipline and is the type of person who does engineering but is also viewed by others as someone who is an engineer.

Therefore, in order for students or members of the community of engineering to depict who is and is not seen as an engineer, reference must be paid to the discipline's regime of competence. Tonso (2007) suggests *"being inside a community with a persistent way of life and coming to be thought of as someone who belongs there, means that…one sees the world in ways that cohere to culture practice"* (pg. 3). This was discussed by Rover (2008), who suggest student engineers make decisions in their day-to-day lives about how to act relative to established ways of life. They suggest students work tirelessly to conform to the engineering identity required to create a sense of membership and belonging. Lave and Wenger (1991) argued individuals consistently develop their shared identity through engaging in and contributing to their communities' practices. participants motivation to become a more central participant in a community of practice can act as a powerful incentive for learning. Students will have a desire to develop skills (engineering competence) to join the "engineering club" and will work towards becoming a member. This was studied by Gonsalves, Danielsson and Pattersson (2016), who carried out case studies which explored the gender imbalance in physics. Although this article explores a differing discipline to the one focused on in the following research, both disciplines are grouped under the STEM field and share many resemblances. Their research explores how practices in the discipline of physics shape discipline identities. The practice their research focuses on is laboratory work, suggesting such practice relates to conceptual knowledge

construction in physics. They argue laboratory work also provides a means by which students are apprenticed into the community of physicists, a process of enculturation. Therefore, suggesting that learning in the physics discipline entails the construction of conceptual knowledge, but also the construction of identities as insiders to the discipline. The research argues that a critical part of learning to be a physicist is focused on students deciding to be "a certain kind of person" and then partaking in activities to garner recognition as a member of that community. This research concludes that how a student perceives themselves in comparison to the field of physics, will impact their performance and conceptualisation of physics knowledge and identity.

Performance/competence

Although the development of students' identity is influenced by others recognition of what an engineer should be and whether the individual fits into such cultural ways of being, as of which are influenced by the regime of competence. However, whether an individual view themselves as someone who can perform in the discipline is also important. Do they believe they can be an engineer?

Students self-efficacy has been a major topic discussed in engineering education research, as touched on in the previous section. It is suggested that students' beliefs about their capabilities to learn and perform a variety of engineering tasks influences their engineering identity (Godwin, 2016). The engineering curricula programmes set out learning objectives that are stated by accredited agencies and the engineering community (Stevens et al., 2008). The engineering students are envisaged to learn and apply principles using a combination of logical thinking, problem-solving and communication skills. Students must also develop a range of skills in special ability, tinkering and technical skills, and engineering design. However, student performance is not only a function of the acquired skills but also the beliefs they hold about their own capabilities to perform tasks (Godwin, 2016). Her research suggests efficacy beliefs to be better predictors of achievement and persistence in engineering than previous accomplishments alone.

The research suggests that when students believe in their efficacy to achieve tasks, they become more motivated to act in a way which makes their success more likely (Mamaril et al, 2016). For example, in Mamaril et al's research, both men and women in engineering were influenced more significantly by their self-efficacy than other factors in their studies. Students self-efficacy usually works in sync with other motivational beliefs which can have an influence students' academic motives such as, mastery goal-orientated, interest and task

value (Mamaril et al., 2016). Their research found that students who believe in their own capabilities also tended to engage in work for their own mastery or because they find their work useful and interesting. This research was useful as it supported the definition provided by Faulkner (2007) which describes engineering as a masculine discipline which focuses on students becoming masters of skills and knowledge. This further highlights how the culture and context of the discipline perpetuates the required self-efficacy within students to enable them to participate and achieve in engineering, a point which I will demonstrate in my analysis.

Although research highlights the importance of self-efficacy in engineering education, Marra, Rodges, Shen and Bogue (2009) suggest the nature of how engineering curricula and practices impact self-efficacy in students is unclear. Marra, Rodges, Shen and Bogue (2009) explored gender differences in self-efficacy of students studying engineering. They suggest women who enter engineering report high levels of self-confidence and self-esteem, but this declined throughout the course. This is because women compared themselves as being less superior to their male peers and judge themselves more harshly. Women also faced low self-confidence (connected to self-efficacy) as a large barrier in preventing them from completing their engineering degree (Marra, Rodges, Shen & Bogue, 2009). Their research found women express less confidence in their abilities causing them to leave the discipline, opposed to men who regardless of whether their performance was the same or better, did not leave. It was suggested that although women may proceed to perform well in their engineering studies because they viewed themselves as someone who did not belong or identify with the discipline, their perception of their performance and competence to achieve in engineering declined. Therefore, self-efficacy can be both a predictor of outcomes (such as retention), but it can also be predicted by influences such as the classroom environment. Making the argument that distal factors which reside outside, such as cultural norms, should be considered when exploring the participation of peripheral members, something my research considers.

As students acknowledge that their competence in engineering is a predictor in being recognised as an engineer, they ensure demonstration of knowledge and performance is displayed. For instance, Dutta (2015) suggests in order to succeed in engineering you must demonstrate that you know. Case (2007) suggest that in order for students to ensure such knowledge, they experience commitment and hard work through their studies. They suggest the students on engineering courses understand the volume of work they must undertake to succeed to become an engineer and work tirelessly to conform to this. In Case's (2007)

research students commented *'all you have to do is work, and it takes over your life.'* Their research discusses how students discussed *'days filled with lectures and tutorials and evenings and weekends devoted to meeting course demands'*. Students acknowledged that as part of become an engineer, they must negotiate the gruelling course demands and demonstrate competence in their studies. Students need to have the will and skill to succeed in the school (Seth, Tangorra & Ibrahim, 2015). Therefore, students strive to have the competence and demonstrate the performance required to become an engineer and gain such an identity. Again, this research is useful as it highlights the disabling contextual practices students partake in during their engineering studies and how these become a norm in which they must conform to so as to get the recognition of an engineer.

Interest

Student's interest in the discipline was also found to be a significant predictor in the development of an engineering identity. This has been something which has received little attention in previous research, which tends to focus more on the skills and knowledge students must attain. In relation to self-efficacy which was previously discussed, Fantz, Siller, DeMiranda (2011) suggest students who had engineering-related hobbies and interests within the discipline had higher self-efficacy scores in their performance and competence in the discipline in comparison to students who did not have such hobbies and interests.

Students who apply to study engineering at university often view themselves as the type of person who wants to understand the world scientifically (Godwin, Potvin, Hazari and Lock, 2016). Freitas, Figueirdo and Iano (2013) state that engineering students are driven by passion, curiosity, engagement and dreams. For many students, studying engineering is not just about getting a degree in the subject but is about following a dream and a passion. For instance, Montgomer, Penlington, Tan and McDowell (2008) interviewed students to explore their experiences of engineering in higher education. Aside from students fore-grounding themselves as engineers, emphasis is also placed on the social and personal factors which contributed to them making the decide to become an engineer. Their research found that being an engineer was termed a "childhood dream" and some students were motivated by the desire to call themselves an engineer. For many students', making the decision to become an engineer is something which stems from past endeavours, as there is no previous study of engineering in high school or college (Matusovich, Streveller & Miller, 2010). Therefore, a vast number of students enter the discipline just through the pure interest in engineering-related concepts, experiences and an attraction to maths and physics (Matusovich, Streveller & Miller, 2010).

As many students have such an intrinsic interest in engineering, they partake in many hobbies related to the discipline. Freitas, Figueirdo and Iano's (2013) research explores the incorporation of competitions and extra-curricular activities on student's skill development, suggesting many students develop skills independently outside the classroom. Their research suggests engineering students were motivated to create new products and solutions regardless of whether this is in their own time or in the classroom. Such hobbies also provide students with tinkering skills. Tinkering skills have been noted by Tonso (2007) as being cultural capital in engineering education. She suggests students actively partake in engineering activities to improve their skill set, not only as a way of achieving in engineering but also out of their own interest. Tinkering is something which research has suggested improves engineering achievements, yet the process of actually learning through tinkering has been overlooked (Gutwill, Hido & Sindorf, 2015). Gutwill, Hido and Sindorf (2015) suggest this process involves creatively developing personal meaningful ideas, encountering roadblocks, recognising ideas, persisting and experiencing breakthroughs as solutions emerge. They also argue tinkering involves learner's authorship in that they pose problems or challenges for themselves, where they must consider the material and other design constrains within a maker space. As stated above, student's motivation to learn skills and knowledge both inside and outside of the classroom is driven by their intrinsic interest. Students acknowledge in order to achieve in engineering they need such cultural capital which cannot be learnt in the constraints of the classroom and that the drive to achieve such capital in through their own interest in the discipline. In considering interest we can see how students join communities of practise outside the educational institute in order to enable their engineering identity to be further aligned and practiced with engineering communities' regimes of competence. We can also see how student's participation in engineering activities and the development of an engineering identity extends beyond skill/knowledge development or recognition but has aspects of personal motives impacting students incoming identities. As discussed, personal motivates usually revert to before the student entered the engineering community, therefore it is necessary to understanding students incoming identities to their engineering studies and how these impact their participation. This is a factor overlooked in previous literature, but something considered in the following research.

In concluding how students inform their decisions as to if they are the type of student to engage in engineering, I draw on literature by Capobianco, French and Diefes-Dux (2012). They suggest student's identity structures are negotiated through discourse such as

'*antecedent histories, assumptions and cultural knowledge embedded in any interactional exchange'*. With this knowledge, students question whether they are the type of person who is a member of a community. This suggests cultural expectations are used to make sense of and shape everyday life. This was discussed by Tonso (2006), who suggests how students practice engineering is cohered to cultural pasts and shapes what the identity of the student should be. This was noticed in her results. She suggested as oppose to students moving along a trajectory to a shared notion of becoming an 'engineer', students decide whether to affiliate and align themselves with academic engineering by therefore, devote themselves completely to their studies. Ultimately, students must accept such cultural facts and deploy them in order to understand how their world is supposed to work.
This was also noted by Holmegaard and Madsen (2014) who researched the transition to higher education in the engineering discipline and how students negotiated their journey to belonging. In conducting narrative interviews, they found that students' transition was not so much a linear process but rather students needing to make sense of a new cultural and social field. Their results suggest students work on their identities to shape them to become somebody who typically fits into what is recognised as institutionally and culturally accepted pathways and reach a sense of belonging. This is a continuous process in which meaning making of and relating to the new cultural setting occurs. This was discovered in their findings as students proceeded through their studies, they uncovered that although some practices were not formally or explicitly required, they found them to be crucial for attendance on the study programme. Aschbacher, Li and Roth (2010) conducted research exploring student's identification as engineers. They suggest although many students held engineering qualifications at the time of the interview, many did not depict that this made them engineers. It was, in fact, their experiences at university which provided them with holistic development, such as social and cultural factors which played a part in their success. In relation to the aims of the following study, this previous research acknowledges the role of both proximal and distal influencers on students' identity construction. Some factors covered in the previous research lack detail and discussion, which my research intends to expand upon.

As the context and culture of engineering provide accepted pathways for the peripheral students entering the community to follow, a prescriptive engineering identity is formed. Whereby students construct and shape their identities to affiliate and align with the expected, in order to participate and become practising members of the community. Tonso (2007) further emphasises this point by depicting what is expected of an engineering identity to be particularly rigid. She argues the engineering community to promote a "cookie-cutter" engineer which holds a strict regime of competence of accepted ways of

being. Questioning when individual identities are not compatible with what is expected in engineering if the fault lies with the individual or in the hostile climes into which they nonetheless attempt to insert themselves? It is because of student's socialisation, their lack of childhood time spent 'tinkering', or their deficiencies in mathematics and the sciences as to why they do not fit in? This research is useful as it highlights the cultural and contextual practices students negotiate in order to become members within the community. The research does, however, fail to provide insight into how students negotiate these practices. The finer details of student's day-to-day interactions, activities and negotiations are ignored, instead providing an overview of their overall experience.

The membership categories established for engineering identities can be seen as a closed club (Ohland et al., 2008). This was acknowledged by Dutta (2015) who suggest engineering students' identity must fit into the pre-existing categories in the culture, society and the practices in context. Students must shape their identities into the narrow categories to become what is expected of an engineer. Godwin, Potvin, Hazari and Lock (2016) do however argue that close attention must be paid to the type of person whom we ask students to become while drawing attention to how students embrace or avoid the promoted identities in engineering education. Arguing such categories need to be more flexible to enable wider participation in the engineering discipline.

In the next section, I will demonstrate the rigidity of the curriculum in engineering and how this shapes not only the learning process of engineering study but also becoming an engineer. This will provide a discussion of the context of engineering study, the practices and participation within the discipline and how this shapes identity formation. Addressing two of the research aims.

1.4- Engineering education

I will now provide a discussion of previous research which has explored engineering studies in higher education. As touched on previously, a lot of the research exploring engineering education tends to be focused around specific factors, be that self-efficacy, attrition rates, women in engineering. Much of the research surrounding engineering education is conducted in America and is largely carried out by engineers themselves, with such research holding a strong insider perspective, producing a more normalized view of the culture and education within engineering, as well as predispositions (Graaff, 2016). Discussed below is a range of literature surrounding students' experiences of studying engineering education, the set curriculum and how this impacts engineering practices. Underpinning much of the

literature in engineering education is the notion that students should adapt to the educational establishment where they enrol. In order to succeed, students must learn to do things "as they are done round here". When discussing the literature, as opposed to enforcing a model which argues that students should fit into the often-alien culture and new community while they leave their own behind, I put forward the argue for the opposite.

Stevens et al (2008) describe the engineering discipline as a comparatively stable body of knowledge that a person progressively acquires. The engineering curriculum is designed and shaped by professional bodies. They depict what students need to know to become professional engineers and what society demands from engineers and the skills they require to meet such demands (Montgomery, Penlington, Tan & McDowell, 2008). Therefore, it is a fundamental goal in engineering education to help students prepare to contribute to the demands of engineering practice (Dunsmore, Turns & Yellin, 2011).

As discussed previously, the culture of engineering and the identity of engineers is set in what it requires students to be like and how they must perform within the discipline. This has led the practices performed in university to follow the same path in shaping and creating engineers. As discussed by Tonso (2007), the engineering curricula in university usually comprises of students studying mathematics and physics theoretical concepts in the first two years, followed by statics, fluids and thermodynamics, and other engineering-focused modules in the final year, building on mathematical and science ideas to understand engineering theory and principles. Therefore, engineering courses can be seen as more than mere applications of mathematical and scientific knowledge, but in fact, principles that are in their own right important academic knowledge. This body of knowledge which engineering students require is something which has been recognised as being stable over time. As Downey (2009) reported from his research, the observations of engineering lectures demonstrated that little had changed over the two decades. He stated the engineering courses, the information covered, and the course organisation appeared remarkably stable over time. Emphasising engineering knowledge to be a stable, uncontested subject. All engineering students must take this path in education, learning the foundation knowledge required and set by practitioners to become engineers, to then apply it to their own new ideas, concepts and designs. As Black (1994) states in his research, students recognise they use the basic physics and mathematical knowledge on a daily basis to understand new concepts and new applications of technology to products. This is a set of stable practices, which have been continued through time to provide a recognised curriculum in engineering (Hartman & Hartman, 2006). In considering Lave and Wenger's

(1991) theory here. We can depict how engineering practices have been set by practitioners, to form a stable body of knowledge in which apprenticing engineers must acquire to become recognised as practising professionals. This places the already practitioners in the field as being all knowledgeable experts in which students must aspire to be. Again, this emphasises the "cookie-cutter" engineer being produced by educational establishments (Tonso, 2007).

When exploring the trajectory of studying engineering, Stevens et al. (2008) state we must understand learning in engineering in a broader framework that encompasses 'becoming an engineer'. Instead of learning focusing on changing individual cognitive capacities, in engineering when considering learning, we must explore the notion of 'becoming'. This incorporates studying additional dimensions of change over time and a broader set of social organisational practices which the engineer-in-the-making is rooted within. Engineering education is a process of teaching students to become professionals, they are not just being taught engineering, but taught how to become an engineer.

Therefore, in studying engineering, students are not only learning skills and knowledge to achieve in their studies and pass exams but also succeed in the profession of engineering. The knowledge students learn in their engineering studies is to be applied to real life engineering situations. Montgomery, Penlington, Tan and McDowell (2008) carried out interviews to explore students' experiences of studying engineering in higher education. Their results found that students who were provided with real-world engineering examples felt more enabled to contextualise the issues and transfer conceptual ideas into practice. Students in their research made comments such as "unless we see things in practice, how they are happening, we won't get that knowledge". Ascribing value to the development and process of learning and its meaning in engineering. Ponton, Edmister, Ukeiley and Seiner (2001) states, it is the professor's role to develop an educational environment that is encouraging of the acquisition of course content but also must prepare students to become practising professionals. They suggest teaching is not so much about telling students or testing for the right answer but is about providing good study habits that students learn the skills to succeed as lifelong learners in engineering. This involves building confidence and self-efficacy in the student that they have the capabilities to perform real-life engineering. Being a lifelong learner is a skill emphasised in engineering. Students and practising engineers must draw upon their previous knowledge of the common principles which form the core of the engineering curriculum and apply them to different practical standpoints (Katz, 1993).

Teaching engineering is not just about providing or offloading knowledge to students but entails a process of enculturation. As stated by Lave and Wenger (1991) in their theory of learning. Individuals enter a community as practising apprentices. They learn with already established members of the community to equip themselves with the skills and knowledge required and also to familiarise themselves with the practices and culture valued in the community. This enables individuals to shift from legitimate peripheral participants to become full participants of the community. In terms of learning or becoming an engineer, students go through a process of enculturation. Not only must students negotiate the practices of higher education, but also the practices valued in the engineering community. As stated previously, engineering is a vocation. Students studying engineering tend to have the motive to become practicing professionals. Therefore, part of their learning process involves the incorporation of negotiating how to become an engineer and the culture this involves. Students must submerge themselves in the reification of the culture and the regime of competence to establish their membership as practising professionals. This process of enculturation involves students establishing what is expected of them as engineers and how they can achieve this through active participation in the practices in higher education. I make the argument that the way of learning and become suggested by Lave and Wenger's (1991) theory is not achieved in engineering courses in HE given the fixed curriculum, teaching methods and established deficit discourse. This will be an argument I will expand upon with the analysis.

The process of teaching engineering students' skills which are required in the profession is difficult in the university context (Katz, 1993). Therefore, students on engineering courses are required to partake in a range of different practices. The bulk of knowledge is relayed in large lecture theatre sessions, then students are often split into smaller groups to do practical based activities (applying), which often includes student competition activities. Davies (2013) discusses the incorporation of a design competition on the engineering curriculum in the UK. I make the point here that the nature of the community of practice in engineering is competitive rather than collaborative, shying away from Vygotsky's and Lave & Wenger's notion of learning being a collaborative two-way process. The professional body in engineering, The Institute of Mechanical Engineers, launched the inclusion of such competition into the curriculum to enable students to demonstrate and provide their creativity and engineering skills. The competition provides students with the experience of applying theoretical knowledge to understand real-life problems and enables skills to be enhanced which engineers require to operate effectively in a commercial working environment. Experts in the field believe if students are faced with true-to-life examples in

which they practice methods that they are destined to use in their future employment, then they are more likely to learn. The competition requires students to produce a design to a specific specification, apply engineering principles and working within commercial constraints. They suggest such competition also enables the development of a range of 'soft-skills' which are often looked past in traditional engineering learning. Things such as teamwork, presentation skills, negotiation abilities, research skills, lateral thinking, and project management enable students to develop their own approach to the design challenge. It provides students with control over their own learning and developing negotiated understandings of the situation, to become independent learners and encourages students to think like a professional engineer. Freitas, Figueiredo and Iano (2013) also discuss the inclusion of competitions on the curriculum in a Brazilian university. They suggest such competitions enable the preparation of future engineers to face global challenges as they provide them with the chance to develop many different skills required by the labour market, allow them to observe engineering in practice, and have the opportunity to explore their aptitude within the discipline. Competitions enable students to comprise a connection between what they have learned in the education setting and real life. However, I highlight here how this competitive environment and focus on developing engineering competencies further instils the masculine culture in the discipline. The focus of the practices in the community pursue competitive, rather than collaborative participation and marks a disabling practice in the discipline.

This has therefore led to numerous areas of research which have explored how the practices in the discipline cause disabling participation of many students. For instance, the large lecture-style teaching has been noted as being a motivator for students making the decision to leave the discipline. The large lecture classrooms made students feel isolated and uncomfortable interacting, contributing to a poor-quality learning experience (Haag & Collofello, 2008). The lack of smaller group time spent with lecturers and the masculine culture which is dominant in engineering meant students felt unable but also disempowered to ask for help. This was something particularly highlighted in the research exploring dropout rate. Students would often comment on how they felt overwhelmed by curriculum demands and experienced conceptual difficulties with the material taught (Meyer & Marx, 2014). Students discussed the engineering curriculum to be complicated and demanding, with students being advised to navigate their studies as a lifestyle rather than degree course (Dunsmore, Turns, Yellin, 2011). Although students expressed such feelings within their studies, research particularly lays a fault within the student for not being prepared for the rigours of the engineering program. For instance, students are expected when entering

the discipline that they will have the degree requirements of being successful in maths and science courses in previous education establishments (Meyer & Marx, 2014). Practitioners view students entering the discipline as "engineering material" and are automatically seen as being able to successfully navigate the practices almost naturally (Stevens et al, 2008). This expectation of knowledge is something continued throughout engineering education. If students are unfamiliar with a particular concept or program, for instance, it is up to them to go and discover the answer for themselves (Stevens et al., 2008). This was studied in Stevens et als' (2008) research. They explain how third-year students reported the need to use METLAB software to successfully complete their final exam, however, the software programme had never been taught on the engineering course. Students were simply required to know the software and had to learn it outside of the official curriculum. They reported lecturers taking a hands-off approach to teaching where instead of lecturers prosing questions to students to test their understanding, they expected students to ask them questions that would improve their knowledge.

This further reiterates how the masculine engineering culture feeds down into how the practices in the context impact student participation. The notion of independence, deficit, competition and becoming the ideal all compose disabling practices in the discipline. Research does, however, fail to answer the question of why students stay in the discipline and endure such disabling practices and culture. This is a question this research aims to answer.

1.5 Conclusion and Aims

In concluding the literature review, previous literature has highlighted that the engineering culture and context largely focus on a deficit within the student and how this impacts attrition rates. Previous research has also focused on the masculine culture in the discipline; the hostile climate this creates in education; the skills required of engineers which are set out by industry professionals, and the identity students must follow in order to become/be recognised as a practising engineer. Research which has been carried out to explore these concepts tends to focus on the impact/influence of factors outside the individual. For instance, when researching student engineering identity, previous research argues this is influenced by outside factors such as being recognised as an engineer by others or thought judgements on performance/competence by already practising members.

The previous research centred around engineering education takes a top-down approach in exploring students' experiences of their studies. As discussed above, most of the research in engineering education is conducted by engineers themselves, meaning they have strong

insider perspectives, leading to more normalized views of the culture and education. Being an insider in the discipline which is being studied has also meant a lot of the research is focused on preconceptions which students are specifically questioned on, mostly using either interviews or quantitative methods. Such preconceptions could be attrition rates or why they chose to study engineering, for example. However, as I came from an outside perspective, I had no preconceived ideas about what engineering was or what studying it entailed. I therefore took a bottom-up processes and openly explored the discipline, its culture, and students' experiences of their studies and how they felt they negotiated them in the context's practices of the higher education environment. This enabled me to gather an in-depth personalised understanding of what studying engineering was and provide strong theoretical grounding to help understand what learning in engineering entails.

In addition, as discussed in the literature review, the large majority of engineering education research takes a student-deficit stance, arguing learning resides within the individual. However, the following research is underpinned by sociocultural theories, arguing instead that learning resides in the socially constructed processes. I take the stance that learning is a social enterprise whereby students successfully participate in valued practices of a community. Learning needs to be considered this way to understand the complexities of student's educational trajectories and experiences. Such understandings demand ethnographic data to fully explore the interaction of person, process and context. To my knowledge, an ethnography has only been used in one previous piece of research exploring engineering education. In conducting an ethnography, connections between the life worlds of engineering students can be recognised to gain an understanding of how their identities evolved in the HE context.

Therefore, the main aim of my research is to:

- Explore the culture and context of studying taught engineering programs in higher education.

With sub-aims to:

- Explore engineering identity and participation in higher education
- Understand engineering identity and participation through the lens of sociocultural theories.

Chapter 2 - Methodology

This chapter will discuss the epistemological decisions made surrounding the use of an ethnography in the following research. I will provide a discussion of what an ethnography entails, the methods it makes use of and justification for its use in exploring the culture and context of studying engineering. I make the argument that in order to explore the trajectory of studying engineering, an insight into the culture and context of behaviour, the social setting and the complexities of group behaviour need to be considered. I will then provide an explanation for the process of carrying out the following research and the ethical considerations made.

2.1 - Epistemology

Epistemology is focused around presenting a philosophical grounding for depicting what sorts of knowledge are possible and how we ensure it is adequate and legitimate (Maynard, 1994). Essentially the nature of knowledge centres on the questions "how we know what we know" (Crotty, 1998). In the following section, I will provide a discussion of the use of ethnographies and justification for their use in uncovering knowledge, particularly focusing on the following research.

2.1.1 - Ethnographic meaning and method

An ethnography is a tool or method researchers use to explore and understand a particular field, social group or situation. The researcher immerses themselves into the field, observing individuals in their natural contexts by means of methods which depict their social meaning and typical activities (Brewer, 2000). Therefore, at a basic level, an ethnography is simply the collection of data through this use of multiple methods or triangulation, over a period of time within a specific context or field. An ethnography can involve data collection methods such as interviews, observations, document analysis, along with quantitative methods such as questionnaires or demographic data (MacDonald, 2001). The data is observed, recorded, and analysed. A key feature of the method is that the researcher is in the context or environment of the participants over a long period of time to gather detailed, in-depth descriptions of everyday life and practice within the community.

The accounts yielded from data collection are usually insider accounts which attempt as little as possible to be undistorted by the researcher, and which express the subjective reality of the internal world of the participants (Pole & Morrison, 2003). There is no single method which constitutes ethnographic research, but rather a range of different methods which researchers can make use of, including different forms of observation, conversations,

interviews and some written sources of data, such as a wide range of documents. The flexibility in data collection methods has meant there is a scarcity of instructions in the literature on how to complete an ethnography (Pole & Morrison, 2003).

This was something I noticed when searching for ethnographic literature. There is a heavy focus on how to analyse data and the feelings and responses of the researcher, but not so much a focus on how to accurately collect and record ethnographic data. One example of this in the literature is Gill (2008), who investigated the young adult male identity using an ethnography. When referring to his method, he simply states "Participant observations of the men's behaviours and interactions were recorded at the end of each day in a journal. Where applicable focus groups were conducted in field settings and were either recorded and transcribed" (pg 95). Gill (2008) goes on to say, "In total there were four A4 notepads containing journal notes" (pg 98). Gill does not provide any further explanation as to what constitutes the observations he observed and does not provide any record or detail of how he did them, he also fails to discuss how information was elicited from the male participants.

This less directive approach is indicative of the relativist position in ethnographic research but does however call for researchers to be aware of their part in the ethnographic process (Hammersley, 1992). Hammersley and Atkinson (2007) have highlighted this when discussing observational data in ethnographies. They state that observations are a representation of the observed event, which is something of a selective process, as it is not possible to capture everything. What is recorded is heavily influenced by the researchers' own interpretation of events, what they see as important in answering the research question and how it relates to the theoretical framework of the research (Hammersley & Atkinson, 2007). The data collected from interviews and conversations can also be impacted by the research. Bloom and Crabtree (2006) state what the interviewees choose to discuss with the researcher reflects conditions with their relationship. Fundamental within this process is how interviewees reconstruct events or features of social experience, as well as how interviewers make sense of what has been said. Although the data collected in ethnographic research is very much up to the researchers' discretion and their interpretation, similarly with many qualitative methods, the use of triangulation enables comparisons to be made between the data sets to account for accuracy and reliability between data.

2.1.2 - Ethnographies in education

I sat in class for days wondering what there was to 'observe'. Teachers taught reprimanded, rewarded, while pupils sat at desks, squirming, whispering, reading, writing, staring into space, as they had in my own grade-school experiences, in my practice teaching in a teacher-training program, and in the two years of public school teaching I had done. What should I write down in my empty notebook?

(Spindler and Spindler, 1995).

When Spindler initially started his ethnography in elementary schools, he could not see the strangeness in the situation as it was a mirror of his own cultural strangeness (Spindler & Spindler, 1995). Making the strange familiar is the usual goal of ethnographies, but in educational ethnographies this can be a challenge for the researcher, as they themselves have usually experienced education as participants. Mills and Morton (2013) suggests everyone has deep, long-lasting memories of school life which can influence our imagination and shape our emotions. Therefore, ethnographers within education have the challenge to *'weave the immediacy and rawness of educational experiences into a context from which analytical patterns and insights can be discerned'* (Mills & Morton, 2013:2). However, making use of ethnographies to study educational contexts has many benefits, including the ability to focus on people and lived experiences in educational contexts, while also being able to study educational texts, policies, discourses, ideologies and ideas.

Ethnographers have studied higher education, but the research is fairly sparse and tends to focus on specific aspects within the university setting, as opposed to the whole picture (Pabian, 2013). For example, Pirttimaa, Takala and Ladonlahti (2015) used an ethnography to explore students' experiences of reading and writing difficulties within higher education. Their research found understandings of such difficulties had improved but considerable ambiguity still remains about what these practices mean. Another example of ethnographic educational research in higher education was that of Nespor (1994). He explored US undergraduate students' experiences of studying physics, specifically focusing on academic experiences. His research concluded that the "learning" which took place within the physics department was not about internalising knowledge because it became known within the department that 'passing and failing was not necessarily connected to knowing anything'. In addition, the loose curriculum structure of the department failed to integrate students into the academic discipline. However, questions arose from Nespor's (1994), suggesting there is conflict between the emphasis ethnographers place on being able to make claims about learning due to the differences in what can be observed by ethnographers and the

psychological functions of learning being something that happens in students' minds and being unobservable.

Other ethnographic research was carried out by Nathan (2005). Nathan (2005) was a professor who decided to enrol as an undergraduate student in a US university as part of an ethnographic study to explore students' experiences. In doing so Nathan (2005) claimed his research enabled him to get a better understand student life in relation to their academic life, social life within and beyond their halls of residence and their social networks and community involvement. This research enabled Nathan (2005) to observe the new challenges students face which the academic institutions have not adapted to and also the misperceptions, misunderstandings and mistakes made by the university which negatively affect the college experience. A current ESRC/NRF funded research project makes use of ethnographic methodology to explore how rural South African students negotiate their move to study a STEM discipline at university and how their prior cultural and educational experiences may influence their higher education trajectories. The current findings question previous notions of a 'lack' or under-preparedness of the student and instead put forward the notion of inadequacy and inappropriateness of the curriculum to meet student's needs. The research sets to develop inclusive teaching and learning practices, and support mechanisms in universities (sarihe.org.za).

Tobbell and Turner (2018) considers ethnographic data to explore undergraduate students' transition to higher education. Their research enabled them to decipher how identity shaped participation, the practices that influenced participation and how participation subsequently influenced learner identity. The research concludes that past, present and future identities challenge students during their educational transition and influence their individual trajectories. They also argue that the practice within the university already assume an autonomous learner rather than enabling development of autonomy. Some practices also negatively impacted learner identities which delayed their full participation, therefore, it was suggested universities should consider enabling systems and practices which acknowledge student differences and fully support successful changes in learner identity (Tobbell & Turner, 2018).

From the brief discussion of educational ethnography research, it is clear the focus of an ethnography is to attempt to explore wider contexts and societal drivers to understand the experiences of the participants. The research studies make use of ethnographic methods to support understanding of the impact of university practices on the identity and success of students. The use of ethnography in the following research enabled the culture and context

of studying engineering to be explored and understood and an insight into engineering identity and participation in higher education as a way of identifying areas which impacted the success of students.

2.1.3 - Ethnography in the following research

As can be seen from the literature discussed in the first chapter, it is evident the methods exercised in previous educational engineering research tend to explore experiences from a first-hand participant perspective, be this interviews, questionnaires or statistic based results. Although this is useful in gaining first-hand insight into what it means to study engineering or be an engineer, it fails to capture the complexities of group behaviour, explore the interrelationships between multifaceted factors within group interactions and fails to provide context and culture for behaviour. As ethnographies are carried out in the everyday contexts of individuals, they capture behaviour in the different contexts of everyday life and help reveal unarticulated needs and emotional behaviour to be captured. I therefore decided to undertake an ethnography in the following research.
My reasoning behind this was that in order to explore identity and participation in engineering higher education and explore the culture and context of studying engineering, both aims of this research, I felt it was vital to be immersed into the field, social group and situation to gain a real understanding of engineering education.

As stated by sociocultural theories, learning and participation in education is a social endeavour. Simply questioning individuals on this process would provide me with an account of what they believe study to be like. Although this information is useful, it fails to provide a culture and context for learning and behaviour. However, through researcher participation/observation of the field, a fuller, deeper picture of the social process in which learning occurs can be captured. In the following section, I will provide a reflective discussion on how my position may have impacted the ethnographic data collected in this research and also how the data may be shaped by my ontological position.

2.1.4 Positionality

Within this chapter so far, I have discussed what an ethnography is, it's value in educational research and why such method was used within this research. Before I discuss how the data collection method was carried out in the following research, I will provide a reflective discussion of how the method was underpinned by my ontological position and how this may have shaped the data collected. I will also consider how my position as an 'outsider' to the field may have influenced the data collected.

As stated in the introduction, this research takes a sociocultural stance and is underpinned by Bronfenbrenner's, Lave and Wengers' and Vygotsky's theory. Therefore, within interviews and observations, I will have obviously placed more emphasis on questioning or observing specific notions from within the theories. This could have been exploring the importance of micro system relationships within engineering education from Bronfenbrenner's theory or exploring the academic practices students have to follow within engineering education in order to succeed, as taken from Lave and Wenger's theory. Therefore, the approach to data collection has been to have a theoretical position based on my understanding of learning, so that the research is underpinned by a theoretical framework. Paradoxically, this position lends itself to an ethnography as the only way to truly understand the social and cultural experiences of a community is to participate within it (Pole & Morrison, 2003). This is because ethnographies explore the social actions within a location, event or setting to uncover the meanings of social actions and experiences which can only be understood by exploring the location in which they are constructed (Pole & Morrison, 2003). However, I have to acknowledge here that all observational data collected is a reflection of my understanding of the situations and experiences. I am therefore a participant in the construction of reality (Palaganas, Sanchez, Molintas & Caricativo, 2017). Although I acknowledge how my ontological position may have influenced the data collected, I want to clarify my approach to reflexivity. I cannot move away from the part I have played in the sense-making of the social world I have studied, as it is a fundamental expectation within qualitative research (Lazard & McAvoy, 2017). However, in keeping reflective notes/insights throughout the data collection process revealed ways in which my involvement may have influenced or informed the research. Also, by comparing observational notes with interview transcripts enabled me to check the consistency of the data collected. In addition, I also had to be aware of my reasoning for conducting the research. My interest lies in exploring experiences within educational contexts and ways in which students' success could be improved through refining educational practices. I chose to study this within the engineering discipline due to the lack of research in the field, particularly exploring this context using sociocultural theories. In exploring this particular discipline, I did not have any personal connections which may have impacted the data collected, however, being an outsider to the field could have influenced this process.

As suggested by Geertz (1973), the nature of ethnographic work involves the interpretation of cultures, which is carried out by the researcher. Therefore, there must be acknowledgment of the perspective and responsibility the researcher takes as this can impact the knowledge produced about that culture/community (Naaeke, Kurylo, Grabowski, Linton & Radford, 2012). Researchers can either be insiders to the research community

where they share the characteristics, role or experience with participants or an outsider to the commonality shared by participants (Dwyer & Buckle, 2009). Although researchers can have two different positionalities when entering the research field, it is acknowledge by Rose (1985) that there is no neutrality in data collection but instead a greater or less awareness in one's biases and consideration of how ones preconceptions may be influencing what one is trying to understand. Although this is the case, a large amount of research explores the impact each positionality can have upon data collection. I will now provide a discussion of this.

An insider perspective means the researcher shares an identity, language and experiential base with the participants, which means the researcher is often more accepted by participants (Dwyer & Buckle, 2009). As an insider's presence is usually more accepted, the researcher's membership level to the community usually encourages the participants to gain trust and be more open to the researcher, which enables greater depth and breadth to the data. Participants are often more willing to share their experiences to insiders due to the assumption of them being more understanding and distinctiveness than outsiders (Dwyer & Buckle, 2009). Although the insider positionality affords access, entry, and a common ground from which to begin the research, the position can also impede the research process. This is because participants may often fail to fully explain their individual feelings due to the assumptions of similarity with the researcher (Naaeke, Kurylo, Grabowski, Linton & Radford, 2012). Researchers may also find they have clouded perceptions due to their personal experiences, which they may find hard to separate from that of the participant, meaning interviews may be shaped or guided by core aspects of the researcher's experiences and not the participant's (Dwyer & Buckle, 2009). Furthermore, this clouded perception may influence the analysis of the data, leading to an emphasis on shared factors between the researcher and the participants and a lack of focus on factors that are discrepant. This therefore raises questions about the objectivity, reflexivity and authenticity of the research project because the researcher may be too close or know too much about the research field to retract their own perceptions and experiences (Naaeke, Kurylo, Grabowski, Linton & Radford, 2012).

This leads onto a discussion of the advantages of having an outsider positionality. Dwyer and Buckler (2009) suggests that it is not necessary to be a member of a group in order to be able to understand it. Knowing an experience is more about being able to identify, describe, and explain, rather than experiencing it yourself. Being an outsider when conducting research has been suggested by many researchers to be of better use. For example, Hammersley and Atkinson (2007) suggested when researcher's feel comfortable

and have a sense of being "at home", there is the danger of the research being invalid. They suggest in order for ethnographic research to be valid, there must be some social and intellectual distance for the analytic work in order to maintain objectivity and emotional distance. In addition, insider researchers may not have the adequate distance to know their own experiences and separate these from the reality, whereas outsiders are more able to adequately conceptualise their experiences (Dwyer & Buckle, 2009). Outsiders can often also uncover, observe and appreciate the wider perspective and influences which an insider might perceive as being normal and overlook (Naaeke, Kurylo, Grabowski, Linton & Radford, 2012).

However, being an outsider does bring some limitations such as the possibility that an ethnographer may be deliberately told partial truths by interviewees due to the lack of trust and openness with the researcher (Dwyer & Buckle, 2009). Additionally, an outsider may only be exposed to a communities/ culture's body of knowledge bit-by-bit in separate and apparently disconnected events and messages that are not immediately known to the ethnographer (Naaeke, Kurylo, Grabowski, Linton & Radford, 2012). Making the data validity questionable and the process of collection challenging.

However, as suggested previously, regardless of the positionality taken, all ethnographers are part of the fieldwork and the data (Brayboy & Deyhle, 2000), therefore acknowledging two separate positionalities sets up a false separation between the researcher and researched, which neglects the interactive processes involved (Naples, 2003).in the following research, I am an outsider to the discipline but an insider in the university system. Therefore, according to Lave and Wenger's (1991) communities of practice theory, my relationship being a student at the university and an outsider to the particular discipline under study would be a continual negotiation and renegotiation in fluid, shifting relationships between the different members of the community. The dualistic notion of being either an insider or outsider when conducting research does not account for the richness, complexity and chronological shift of researcher identity.

In the following section, I will provide a discussion of the process of data collection for this research which enabled the experiences of engineering students to be explored.

2.2 - Method

The following section will explain the procedure of carrying out this study. I will discuss the method of data collection, how participants were recruited, ethical considerations and finally the method of data analysis.

2.2.1 - Data collection

As discussed in the previous section, ethnographic research is heavily qualitative in nature and can take its form in numerous data collection techniques. Denzin and Lincoln (2011) provide a discussion of qualitative research…. *"a set of imperative, material practices that make the world visible. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings and memos to self… qualitative research studies things in their natural setting, attempting to make sense of or interpret phenomenon in terms of the meaning people bring to them"* (pg 3). The use of multi-methods or triangulation in ethnographic research has been highlighted by Ritchie, Lewis, McNaughton and Ormston (2014), suggesting such approach increases the richness and volume of the data in terms of multiple views and foci. I used two methods in the following ethnography; interviews and observations. Rabionet (2011) describes interviews as 'flexible and powerful tools to capture the voices and the ways people make meaning of their experiences'. Furthermore, Watt and Scott Jones (2010) argue observations and conversations in ethnographic research to be crucial in constructing a true picture of the research culture under investigation and adding dimension.

2.2.2 - Observations

My data collection initially started out by conducting participant observations. As the main aim of the research is to explore the culture and context of studying engineering, I felt that immersing myself into this setting would enable me to gather a deeper, more meaningful understanding. Also, as I came from a discipline outside engineering and it was a subject I had never experienced before, I thought the best way of me gaining insight is to experience the setting first-hand.

The observations were conducted over term one and two of the academic year. Participants agreed for me to join them, intermittently, throughout their day to watch and record their day-to-day experiences. I observed both electrical and mechanical engineering lectures and tutor sessions, at undergraduate and masters level. I also observed the engineering study space, which was either an observation of one particular mechanical engineering undergraduate student or of two of the masters team project groups, which were a group of around 25 students (they were not all present at one time). The masters team project groups also had meetings and workshop activities, which I also observed (there were around 15 students at each event). All observation sessions varied in length, however for each observation I stayed for the full event, for instance, if the lecture was two hours I would stay for the full duration. In the engineering study space or workshop setting, I would

conduct two-hour observations as I felt, after numerous trials, that this was an appropriate amount of time to capture the event occurring. A total of 31 observations were carried out.

Following is a discussion of what was recorded during the observations, however, I first want to provide a critical discussion that reflects on the use of participant observations within an ethnography. Initially when I began reading literature to secure my knowledge on ethnographic observations for my data collection, I noticed ethnographic method books did not explicit state what should be observed by researchers (Seale, Gobo, Gubrium & Silverman, 2007). Therefore, knowing what to observe within observations is free to the interpretation of the observer. This means all data collected within observations is at the researcher's discretion as to what they perceive as being important in providing insight into the participant's world/experiences. This is acknowledged as a limitation of ethnographic observations by Hegelund (2005), who suggests observations carry a large amount of subjectivism as one can only interpret what one sees in term's of ones own experiences and of what one is. Questioning the reliability of ethnographic observations. In addition, as the observers are the main instrument in data collection, their attitude changes, fears and anxieties, and social meaning when engaging with the field and people within it form part of the data collected (Brewer, 2005). Data is therefore affected by external stimuli and influenced by interpretation or bias of the researcher (Brewer, 2005).

As discussed previously within this chapter, being a researcher from an outside perspective to the field of study under investigation can cause issues with data collection. An outside observer is suggested by Brewer (2005) to be cold and distant from people within the field, to maintain a professional identity throughout data collection and demonstrate a lack of rapport with participants which can all diminish the richness and detail of the data collected. However, being an insider to a field of study can also create data collection issues such as overlooking a loss of critical faculties and feelings of becoming an ordinary member of the field. Brewer (2005) suggests observers in ethnographic observations should aim to maintain a challenging balance between member and non-member to reflect critically on what has been observed while also being able to gather detailed data to do so. This requires observers to maintain involvement and detachment to enable them to socialise into the practices and values of the group, gain acceptance within the community and have a commitment to the field in order to experience all events and activities (Brewer, 2005). This process makes ethnographic observations extremely time consuming and restrictive due to physical constraints of role and location of data collection. What the observer observes is only a partial view of the way of life within the field which is compiled of selective records (Brewer, 2005). Only a partial view is obtained as only a personalised collection of takings

from the observation are made and a vignette developed, which representativeness of the field is debatable. Questioning the true representativeness of ethnographic observational data in enabling insight into other's domains.
However, it is suggested that observations enable a close involvement and associate to what people naturally do and say in their field in order to discover their interpretations, social meanings and activities. Ethnographic observations also add a dimension of personal experience and sharing the same life as those under study to provide dependability of collected data (Brewer, 2005). Such observations enable researchers to understand the world as it is seen by those acting within it and to reveal the taken-for-granted, common-sense nature of the everyday world itself (Brewer, 2005).

2.2.3 - Field notes/note taking

I wanted to ensure I noted everything down that happened during my observations, I therefore decided to make contemporaneous notes. Hammersley and Atkinson (1995) have created a checklist for researchers who are observing within a context, which I adopted. They suggested field notes should include:

'1) Space – the physical place or places
2) Actors – the people involved
3) Activity – a set of related acts that people do
4) Object – the physical things that are present
5) Act – single actions that people do
6) Event – the set of related activities that people do
7) Time – the sequencing that takes place over time
8) Goal – the things people are trying to accomplish
9) Feeling – the emotions expressed'

(Hammersley & Atkinson, 1995).

I aimed to ensure I typed up the observation notes I made each day as they were collected whilst my memory of the event was still fresh. I am not stating, in any way that my note-taking records capture all the behaviours, actions and conversations of the research environment in question. Conversations which could not be heard, obviously could not be recorded. In addition, it was unfeasible to note down everything which was said or done, particularly in lecture and group work situations.

2.2.4 - Conversations

Silverman (2000) pointed out that *"much of what we observe in formal and informal settings will inevitably consist of conversations"* (p821). Fontana and Frey (2000) refer to talk in the ethnographic literature as unstructured interviewing. However, conversations are informal casual encounters which are relatively unplanned in contrast to the more planned, formal encounters of interviews.

Casual encounters, framed in talk, which I either experienced personally or witnessed became part of my note taking. I recorded casual conversations I heard or had, which seemed to be applicable to the aims of my research using either direct dialogue in cases where I could recall what had been said or through a summary. If I overheard a conversation of relevance in group work or study space environments and I had not previously come into contact with that person/s, I would approach them to discuss my research and the occurrence I would like to record. If they agreed I would request them to complete a consent form and proceed to record the conversation of relevance.

2.2.5 - Interviews

Once I gained rapport with my participants, I undertook formal one-to-one semi-structured interviews with them. My reasoning for interviewing participants was to gain further understanding of individual's experiences of studying engineering and to also gain further information and details that was not possible to gather through observation. Hammersley and Atkinson (2007) state the aim of ethnographic research is to provide rich, holistic insights into a group of people's views and actions and the nature of the social context in which they inhabit. In other words, the objective is to get an inside view of the way a group of people view the world.

I carried out 29 interviews in total. My sample broadly reflects the gender ratio on the degree courses and was the inclusion of individuals who were willing to share their experiences.

- 6 male undergraduate students from electrical and mechanical engineering courses.
- 13 male masters students from electrical and mechanical engineering courses.
- 10 male and 2 female staff members.

Participants were given the interview schedule (which can be found the in appendix) before the interview took place and advised they could add any topics they felt were necessary to explore their experiences of studying engineering and told they could stipulate any questions they did not want to cover without reasoning. Interviews took place in a small quiet room on campus. The interviews used in this research were semi-structured.

According to Longhurst (2013), semi-structured interviews tend to unfold into a conversational manner, offering the participant the opportunity to discuss subjects they feel important. This provides the research with much more flexibility in exploring particularly interesting topics that emerge in the interview, so the participant can reveal a fuller and more detailed picture of what is significant to them. An interview schedule was used to guide and gain a detailed picture of the participant's experiences of studying engineering. The interview schedule consisted of a brief introduction to the aims of the research, a reminder of consent (including the audio recording of the interview), and topic areas which each consisted of several questions and prompts. I devised the topics, questions, and prompts by reading previous research in the field which has explored engineering education to gain background on the topic and inspected the aims of my research and how these could be achieved while bearing in mind the underpinning sociocultural theories. The questions focused on the background interest and experience of engineering, moving onto studying engineering and what this entails. Questions on this topic focus on the culture, context and practices of engineering study and how students negotiate these. I then focused on student's opinions of engineering and holding an engineering identity. As I got more insight into the discipline, my interview schedules shifted. I asked more discipline-specific questions and probed occurrences I had witnessed in observations.

All interviews were digitally recorded and then transcribed. Participants were presented with a copy of their transcript from the interview and asked for confirmation whether they felt it was an accurate representation of our conversation. Participants were informed that they could remove any parts of or all the transcript without having to provide any explanation, no participants requested to do so.

2.2.6 - Ethical issues

In composing the research, I made three major ethical considerations which were all underpinned by the British educational research association (2018); protection of participants; that the research conducted serves the interests of the individuals, groups and/or society involved; ensuring that individual research activities was ethically sound, with regard to protection of confidentiality and the process of informed consent. The research was approved by the ethics committee of the University where the research took place. The submission form submitted to the ethics committee can be found in the appendix and consists of the consent form, information sheet and interview schedules provided to participants.

Some specific ethical issues I considered for ethnographic research, referred to in the British educational research association (2018) framework was ensuring consent from all participants involved in observations. For example, as ethnographic observations are conducted in the natural field environment of the participants, consenting participants would often have conversations with non-consenting participants. Often these conversations were of value to the research aim, however, until consent was secured by all parties, the data was not recorded or used. In addition, as ethnographic research often requires time and effort from participants through interviewing or numerous observations, I had to be aware of the impact this could have on the students' workload/lives. I continually reminded participants that they have no obligation to partake in any of the activities proposed, that they could withdraw from the research at any point or withdraw any data without question, to adhere to ethical guidelines.

2.2.7 - Access to the field

Initially, the head of department for the engineering school was approached to discuss my proposed research. Once permission was granted for my research to go ahead in the department, I requested the administration team to send an email round to all individuals in the Engineering school with a brief explanation of what my research entailed, aims of the research, and an invitation to both staff and students requesting their participation, and what this would involve. Once individuals responded to the email, I requested a meeting with them too; informed them of what their participation would entail again, provided them with an information sheet, answered any questions they had, and to ask them to complete the consent form if they were happy to do so. Dates were then arranged to conduct interviews or observations. Observations were based around the Engineering study space, lecture theatres or workshops. When observing participants in the study space, I would converse with other students working in there, explaining my research and welcoming their participation. The more participants I recruited, the more word got out about my research. Participants would inform their colleagues/friends about my research and pass information sheets on, so they could contact me if they were interested.

2.2.8 - Ethics in the university

Within large lecture theatre observations, I sat at the back, so as to ensure my presence was not intrusive. In smaller tutorial sessions, I again tried to sit towards the back of the room unless indicated by the staff member running the session to do otherwise. On many occasions, I would know a number of students in a particular lecture or tutorial and they would sometimes sit next to me or invite me to sit with them.

Observational data from within teaching session did not identify individual staff and students by names. As all the teaching was in a public setting and could be openly observed by others, and with my presence being openly acknowledged, it was not obligatory to gain written consent from everyone in the lecture theatre. In individual observations, I got consent from the particular participant being observed but again as the observations were in public forums, it was not necessary to obtain written consent from all individuals within the setting (BPS guidelines).

Coming from out outside discipline, I felt it was important to stress to both staff and students that the aims of the research did not entail judgements or conveying values to either individuals or settings. Instead, the aim of the research was to explore and compose a 'true to life' of the culture and context of studying engineering and how that shaped people's worlds. I found conveying this message an issue throughout data collection, particular involving approaching lecturers to observe their teaching sessions. This caused my data collection to be put on hold until a meeting was arranged between senior staff members within the department and myself. Misconstrued constructions of psychology and perceptions of my research were discussed at length. Once my research was accepted to continue, the head of department and head of teaching and learning for the school of Engineering sent an email to all staff and students in the departments to help me further recruit participants.

2.2.9 - Summary of ethical precautions as advised by the British educational research association (2018):

- Informed consent from taught undergraduate and masters students, academic staff and the head of the engineering department.
- Anonymity – the names of the staff and students have been altered. The name of the university where the research took place is not provided, the location is given as Northern. Confidentially cannot be fully assured as the data will be considered in numerous forms.
- Right to withdraw – Continuing caution in regard to consent.
- Data protection – All data is kept in a locked cabinet at my home, all electronic data password protected on my computer, all data to be destroyed on completion of the research project.
- Respect for individuals – Reserving judgement, not demanding time and resources from individual participants.

2.2.10 - Ethnographic analysis

A day in the life of an engineering student (Vignette)

Following is a vignette to explore a day in the life of an undergraduate engineering student (Tommy), considering his daily interactions with staff and students and the practices and activities he partakes in in his community.

It was Monday morning and Tommy was walking to university from the house he rents with his fellow engineering peers. He was walking alone as his friends were not up yet as it was early and he wanted to get in before his full day of lectures started, to do some work on his assignment. The walk from his house took around 15 minutes along the canal which he enjoys as it is some peace and quiet before his hectic days start. Tommy usually went into university before his first 9am lecture of the day as it gives him time to catch up on any work - as he finds the course pretty demanding with days full of lectures and no spare time to work on assignments or further reading of aspects he was struggling with. As he walked, he reflected on the busy weekend he had had. One of his hobbies involves being part of a go carting team, where they race on Sundays against other teams. He really enjoys this as it has enabled him to use the knowledge he has learnt from university to improve or help fix the cart when it is broken, but has also enables him to apply many of the practical skills learnt when carting to the university context. He has also been working on his assignment this weekend as the hand in date is looming.

Tommy is dressed fairly casually with a backpack full of books, notes and workshop clothing. He enters the engineering building which is on the outskirts of the university campus and separated from the rest of the university by a canal. The building is extremely large and is a renovated old mill. He walks through the building, past the cafeteria, lecture halls, smaller seminar computer rooms and past the institute of turbocharging engineering which is a large sectioned off community area and offices for staff and PhD students who are part of that institute. There are a number of these in different areas in the building for different institutes. Tommy gets to the engineering study area which is on the 5th and top floor of the building and is a large space which comprises rows of computers (approx. 50), an area with sofas and a meeting area for students to congregate and share ideas. As Tommy enters the room, he says good morning and asks how the nine other students are who are already working in the room as he walks past them to a computer in the corner. He sits opposite a workspace which is cordoned off for masters students only (there is a sign saying no undergrads). There are two of these spaces in the study area and are for the different group projects which students are placed on for their dissertation project.

It is 8am and Tommy logs onto his computer, plugs his memory stick in and pulls a few of his own notes and an assignment brief out of his backpack. He loads up his assignment and starts to re-read the brief. The brief contains an introduction and background of the focus on the assignment, learning outcomes, a step by step detailed discussion of the laboratory demonstration (which students watched two weeks previous and was conducted by a PhD student), the equipment used and labelled diagrams of this. For the assignment the students have to produce an experimental laboratory report, demonstrating an understanding of the application and function of a strain gauge rosette and be able to apply two concepts in engineering to calculate the results under different circumstances (angles, heat, etc). Tommy works through the report following the step by step guide provided to calculate the results and to create a graph. The first section of the report once students have written up how the experiment was carried out is to calculate Mohr's circle for the experiment. The brief in the assignment guides students to look at their previous lecture notes where they have gone through Mohr's circle and watch the video which has been uploaded onto student portal with a guide on the how calculate Mohr's circle. Tommy is aware he needs these calculations to follow on with the rest of the results section, yet is struggling to understand the concept from just reading his notes.

He decides to go and ask for help from a masters student, Matt, who is working in his designated masters working area. Matt goes through how to work this out using a step by step guide and example from which he has got from an engineering website online. They then work through the Mohr circle for the assignment together. Matt provides Tommy with a few hints and tips to help him with the results for the rest of the assignment. Tommy thanks Matt and tells him he has been particularly stressed as there is a two-week turnaround from watching the demonstration to the assignment being handed in. Matt says it will only get worse as the year goes on and when you move into your masters year. Tommy thanks him sarcastically – talk about bringing the mood down. After 40 minutes of working through the equations for the Mohr's circle and creating a graph, Tommy gets to a section in the brief for the next part of the results which states…. 'you will need to find a citation or source (online or in a book) for the values of Young's modulus'. He decides to leave this for when he goes home tonight, packs his stuff up and heads to his first lecture of the day, thermodynamics.

He sits himself on a desk towards the front of the lecture hall along with a few of his friends who are already in the room. The lecture hall is very large, and fits around 300 students in.

Tommy's class is around 120. Him and his friends are discussing the assignment which he has just been working on. They discuss which part they are up to and Tommy informs them of the hints and tips Matt just told him. The lecturer, Dr Michelle, begins with a brief discussion of how they covered the introduction, background and the four laws in thermodynamics in the previous lectures and will now be exploring this theory in more depth, focusing on the mathematical equations today. He says if they feel they need refreshing on any part of this then they have their notes to look back through. Dr Michelle states they will be going through the four fundamental equations today. Tommy sighs to himself and as he knows how quickly lecturers usually run through equations. He gets his notepad out ready to scribble his notes down. The lecturer starts going through one equation at a time, stating what it is used for, the equation and what each algebra symbol is, then runs through an example and onto the next. The 50-minute lecture runs like this, with students in silence scribbling notes down. The PowerPoint slide has the main equations on and then the lecturer does a worked example on a whiteboard at the front of the room which he copies from a piece of paper. The lecturer finishes and goes through what they will be covering next week. He advises students to read the recommended reading he has uploaded onto portal for next week's lecture.

Tommy and a few of two of his friends, Jake and Nathan, have a free period together so they decide to go back to the study area and crack on with some work. They sit together on a row of computer stations and log on. Tommy purposely positions himself at the end of his two friends as so to not get as distracted. Jack and Nathan start talking about formula one which was on at the weekend and the mechanical faults which occurred with some of the cars and how they believe they could have been avoided. Tommy decides he is going go over what they just covered in the lecture and works through some more examples to ensure he understands. He googles some worked examples of each equation and works his way through them. Jack and Nathan are working on the assignment Tommy was working on this morning. He wishes they would quieten down a bit as they are both continuously discussing ideas as they go through this, which is usual with engineering assignments as students receive the same linear briefs which require all students to complete the same assignment, with no deviation of opinion, interest etc. Jack and Nathan are now discussing the meeting all the boys have last period. The meeting is a weekly occurrence where the boys are part of a team building a race car which is run by the IMechE (institute of mechanical engineering) and also part of their end of year project. The team comprises of both masters and third year undergraduate students and two lecturers. Although this is a team project, the different parts of the car all have different sub-teams and then within each sub-team a student is working on an even smaller component – this is what they have

to write up in their dissertation. Jack and Nathan are discussing an idea the group have been having difficulty overcoming, they think they have a solution which has excited them, and they go over to tell the masters students (who are in charge of delegating tasks), Tommy follows out of interest. As they are discussing this idea with the John, the masters student in charge of their sub-team, one of the staff members on the team is present discussing parts with another student and John shouts him over. The students and Dr Briggs - one of the two lecturers who helps the students run the project - play back and forth with this idea, discussing previous experiences and uses of this concept and how it can be applied to the car. They conclude that they will take time to think about it through the day and return to discussing it in the meeting later. The students pack up and head off to their next lecture, Eco design and IPR. The lecture runs in the same format as previous, where the lecturer stands at the front of the room and conveys knowledge to students. However, Dr Yang does ask students throughout the lecture if they have any questions and if they are following content. No students respond to his queries. The lecture focuses on discussing ways of designing new and novel products in an attempt to 'save the economy'. Towards the end of the lecture, he says they are coming towards the end of the topic and are going to go through the assignment. At the end of each topic students have an assignment to sort of prove their competence and to consolidate their knowledge – Tommy was expecting this today and already had an idea in mind. While away on holiday at his caravan, he always goes to visit the local tractor/trailer retailer nearby, as this is a fascination of his. The retailer also sells other components, one being tow bars. While doing some work experience there while away at his caravan over the summer, the company asked him to redesign one of the tow bars they sell to make it more operative. Tommy knew for this assignment he would use the work and modelling he had done for that and write it up for his report at uni. The lecturer went through the assignment and the regulations – you should know the drill by now he said.

The students scuttle off to the cafeteria in their building. They are lucky that there is never a que as they are the only discipline in the uni to have their own cafeteria in their own building. Tommy and his five friends from his course sit down and discuss the assignment brief they have just been given. A few of them have ideas of what they want to focus on and appear excited as this is one of the only assignments all year where they have some flexibility in the brief and can put their engineering skills to the test. Some of Tommy's other friends are apprehensive as they find this undisciplined approach to the assignment difficult to comprehend as they are so use to being given direct instructions. They discuss the workload they have got on at the minute. Three assignments and three exams to be revising for. Josh one of Tommy's friend lives with someone doing a history degree and he

says he only has one 2000-word assignment to be in in January. Nathan says well that is just the way engineering is, if you want to be an engineer you have to put the work in. The conversation moves away from university work and onto a job Alex has applied for. Alex made the decision, unlike to rest of the friendship group to enter industry rather than carry on for another year and graduate with an MEng. Alex tells the rest of the group the long application processes, all the tests he has had to complete and the stringent selection process for the engineering jobs he has applied for. Tommy explains how he has no idea which area of engineering he wants to venture into once his degree is finished and hopes the narrower fields in the masters engineering degree will provide him with some inspiration. It is time for their next period which is a practical seminar session, building on student's CAD knowledge.

Tommy walks to the lesson with Alex as he is the only one in his same seminar CAD group out of their group of friends. The groups only have around 30 students in them. Tommy and Alex sit at the back of the room and are handed a worksheet by their tutor, Simon Flinch, he is a workshop technician but runs some tutor sessions for CAD. The sheet has step by step instructions on how to go through the equation and a practical model they will be running today. The equation is written on the whiteboard and the graph and model they will be making on CAD are already on the projector. Simon explains how the equation is something they could get in an exam, so they will have to memorise how to answer it and what all the algebra means. In today's session they will be running through how to answer the equation and will then apply it to a real-life model in this session. He says they went through the theories and concepts behind heat exchange in their lecture last on Thursday with Dr Kumar and they will now go through the equation and practical side today to help consolidate this knowledge. Simon goes though the equation in detail, talking students through the step by step process and asks them to work out the maths for each step. Tommy shouts out the answers for a few of the steps. As Simon works through the example, numerous students ask questions to clarify certain points. Tommy scribbles the process down. Students are then left to input the results from the equation into CAD and create the graph – Simon says they should already know how to do this. Tommy remembers how to do this from a few sessions ago but pulls his notes out for clarification. Alex gets stuck with this and asks Tommy for help. Tommy does not mind as Alex seems to struggle with the mathematical/conceptual side of engineering but exceeds in practical skills which Tommy sometimes requires help with. Tommy goes through step by step with Alex, making him do the graph on his own computer and asks him to write it down for future reference. Simon then talks them through the process of inputting the data to create a model. Simon runs through this on the computer at the front of the room and students

follow on their own computer. Once they have all created the model, he discusses the different components of the model and how changing certain functions on CAD can change the heat capacity and density within the model. He says how they can use this to test for how real-life objects would react under such functions. He then emphasises again how students must learn this equation, not only to be able to perform real-life engineering but also to pass their exam. He provides students with another example of the equation and asks them to complete it on their own. Tommy can see some of the students still haven't completed the graph stage as they cannot remember how to do so – how will they pass their exam if they cannot even remember how to make a simple graph. Tommy and Alex work through the equation in their notebooks and are told they can leave once they have done so. They notice as they leave a number of students still left in the room struggling with the equation workings and creating the graph – Simon is slowly going around helping them individually.

Their last period of the day is the team meeting for the 3rd year undergraduate and masters formula one project then over to the workshop to work on the car itself. They have these meetings once a week, but the masters students have them almost every day and are in the workshop most days. The meeting is held in the engineering student study space, around the large table at the end of the room. Around 30 students and two lecturers gather round this table and Liam, a masters student, uploads a PowerPoint onto the projector. The student's group into their sub-teams and start discussing what they have been working on in the past week before the meeting starts. Tommy is on the fuel tank system with four other students, one masters. He chose to be on the fuel team as it is what he is interested in the most. Tommy feeds back to his fuel group what he has been researching for the past week, his solution, and the price he has found for the part which is required. Jamie, the masters student, makes notes of this and asks numerous questions within the group to see if the solution is viable. The other students in their sub-group play back and forth with the idea, questioning Tommy more and exploring other options/solutions they come up with off the top of their head. Tommy argues his case and justifies his reasoning for picking the solution he did. They agree this is the plan they will move forward with – Tommy is relieved and feels pleased with himself as he put a lot of thought and work into this.

The meeting starts with Liam who is the project manager, providing general update information from the past week about costings and parts being delivered, etc. He then goes around each sub-group asking for updates from their past week – there is a different slide for each sub-group with their jobs list from the previous week. The masters students are usually the one who speaks for the sub-group, with undergraduate students speaking up if

required. Some students have photos or videos from what they have been working on in the workshop and these are already uploaded onto the PowerPoint. Each update from the group takes the same form - students relay what they have been working on, ideas they have and solutions they have established. Other members from the other sub-groups and the lecturers' question these decisions, and students making strong arguments, backed with facts, theory and mathematics to provide justification. One of the staff members in the team suggests as students are struggling with the issue of attaining a good breaks system, they could contact the student who ran this part of the project last year for some help, as he is sure he would be happy to help – he provides them with this ex-students name and email. Dr Briggs then says he has been in contact with an old friend of his, an ex-race car driver who now has a passion for building race cars himself. He says he has agreed to help the team with anything they require and can go and use his track to test their car out, as long as they help steward a race event in a few Saturdays. They team all cheer. Each sub-group, along with Liam and other core masters members then discuss further action and ways of moving forward and set deadlines. Tommy hates these sorts of meetings, he doesn't understand why everyone always appears against the ideas each other put forward – they are supposed to be a team at the end of the day. The meeting ends, and most people rush off as it is 5pm. Tommy already agreed a few days previous to go to the workshop with his team and the masters students, to go through some running's of the fuel system.

They make their way to the workshop which is in a building on its own and contains many other workshops for the institute of railway, institute of turbocharger, computer labs and other projects run by students, lecturers and the technicians. Tommy is not so keen on workshop exercises as he knows his strengths lay in the more theoretical, mathematical side of engineering. As the group on students enter the workshop, the technician shouts form the other side of the room, back again. Tommy overhears that the masters students have been in here all day as they are struggling to get the engine started. He observes as one group of students starts uploading the system onto the computer and the other group of boys stand by with tools at the ready. Him and the other undergraduate students stand to one side as they have only been in the workshop a handful of times, but he is in his workshop clothing just in case. The students, technician and Dr Briggs stand round as the boys try again to get the car started. It's just doing the same as earlier Josh shouts, it's backfiring as he observes the engine. Tommy has heard this term before when doing independent reading and knows it isn't good. They try a few more times and the technician says god you guys have persistence and it is admirable but its time to close up, you will have to come back tomorrow. The students cannot do the fuel tank testing as they cannot

even get the engine running – they agree on another date for the fuel tank sub-group to come down to the workshop. As the lecturer leaves, he says to the undergraduates, don't worry lads they will get it working, I have every faith in them. Tommy and his group must have looked worried.
The boys pack up their belongings and leave the workshop. 5:50pm and Tommy finally makes his way home.

In the current research, I adopted a narrative analysis approach in constructing a story of the trajectory of studying engineering and becoming an engineer (as seen above) from the observational data collected. Narrative analysis is the construction of a story that provides a rich framework through which the complexities of human experiences and meanings of the world can be understood (Webster & Mertova, 2007). I felt this was an appropriate method to represent my observational data as the experience and meanings analysed are considered as not an isolated concept but as being shaped by personal, cultural, and contextual factors.
This supports the epistemological and ontological assumptions of the research, in that human development cannot be considered an individual internal process but a social construction between the individual and culture in which they live. I then used thematic analysis as a way of recognising reoccurring patterns within the interviews.
Using a narrative analysis enabled me to address the research aims:

- Explore the culture and context of studying taught engineering programs in higher education.
- Explore engineering identity and participation in higher education

The narrative is a fictional story which I have constructed for the purpose of the research. It was constructed by considering and reflecting upon the observational and interview data collected throughout the research to form a single narrative of the daily life of an undergraduate engineering student. I wanted the trajectory narrative to provide readers with a comprehensible way to view and understand the daily life of an engineering student and the culture, context, practices and identity which constructed this. In composing a narrative of the trajectory of studying engineering, I reminded myself of Wenger's (1998) use of vignettes. He told a story of an insurance claims processor, Ariel, using a vignette to illustrate the practices which she negotiated when participating within her workplace. The vignette was a comprehensible and compelling way for me to gain an understanding of Ariel's working life. I therefore wanted my narrative to provide the reader with an understanding and insight into student's trajectories of studying engineering and becoming

an engineer, an aim of the research. Bochner (2001) provides support for the use of narratives, suggesting they are a useful tool to enable the reader to not simply think about but think with a story through a process of engagement. I am by not means suggesting the narrative is free from my own interpretation as there is no doubt my theoretical perspective meant that I focused on some aspects of the data over others, but I accept this as a feature of my analysis.

I decided to undertake a thematic analysis to identifying commonality across participants, through the idea of shared themes. As the main aim of the research was to explore student's experiences of studying engineering, with no preconceptions or ideas, I felt this was the most suited method for analysis. The analysis method enabled me to flexibly explore the experiences and perspectives of my participants and explore unanticipated insights surrounding context, identity and culture, as opposed to focusing on pre-determined categories and being tied to a theoretical framework (Braun & Clarke, 2006).

Braun and Clarke (2006) provide a six-stage guide which I used as a framework for conducting my analysis. The first step involved familiarising myself with the data by reading and re-reading all interview transcripts and observation notes then jotting any first impressions down I gathered from my reading. The second stage involved generating initial codes which makes the data more meaningful and systematic by reducing it down into meaningful parts. Braun and Clarke (2006) state the initial codes are determined by the research perspective taken and research questions. For example, I coded each segment of data which was relevant to or captured something interested about my specific research aims. To do this I used hardcopies of the data transcripts and worked through them with a pen and highlighter, jotting down any reoccurring codes. The third step involves developing themes. A theme is defined as a pattern that captures something significant or interesting about the data and/or research question (Braun & Clarke, 2006). It is suggested within this stage to explore codes which could be combined to form themes. For example, I had several codes which spoke about engineering being a discipline they were interested in since childhood. I organised these codes and joined together to create the broader theme 'born not made', which then provided me with the opportunity to say something specific about the research question. Stage four involves modifying and developing the preliminary themes to ensure they make sense. Within this stage Braun and Clarke (2006) suggest it is useful to gather all the data associated with the theme to ensure the theme is well supported. There also needs to be considerations as to whether themes work in the context of the entire data set and not just one transcript. Step five involves a process of fine tuning of the themes, with the aim of *'identify the essence of what each theme is about'* (Braun & Clarke, 2006:

92). This process involves exploring exactly what the theme is saying and how sub-themes or main themes interact/relate. Within this stage I also started the process of interpretive analysis. This involved consider each theme in relation to the sociocultural theories of learning to consider underpinning assumptions, an aim of the research. The last stage proposed by Braun and Clarke (2006) involves writing up the analysis into a report style journal article.

Chapter 3 – Analysis

3.1 Theme one – Born not made

In the following sub-theme, I explore the monolithic identity of engineers and the way in which this is perpetuated within the community. This explores the process of engineering identity construction from childhood which entails notions of innateness, ability and inbuild characteristics while also considering micro system influencers on this process. I argue how this forms an incoming trajectory to the community which enables successful participation in the community of practice of engineering education. By members of the community perpetuating the monolithic identity that in order to participate in the practices and be recognised as an engineer, an incoming identity must be demonstrated as this holds characteristics required within the community's regime of competence.

The second sub-theme explores the regime of competence in engineering education HE and how students adapted themselves and their identity to negotiate this. This theme discusses how the regime of competence is heavily focused on skill development, with students defining themselves and their peers in terms of skill possession. I explore how this regime of competence creates a tribe in engineering where students are included or excluded depending on their ability to develop or already possess the skills required to succeed in the community.

The last sub-theme explores the unspoken yet valued practices in engineering education. This theme argues that members of the community perpetuate the image that engineering should be viewed as a lifestyle choice not merely a job or an educational course. In this image, being ingrained into the regime of competence, students negotiate their identities to extend beyond the realms of their studies to participate in differing engineering communities of practice. This theme argues that becoming an engineer is not a linear process of achieving good grades or carrying out a profession but entails a process of becoming.

3.1.1 Sub-theme one: Perpetuation of image – An inbound trajectory

The first sub-theme I will discuss is students' trajectories of identity construction and how this perpetuates a monolithic engineering identity in the discipline. Students reflected on

their engineering identity as it being something which began construction from a young age. Students spoke of how they partook and were interested in engineering focused concepts since childhood. (70) discusses his childhood experiences of engineering….

I was interested in engineering when I was in school. I would always watch engineering trades and ask how it would work and what happens and try and get my head around it. I always found myself to be more inquisitive, how things work and practical. Like building ramps out of wood. Now I understand the mechanics and science behind it and its more interesting. I have always enjoyed problem solving.

In (55)'s interview, he acknowledged the point in his life when he decided he wanted to study engineering….

I knew I was going to study engineering pretty much from nursery school. I knew what engineering was and so I got into secondary school and fortunately my best subjects were maths and physics. Naturally I enjoyed those subjects because I could relate it to everyday life.

(76) also spoke of activities he partook in from a young age which he believed to be engineering related…

From a young age I would de-assemble my toys and then re-assemble them again or make something different.

When (72) was asked what it means to be an engineer, he responded by considering his identification with engineering since the age of 6…

Well it depends what you judge it on because I could say I've been an engineer since I was 6 years old. My theoretical knowledge at degree level is now good enough I believe but I have always had practical knowledge

A lecturer in the department also commented on the point at which she felt students started to identify as an engineer….

The minute they walk through the door and some before. I'm sure some people are born believing they are engineers.

The quotes above clearly demonstrate students view that their engineering identity is something which has been constructed from a young age. It is as though this view is an accepted belief amongst the discipline that an engineering identity is something which naturally occurs, almost from birth, as the last lecturer commented. This accepted view of identity construction perpetuates an acceptance within the discipline that in order to become an engineer, it must be a something you have participated in since childhood.

An almost natural, innate identification with the discipline from a young age was something students spoke of throughout their interviews. They commented on notions of having an innate interest in engineering and being naturally talented in the discipline. For many students, they recognised these ideas as being something which stemmed from childhood and was demonstrated in their school environment. In having these established ideas of how their engineering identities initially formed, a construction of an inclusive criteria that - in order to become an engineer you must have this discipline background - is created. This was further emphasised in (2)'s interview….

I just had the knack, it was something I could do naturally. Something instinctively I knew I could do

59 also commented in his interview….

When I left school I really liked maths and science and I wanted to know how the world works. I always saw myself as sort of breaking numbers down rather than fixing something manually. This is really interesting and you always strive to want to know more and more. I was more intrigued to learn more about how the world works. I've always had that self-sufficient mind

Students emphasised the fact that they believed engineering was something they were naturally good at (57)…….

I decided to go with engineering because it just seems like something I would enjoy more. Mostly because I understand it well, not just from a study point of view but a hobby as well.

A lecturer also commented when questioned on dropout rate in engineering …
I think some of it is just difficult to understand and it takes a certain natural ability and an interest in engineering.

The quotes above which focus on students' childhood experiences of engineering further denote the innate interest and talent students believe they have in the discipline, it is as though they believe they have an almost predisposition to become an engineer. For the engineering students, it is evident that becoming an engineer is an avocation and vocation. It is something they both enjoy but also something they see themselves as having a natural ability for career-wise. The performances they demonstrated at school and the talent they believed this equated to in engineering was something they described as being down to having an "engineering mindset". The engineering mindset was something the students felt was key and universal in becoming an engineer, but also something which was part of who they were, a mindset they identified themselves to have. (69) defined the engineering mindset and how he views this as part of his identity….

I see myself as a problem solver and a practical person. I always think of myself as an engineer. Even though I look at the policy side of things, I still think of myself as an engineer because it's still the engineering approach to problem, solution, idea. It's the engineering mindset, having a problem, finding a solution and improving on things.

Students spoke of how the engineering mindset spans across engineering, regardless of the sub-discipline (chemical, electrical) …
it's the mind-set, you could be mechanical or aerospace but the same theories apply, it's how you approach things

(59) also discussed how the engineering mindset was part of his identity, something he exercised in his daily life….
you have to have a certain mentality to want to find out why things work. it's about finding a problem them solving it, you apply it to real life problems as well. If there is a problem, you analyse it and then look for ways to solve it. Its just a mindset you can't get out of.

Engineers are like human computers' my mum is the biggest problem I've never been able to solve.

As can be seen, particularly from the last quote, the engineering mindset students discuss extends beyond the realms of their studies, it is part of who they are as engineers, part of their identity. They ascribe themselves to have these innate characteristics which enable them to succeed in the engineering discipline.
I bring in Wenger's (2010) theory here to discuss students' identity construction. The students state their engineering identity from being young and this stated identity then leads them to participate in certain practices which further enables them to enter the engineering education community. Wenger (2010) describes a person as a social participant and a meaning-making entity in which the social world is a resource for constructing an identity. I argue here that the social world surrounding the students from childhood has facilitated their construction of an engineering identity from a young age. I argue that in being exposed to the regime of competence of the community through connects with practising participants, students are not only learning the acquired skills and information required of them but also experience a process of becoming a knower in the context, they become a certain person (an engineer). However, in the participants ascribing their success to innate characteristics, they are creating a marginalised view that you can only be an engineer if you are born this way. If they all think you have to been born that way, then this constructs engineering in certain ways and perpetuates a monolithic identity which excludes many.

In the second sub-theme I will discuss in further detail the engineering mindset and how this unravels into the skills students depict engineers to require, but here I want to highlight a theme I feel constructs these initial engineering mind-sets and draw attention to ecosystem influencers which mould engineers into ways of being. I make this point as throughout the interviews, and evident in the quotes provided, the students emphasised their innate ability and interest in engineering. I do not deny students having a natural talent for the subject, I do however question student's comprehension of the engineering discipline from such a young age. From within the interviews, it was clear many of the students had numerous influencers in the ecosystems surrounding them which impacted their decision to study engineering. For instance, many students discussed the micro system of their family and the influence they had on their engagement with engineering from a young age.

This included family encouragement (toys being purchased) with toys associated with engineering activities….

I've always liked to build models and like Lego (63)

I've always played with Lego, still play with Lego now (69)

Other influences came from family members and teachers already within this discipline…..

The interest really came from my dad and a lot of members in my family because they work in engineering. For me I just see it as a great opportunity to have a great career (65)

Since I was a kid I was always surrounded by engineers. My uncles and lots of dad's friends are engineers. I was into cars as well so that sort of convinced me (78)

My dad was an engineer in the merchant navy, so I just wanted to follow that kind of route (68)

She (teacher) suggested mechanical engineering and shows me what its all about and I thought do you know what this is probably more me than what I was actually applying for. The content of the course was about everything around you and that's what I kind of like. Like knowing how things work and how things process (75)

The influence and motivation from differing micro systems on the student's engagement with engineering are apparent from the quotes above. Many of the students were encouraged to participate in practices and provided with insights into the community by people who were already members of it. This involved being told stories the family members had experienced in their engineering careers or being provided with engineering opportunities such as attending the family members place of work. A few students noted this event within their interviews...

My dad was a plumber so I use to help him a lot, he was always very practical. It was always the technology side what came to me more (2)

Now the thing with me, the interest really came from my dad and a lot of members in my family because they worked in engineering, especially the oil sector so you start to get glimpses of what certain careers have and for me getting to see my dad working in the oil sector. He speaks volumes (46)

My uncle use to be an electrician and he sort of built up to engineering. I thought using the real-life experience of being an electrician would make it better for me to become an engineer later on (25)

Since I was a kid because of my dad, he is a tuner, he works for racing and stuff. I did motor vehicle studies and automotive engineering since I was 14/15 years old (31)

In the students being provided with these opportunities, they are already being engaged with and learning about the engineering community and becoming aware of the regime of competence that surrounds it. The students are being exposed to different engineering communities from a young age. The members of the community depict what is expected of the students on the peripheral. I argue that in turn this further perpetuates the monolithic engineering identity. Members within the community are providing and encourage perspective peripheral members with the set characteristics, interest and talent require of them to be engineers. This was noted in (69 – a lecturer)'s interview when he discussed the activities he does in school to encourage children to consider a career in engineering…..

It made me think about my approach. How we attract kids and it made me realise most engineers are guilty of this, but we promote engineering to people who are more like us. It made me realise that the way we promote and communicate engineering and the way we go in and think one size fits all. A lot of engineers go in and promote what they are as engineers and say if you're like me you can be an engineer.

By the engineering members of the community appearing to aim to create a replication of themselves as engineers in the students or peripheral participants entering the community, set criteria for what is expected of an engineer and their way of being is created (regime of competence). A mould for students to fit into is developed, in which students have to enculturate themselves and construct their identity within. From exploring student's trajectory to studying engineering, it is apparent this process of identification and enculturation within engineering starts from a young age. Students discussions of their childhood experiences of engineering highlight the 'training' to become an engineer is a life-

to-now process. Through the student's lives, credentials to be an engineer are constructed. Be this the encouragement of engagement with engineering associated activities from individuals in their micro system or students developing or exposing a 'talent' in the field and gaining an interest. Participation in these practices helps construct an engineering identity.

As a result, when many of the engineering students initially enter their educational studies they tended to already identify as an engineer, whereas people may not from other disciplines. Through their social participation and meaning-making throughout their lives, they have already started to become practising members within the discipline. This means when the individuals enter their higher education engineering studies, they tend to have incoming identities as engineers. The students have developed skills in engineering throughout their life which are transitioned and transferred across topic and context when entering the discipline of study. The students have an inbound identity trajectory for the community of practice of their HE engineering studies. This is recognised by Wenger (1998) who suggests identities incorporate the past and future while negotiating the present. In students having inbound trajectories it has been argued by previous research this can further enable successful participation in the new community of practice (Turner & Tobbell, 2018). Students are able to easily reconcile their previous form of community membership and forge a successful learner identity in HE engineering.

Student's previous engagement with engineering activities throughout their lives often enabled them to better adapt to their current learning environment. Their process of identity construction started from a young age which enabled them to adapt to practices within the community of engineering education. From the interviews, it was clear that central to many of the student's success was the ability to take their initiative and act independently. For instance, students spoke of the additional work they have to partake in at university outside taught hours. For every student interviewed, none described this as out of the ordinary or an issue, as partaking in engineering activities outside formal education was something they have done from a young age.

Students commented….

Me and my friend would come in at 7am and we would always be working, sometimes studying for things that weren't covered and we wanted to know more. Sometimes we would tinker with things to learn how they work and we just wanted to know more about them (61)

In an observation of a group of taught masters students, a student commented on the amount of work they do…
He says we all do this (team hare) 9-5 and then do assignments on evenings and weekends (39)

A lecturer on the course also commented on the amount of work the students should be doing…
He says it is only a 45 credit module so they should only put 450 hours into it but they do loads more (39)

Students in the interviews also commented…

We work so hard to meet deadlines. I think as a group of people we are really focused. If there is a deadline coming up, you work really hard and get it done. I think as a group of people we look on that more than other courses (72)

A masters student discussed how in engineering they are not directed but make the decision to optionally read in an area to gain an understanding of the new topic of study before covering it in lectures. He compared this to the business module which they had to take as part of their masters which was run by a separate school in the university. He described the teaching in this school to be directive with less valued placed on independence in comparison to engineering…

I've never had read this book. Its more like you might know we are going to be learning about this set topic so it is good to have an understanding about that. The only time I had you must read this is in a module we had from the business school and that was run totally different. (72)

It is clear from the quotes that students depict independence and initiative as being valued practices in the engineering education community. They identify such practices as being the norm within their discipline and make stark comparisons between the participation in such practice they demonstrate and that of students in other disciplines. In making such suggestions students appear to go through a process of othering. As a discipline, they seem to set themselves apart by identifying factors within their community of practice which they

feel makes them special or different. Such as when a student comments on how hard he believes him and his peers work…'*you work really hard and get it done. I think as a group of people we look on that more than other courses'*. I argue that in students creating such differences between their discipline and others they are further enforcing the monolithic identity. By setting themselves apart and identifying areas of difference they are perpetuating themselves and their identities as unique, specialised and for a set 'type' of person.

A further factor I identified which related to the notion of independence was student's motivation levels within the discipline when they spoke about their workload at university. Again, themes come through of viewing themselves as a group as being motivated people - I argue in doing so they are again perpetuating their monolithic identities.

Students commented….
You need to be dedicated and willing to invest a lot of time into something (73)

Once you get your head down and realise what you have to do and you know what you have to crack on with (75)

If you want to be an engineer you have to really want it, half measures don't work (2)

If you are going to progress as an engineer is it self-learning (88)

You have to go away and do a bit more in your spare time, learn on your own a bit more (4)

These quotes heavily relate to the student's motivation and interest in the discipline. Motivation is one of the challenges of learning independently in the HE engineering environment. If students do not attain a level of motivation to uncover the valued practices within the community, to shift from peripheral to full membership, learning in the individual is marginalised. This process of motivation involves students engaging in a process of meaning-making in learning. This motivation to become an engineer and succeed in the environment is not solely centred around passing exams but involves a process of identification, becoming an engineer, a practising member of the community. I argue that because the engineering students entered the community with previous engineering experiences, interests and talents, their levels of motivation to achieve are higher. The engineering students are completing the degree with the goal of becoming a professional

engineer. For many of the students has been a goal since childhood, their levels of motivation to succeed in the community of practice are intensified. However, I do suggest that in doing so and highlighting this comparison between disciplines, they are again further problematising the monolithic identity the students appear to have adopted.

These quotes further highlight that independence, initiative and motivation are valued in the engineering community and through students' previous experiences and the development of their inbound trajectories, successful participation was enabled. Students were able to reconcile their previous form of community membership and participation to forge a successful learner and engineering identity in HE. I argue here that in order for students to enter the community in engineering, some form of inbound identity trajectory is required. In this view being created, maintained and encouraged by members of the community and passed on to peripheral participants, a perpetuation of the engineering image is maintained. I argue that it is ingrained in the regime of competence of the community that students enter the discipline with preformed engineering understandings. Students have an understanding that in order to become accepted as an engineer there must be some form of previous experience – an inbound trajectory. I will now provide a discussion of themes I gathered surrounding students' inbound trajectories from the interviews. Students made connections between the communities of practice they had previously exercised their engineering identities and how these enabled or disabled their participation in the community of HE engineering.

Within the interview's students made connections between their communities and inbound identity trajectories. Discussing skills which enabled them to participate in their new community, that drew on experiences and understanding from previous communities…

Students made connections between previous hobbies they had….
I raced motorbikes myself for a few years and when I stopped I decided to help a friend stock car racing and I was a mechanic on his team and that's what I enjoyed spending my weekends and evenings doing. For enjoyment and it's a happy coincidence it helped me get on the course (73)

The maths and physics are a requirement and I did another science just as a filler subject and I did business studies which has helped with the business-related modules we do. While I was doing my a-levels I got some practical experience because I worked for a couple of

race teams so despite not getting the results I wanted, my practical experience helped get me on the course (73)

I always found myself to be more inquisitive, how things work and practical. Like building ramps out of wood. Now from going to university, I understand the mechanics and science behind it and its more interesting. I have always enjoyed problem solving (70)

Students also drew on other disciplines which they have previously achieved in which they believe to have connections with the engineering discipline and has helped them achieve in this new community of practice….

I got into secondary school and fortunately my best subjects were maths and physics. Naturally I enjoyed those subjects because I could relate it to everyday life (55)

Physics has always been one of the things that always come naturally to me, not that's its easy but I get a grasp of it easier. That's why engineering is a better course because I understand the theory of it easier because it comes to me easier (67)

As can be seen, many of the students arrived with skills and knowledge which enabled them to participate in their new community. As students' engineering identities appear to extend beyond the realms of their studies, their interest and activities in engineering demonstrate students understanding that successful participation was not just about developing knowledge but also knowing what to do with it. It was about becoming a certain person, becoming an engineer. Students discussed this process in their interviews…

I don't just study electrical engineering, I also have professional development skills so its more than just what you actually have to do as an engineer, its also learning the other jobs you have to do. You are learning the full spectrum of what it means to be an engineer in the workplace. They don't let you forget that this is what its like in the workplace and we are not doing it because we are cruel, it's for your own benefit (67)

If you want to become a manager in the engineering sector, apart from a good technical grounding you need to have an understanding of the business as a whole and having that

foundation of an education background will make you that all-rounded engineer. This day and age you really need to tool yourself up (65)

I realised I needed a degree. You have a more grounded kind of knowledge of what you are doing rather than learning on the job. You kind of having an understanding of what you are doing (68)

On occasion this involved shifting and adapting students' previous skills, knowledge, interests, experiences and expectations in engineering to be in line with what was required in the community. Some of the students acknowledged this in their interviews….

First year was horrible because my theoretical and mathematical bases wasn't strong enough. The college course wasn't as in depth as it should have been. I'm still trying to catch up, sometimes it can feel like I don't know where to start. A-levels would have prepared me better (72)

When I first started I bought the maths books which are made for engineering degrees and I just started working my way through (88)

As can be seen, some students struggled with learning the accepted knowledge to become active members of the community. Students partook in independent endeavours to equip themselves with the necessary skills and knowledge to achieve and become practising members. However, for many students, it was clear what they had recognised engineering as being from a young age, such as building and practical experiences, was not what was valued in this new community…..

The degree offers you the ability to do higher engineering. We have been taught how to do things apprentices haven't, he (an individual completing an apprenticeship) has had the more physical aspect of it and has worked hands on, which you can't really teach at uni (73)

My theoretical knowledge at degree level is now good enough I believe but I have always had practical knowledge (72)

Students recognised the differences between valued practices in the community of practice they are in and other or previous practices in the same discipline. As for many, practical

skills were something they had associated with engineering from a young age and they found the process of enculturation into the new community challenging.
I do however argue here that despite some of the challenger's students faced in developing and shifting their engineering identities when entering the new community of practice at university, there is a strong undercurrent of modulation. Lave and Wenger (1991) discuss identification to involve modulation, in that some individuals identify with a community more than others, feel a stronger need to belong to it and therefore see a need to be accountable to its regime of competence. Through the process of identification with a community and the modulation of it, the practice, the community, and individual's relationship with it become part of their identity (Wenger, 2010). Students entering the community of engineering appear to have an inbound trajectory that in some situations needs shifting to align with the regime of competence in the community. As can be seen within the quotes, the students ensure they are participating in the practices of the community to enable them to establish membership and identification.

This theme has provided insight into engineering students background and the construction of their engineering identities to form inbound trajectories. In the following theme I will consider how in creating this monolithic engineering identity, a tribe is formulated around the regime of competence within the community. The tribe creates an inclusion or exclusion criteria and students are judged depending on their ability to develop or already possess the skills required to succeed in the community. Yes students have the formed engineering identities and inbound trajectories required but can they then become the perfect engineer?

3.1.2 Sub-theme two: The established tribe

In order for students to become and be recognised as members of the community, they must correspond to its regime of competence (Lave & Wenger, 1991). The regime of competence is a set of criteria and expectations by which membership is recognised. Within the interviews, it was apparent the regime of competence and how student engineers defined themselves and others within the community was through the possession of engineering-related skills. Throughout the interviews when students were asked what engineering is, what it means to be an engineer and what they believe they must attain to become/be recognised as an engineer, they emphasised the skill set individuals must have. Within the interview's students listed the reoccurring skills they believe engineers to require….

Straight to the point, hard working, determined, embrace challenges, good at problem solving and analytical, effective communication from someone to senior to a labourer (65)

You need a good understanding of physics, maths is imperative, IT skills and a lot of program based. A methodological way of working, in engineering it has to be right, it doesn't matter about time (70)

Having the skills to pick up software quickly. You need to be objective and have a clear idea about what you are going to do. You need a very precise set of skills and a very precise goal. It is competitive because everyone is trying to design the next best thing. I guess a lot of it comes down to sitting at a computer on your own. In companies there is a lot more push to be open and have groups working together. A lot of group discussion and ideas flowing around (71)

You need to have direction. I would say persistence is the main thing. I think you have to be confident in your ideas, in what you have come up with. And in a team of 20 you have to get your idea across and show why it might be better than someone else's. At the same time you have to be absorbent of other ideas as a combination of two ideas may be better than one. It takes confidence to argue your ideas. Team work and project management are two skills needed (73)

Need attention to detail and a good memory (74)

From the quotes above it is clear students who have entered the community of practice have gained some understanding of what is required of them to develop and/or possess to be recognised as an engineer. Lecturers also emphasised the skills they believed to be required to become an engineer….

I think some of it is just difficult and it takes a certain natural ability and an interest in engineering but it also really just takes grit and determination which not all students have. I think some just fit it too onerous, there is an awful lot to learn. Some of it is really really difficult to understand (119)

Good at maths, good technical skills (117)

Both staff and students recognised this skill set as something evident within the community surrounding them. They identified it as being something which belonged to them as engineers, as part of their community and the members within it. In the interview's students provided a discussion of the skill set to define what engineers are like….

They tend to pal around with themselves, detail orientated people, not the easiest people to get along with, big egos a lot of the time. They are problem solvers but problem solvers in terms of structured organization. Like rules and regulations but in many ways quite creative. Less artistic creativity and more aimed at problem solving (69)

You need a good understanding of physics, maths is imperative, IT skills and a lot of program based. A methodological way of working, in engineering it has to be right, it doesn't matter about time (70)

As can be seen, individuals within the community are defined and recognised as engineers by skills. In order for students to form an engineering identity and becoming practising members within the community, they must conform to its regime of competence. Through already practising members of the community maintaining and promoting this regime of competence, an inclusion criteria of skill development to be recognised as an engineer is created. This was demonstrated in the skill requirements discussed by lecturers and when students described an 'engineer'. When students first began their studies, they were apprentices on the periphery of the community, learning what is expected of them to become practising members. Through emersion into the community students then learn and form their identity around such expectations to become practicing members.
However, in some of the quotes above, it is evident students and lecturers identified an element of innate skill possession. This was something I recognised within the interviews. Students often described themselves as having a general talent for engineering but then often spoke of areas within the discipline where their strengths were. I recognised how students often created relationships with their peers based on these strengths. They saw the friendships as being something they could use to their advantage within the community. This can be seen in the quotes below….

We are all working on the same topic but we have different skill sets. So I can help someone out and they can help me in a different way (52)

People in my department will come to me if they have a problem with programming but at the same time someone will know a lot more than me in other areas (62)

If you don't know something, rather than spending hours looking up or research how to do something, if they can show you within minutes and then you know that you don't have to go away and research it and likewise I know stuff that they don't know (73)

To get a degree yes they are my friends and I don't want to see them fail. Engineering has so many different areas of expertise, and what I'm not good at, others are and vice versa. Its you scratch my back, I'll scratch your back scenario. I don't mean to sound big headed but with the same information I believe I can get the best grades out of my friends. It's partly being helpful but partly being selfish I guess (SMS)

One of my best friends, he has just come from the BTEC route and he struggles with the concepts and he is reliant on me and James for example to teach his some of the higher level maths things. James is a lot more academic and he knows a lot more about maths, he doesn't know much about the practical side of engineering but Josh does (81)

As can be seen, students appeared to make acquittances with peers to counter-match or make up the skill set they had. For instance, participant (81) suggested one of his friends was better at the mathematical side of engineering while his other friend was better at the practical side and so their skills sets complemented one other and could aid each other in their engineering development. I bring in Vygotsky's notion of the MKO and ZPD here to consider the relationships students form within the community of practice. Vygotsky (1978) discusses knowledge construction as a process by which any person who possesses a higher skill level than the learner with regard to a particular task or concept to scaffold and support learning. This is done through the zone of proximal development which provides an appropriate amount of assistance to enable the learner to succeed at the task individually. This can be applied to the engineering community as students appear to form connects within the department based on their ability to help facilitate their participation in the practices of the community. Members within the community enable a shared repertoire of resources and knowledge to support the competence, development and participation of other members within the community.

As highlighted in theme one and again here, students and lecturers identified an element of innateness and ability through their inbound trajectory when entering the community of engineering HE. Students emphasised this within their interviews and spoke of the skills they felt they already had which enabled them to succeed in the new community…..

I consider myself to be very analytical and black and white, very straight forward in my approach to most things. I think people who have that skill will be good at engineering but I don't think you need to it to be good at engineering (73)

It's a thing in engineering that you have to be concise. Concise report writing is a skill in engineering and it is something I have always been good at so write a two page paper is not really that stressful (69)

Both students spoke of the skills they had which enabled them to succeed in the discipline. However, some engineering students who were interviewed described how they had to negotiate the skills they previously had to fit in with what is expected within the community. This can involve a process of realignment between socially defined competence and personal experience (Wenger, 2010). Gaining competence in the community entails becoming someone for whom the competence is a meaningful way of living in the world, it is a process of becoming. Through the community of practice enforcing the skills required to succeed in the discipline and to become members, an 'ideal' in which students must work towards is created. Students on the periphery have to learn to talk within the discipline not learn from talk. This process of skill negotiation to adjust to what was required in the community was evident in interviews carried out with taught masters students…

Erm first year was horrible. The theoretical, mathematical basis what I had wasn't strong enough. Purely because the college course wasn't as in-depth as it should be for maths. So that was a struggle (72)

In masters year they don't want to waffle that comes with the first and second year. They want something what you would give to your manager un industry and that was a step up. Even though you coming back from industry it was a step up and it was like right these have got harder and the level of detail and the specification that they need as the degree goes on. They don't want to know what the result is, they want to know why it occurred and what your theory is behind it and what you could have done differently next time (73)

The skills you gain from regular modules (on masters) and probably are probably not a considerable extension to what you did at bachelors level. The hare project obviously teaches you, not so much teaches you but gets you use to a team environment, a commercial environment. I am not just saying a little bit of coursework together like a regular module because it isn't that. It is team structure and a team presentation but you are dealing with real money, real people, real companies which is what you will be dealing with in industry. So it is application of what you have learnt prior and applying it in the real world while you are still at uni (81)

From the quotes, it is apparent the skills students identify which they must adopt are noted by themselves as skills not only valued in their current community of practice but also valued in the role of becoming a professional engineer in industry. This further emphasises the point that students are not learning from talk but learning to talk within the community of practice – they are learning to become engineers.

In the community of practice demanding a prerequisite skill set in which membership is recognised, a structured tribe is created. It is students aim to become established participating members of the tribe (engineers) and so develop and shift their identities to become what is expected. This is defined within the regime of competence and through the community maintaining this regime of competence, a restricted inclusion criterion is created to become an engineer. This inclusion criteria was something I recognised within interviews as participants spoke of and recognised their engineering peers by identifying them to have a specific skill set.

Can probably be quite abrupt. Again like me we sort of know what we want, its either right or wrong and we know what we want (72)

I think we are very opinionated as a bunch. We all have an opinion of this is right and we like it to be heard. I wouldn't say difficult to work with but it can be clashing opinions of a subject and it can look like we are arguing with each other but you often come out with a better result like a combination of both (73)

They (engineers) tend to pal around with themselves, detail orientated people, not the easiest people to get along with, big egos a lot of the time. They are problem solvers but

problem solvers in terms of structured organization. Like rules and regulations but in many ways quite creative. Less artistic creativity and more aimed at problem solving (69)

In engineering you will be following orders. When you come across something you have never come across before you don't look at it and think I don't know I have never done it before. You need to figure it out because in engineering that's what you do – we are all engineers. We have trained engineers to think, solve problems etc, that's why bankers grab you up (37)

In the quote's students do not describe the skills they personally have as an engineer but provide a generalised view of members within the community. Students form this generalised view of an engineer which then creates an in and out crowd for which an engineer can be recognised. This further reinforces the notion of the established tribe in engineering, by them differentiating themselves as a whole group. The differentiation students spoke of which form a tribe extends beyond the skills they must attain to become an engineer to other factors, such as course demands in the engineering discipline or difficultly of content covered in comparison to other disciplines. This was evident in the interviews.

Engineering students are hard working. All of my friends and everyone I see. You go to the design studio and you see someone there at 8am and then you go home at 8pm and there are still people in there. So they put the effort in definitely (75)

(81) spoke of the fuller timetable they have in engineering compared to other disciplined and stated why this was…
You need to get a lot of contact time because its not like a degree in journalism where you can go and read about journalism, a cut and dried affair. It is a right or wrong subject. Unlike English for example, there is not a right or wrong answer, if you can back your point up with evidence or whatever then it is ok. In engineering it is not the case, you need to get it right, I think it is just a reflection of that, that ideology that the reason why you are in so much compared to other subjects.

(72) discusses why he thinks the context covered in engineering is harder than other disciplines….
You are having to think about things properly. A lot of what we do is validation. You know anybody can run a computer package and get an answer out of it but how do you know its right. A lot of what we do is validation.

(73) discusses the many different levels to teaching and learning in engineering…
There are many levels to learning engineering, you need to be taught it, have a go yourself and also see it in practice so I think that's why we are in a lot and we have a busy timetable.

Erm the timetable is pretty full days to a sense but compared to people out of my flat, it's much greater. I know one person (on another discipline) who has 7 hours, she is supposed to read for 40 hours on top of her study. Its more than just studying electrical because I also have a professional skills which is making a report, managing work load, making a presentation, giving a presentation so its more than just what you actually have to do as an engineer, it's also learning the other jobs you have to do so I've been learning the professional side to is and also the log books I would have to do and keeping notes of your own work and yes as well as learning the general study of going into it, it's doing the general maths of it, it's doing the professional side of it. You are learning the full spectrum of what it means to be an engineer in the workplace. They don't let you forget that's this is what it is like in the workplace and we are not doing it because we are cruel, it's for your own benefit (67)

Within the interview's students spoke of themselves as being differentiated from other disciplines and job roles by discussing the expectations they felt were placed on them as engineers, the course demands and course difficulty within engineering. This will be something I will discuss further in theme two, however, I wanted to highlight how engineering students knowingly differentiate themselves from other disciplines or professions. Further comments surrounding differentiation included..

At college if there was a problem or there was some sort of thing that needed to be sorted out and not sort of maliciously but they would joke like of you are studying engineering you can do it. I think because you are studying engineering, they expect you to be able to solve everything or be able to do anything that should be able to be done (67)

Different between an engineer and a technician is that I would expect engineers to be doing projects and making things better before they go wrong. That's the big difference, you are expected to improve what is already there (73)

Engineering impacts everything in the modern world. Everything is manufactured and the world would not exist without engineering because you just couldn't produce things at the rate they need producing. Engineering is pretty important, I would say that though, I'm an engineer (69)

Engineering is all about progress. I mean the IMechE slogan is improving the world through engineering and its always to improve what you have got (69)

Students enforcing such comments further emphasises how the community in engineering set themselves apart from others. A regimented tribe has been established, of which students are included or excluded depending on their ability to develop and shift their identity to become what is expected of them. Members further highlight the exclusivity of this tribe by emphasising factors which they believe highlight their distinction to stand out from other disciplines or fields. Students then use this to set them apart from others and to enable them to identify themselves and others as engineers. This again provides further support for the perpetuation of the monolithic identity in the discipline.

3.1.3 Sub-theme three: Engineering as a lifestyle choice

As discussed in the previous sub-theme, by establishing a tribe, a specific way of being which defines an engineer, a monolithic identity is created and perpetuated. In the previous theme, I discussed this in terms of the specific skills and knowledge required of student engineers. In the following theme, I will discuss this in terms of the unspoken yet apparent ways of being required to succeed in the community of practice. In the interviews it was evident the most valued unspoken norm to consider in engineering education was students viewing becoming an engineer as a lifestyle choice.

I first noticed this theme when students spoke of their experiences of attending the engineering open day at university. One student in particular spoke of the conversations he had with lecturers on the day and the impressions he took away from this…
They are really enthusiastic because when I came to the open day they were all happy to talk to you about engineering and you could tell it wasn't just a job to them, it was their life passion (67)

As can be seen, 67 recognised from attending an event which provided him with insight into the community of practice, he started to gain an understanding of what was expected of him to become an engineering and that in order to succeed in engineering, it had to become a 'life passion'. As students observe such way of being from members within the community of practice, they learn in order to become practising members themselves, they must mirror such monolithic identity to become their own. This is noted in some of the comments made by students when discussing what engineering meant to them….

I would fiddle with stuff and develop stuff. I love the topic, its so broad and I am always thinking more and more and I will never understand everything in engineering. It's the best thing you could ever do. People do it because they love it (59)

It's a hobby not a job. I'm always looking at new journals, trying to understand something new (59)

He lets me do tours because I like talking about science and engineering (69)

Its more of a lifestyle choice studying engineering than anything else (72)

I always wanted to find something I wouldn't mind getting up on a morning to do and this year doing 9-5 hasn't bothered me to do it, I enjoy it (73)

From the quotes, it is clear that students who have been immersed into the engineering community have been taught/learnt that in order to succeed in the discipline it must be viewed as more than just a job or a discipline of study which involves getting good grades. It is viewed as an avocation and a vocation. Students are shown that in order to be successful in the discipline, they must demonstrate a passion for the subject. Engineering education is not simply teaching students the skills and knowledge to be able to achieve a job at the end of their studies but is about enculturating students into the way of being of an engineer. From students emphasising their 'innate interest' in engineering and the related hobbies they partook in in the first sub-theme, it is clear that having a passion for the discipline was something students required to enter the discipline but also something lecturers particularly emphasised and encouraged with peripheral participants when in the community of engineering education. It was something required to enter but also something required within. For instance, 103 (a lecturer) spoke in an open day at university….

A lot of engineering courses have similar structures and it's the things you do outside this what makes a different. We do formula student, the railway challenge and ICE 24 hour design challenge with a chance to win £500. We are a competitive bunch in mechanical engineering.

As can be seen, from the outset, students are encouraged to partake in activities outside the HE setting in an attempt to further emphasise and demonstrates the passion and interest required in the discipline. The quote provided in 103 clarifies that lecturers enforce that in order to become an engineer, students must take some responsibility and independence for the construction of their own engineering identity. By students partaking in such extra-curricular activities, their engineering identities are extended beyond the micro system of the educational institute to further communities of practice to emphasises their passion for the discipline by interacting with engineering in their personal time. I argue that this is expected of peripheral participants by the members of the community as students have already had to demonstrate their innate interest and talent for the discipline through their inbound trajectories and it is something they are expected to continue in the process of engineering study. In becoming an engineering student, it has to be part of their identity both inside and out of the practising community, it becomes part of who they are and how they define themselves. This was noted in the interviews when students spoke of the extra-curricular activities they partake while completing their studies which are related to engineering….

I am IMechE'ing all weekend, I am completely obsessed (36)

Brought a car over from Huddersfield college who were spray painting it and now they are doing the mechanics on it in their spare time (37)

About 8 of us re-set up the engineering society so we do socials, we do trips. Outside of that I do a lot of events with the IMechE so they do lectures, technical visits so you go to a company and look round the facilities so it's a good way to meet students and professionals and network in a sense (63)

According to my partner I read boring articles. I try and keep up with what is happening in the oil sector (65)

I always read articles for NASA and how that discovering new like stuff every day and I use to work in a small garage fixing cars and I loved it so. I read a lot, all engineering related (66)

As can be seen, students construct their engineering identities both inside and out of the educational institute. Becoming an engineer was not simply about received good grades or getting a degree in the discipline but extends beyond this to becoming a certain type of person. It is about a formation of their engineering identity and the process of becoming an engineer, which extends beyond the realms of education. This can be supported by Wenger's (2010) notion of identity. He suggests learning is not just acquiring skills and information, but it is becoming a certain person: a knower in a context where what it means to know is negotiated with respect to the regime of competence of a community.
This was recognised in the interviews when students spoke of how they view their engineering career…

I was thinking I can do a course and this hobby can become more of a profession (52)

I get to take it apart and half build it back up and do stuff. I don't think you would meet an engineer what just calls it a job (72)

I wanted to wake up, I wanted to come into work, I wanted to know everything what went on, I wanted to know more more more (4)

I would fiddle with stuff and develop stuff. I love the topic, its so broad and I am always thinking more and more and I will never understand everything in engineering. It's the best thing you could ever do. People do it because they love it, but its just so stressful (59)

It's a hobby not a job. I'm always looking at new journals, trying to understand something new (59)

You know how everyone says if you enjoy your job you will never do a days work, for me I have the biggest chance of getting that job through engineering because that interests me the most. You don't I don't have to try and like lectures, I am genuinely interested (63)

I am in university a lot more compared to other people in my flat. I don't just study electrical engineering, I also have professional development skills so its more than just what

you actually have to do as an engineer, its also learning the other jobs you have to do. You are learning the full spectrum of what it means to be an engineer in the workplace. They don't let you forget that this is what its like in the workplace and we are not doing it because we are cruel, it's for your own benefit. My course is a lot more varied (67)

As can be seen, students mould their views of what they believe engineering to be and what they view the job role to entail to mirror what the community already demands. For students, becoming an engineer was more than just a job, it was part of the person they wanted to come. It was about gaining membership to the community which extended beyond their studies.

This was also evident in the practices students participated in within the micro system of the university. Student's lives heavily revolved around their participation in engineering practices. This included students discussing how they come into university early in the morning before lectures started and left after the lectures had finished so they could complete university work. They spoke of how they were working on evenings and weekends and also volunteering to be part of other projects while completing their studies.

A lot of people drop out because they have no idea how much work is expected of them. One boy says they only had 3-4 days off over Christmas (31)

John Baron comes in to the design studio and says I have some sheets for students practicing SVP, a number of students get up to collect a sheet (37)

The company have a lot of stock what goes out of date. If I get that placement I could take it upon myself to try and sort that out in my own time (37)

He says we all do this (team hare) 9-5 and then do assignments on evenings and weekends (39)

He says it is only a 45 credit module so they should only put 450 hours into it but they do loads more (39 - lecturer)

I'm not pushed for time as long as I'm willing to come in earlier and stay later (63)

You need to be dedicated and willing to invest a lot of time into something (73)

Once you get your head down and realise what you have to do and you know what you have to crack on with (75)

From the quotes, it is clear the encouragement provided by lecturers in accepting and assisting them to take up additional work and activities outside the set curriculum. The students are implicitly encouraged to be interested and passionate within the discipline and it is something they clearly adopted in participating in such practices. When interviewing students, they never spoke of achieving good grades in their assignments but spoke of how they were demonstrating engineering skill, practice and knowledge in differing activities or events, for instance. This was recognised by members of the community as successful participation from the regime of competence in the community. I argue participation in such practice is encouraged in students before they enter the community of engineering education (recognised in sub-theme one) and something they further have to participate in once within the community of education (recognised in the theme above). Becoming an engineer appears to be a personal endeavour, it becomes part of their identity both inside the community of practice of engineering, and something they adopt and transfer into their lifestyle. Students imitate the members of the community to shift their lifestyle to incorporate what was expected and required in their new community.

I like the way of life that comes with engineering (72)

3.2 Theme two – Culture, context and community.

As discussed in the literature review, engineers have a persona of importance for themselves but also the discipline they are within. Research suggests this persona stems from the masculine culture which underpins the discipline. Although this research is useful in informing us of what the culture of the discipline is like and how it encourages certain traits to be formed within individuals, such as competitiveness, it fails to ignore how this is operated/encouraged in engineering education. Research depicts how student engineers must be competitive and confident in order to succeed in an engineering career yet fail to recognise how this is taught/developed in the community of practice of engineering HE. The following theme explores students understanding of engineers and engineering, demonstrating their acknowledgment of the superiority which surrounds the discipline. I argue that the regime of competence in engineering education is influenced by exo and macro system influences which feed down into creating an engineering identity in the HE community. I provide a discussion of the practice's students participate in within engineering education and how these encourage the traits required by outside engineering professionals. I will then explore how the macro system of the engineering culture is exercised in HE engineering studies.

3.2.1 'Old boys club'

Data collection within the engineering school revealed a factor which particularly struck me as it was something I had never come across in HE before. This was the precedence students gave to themselves and others within the discipline. In the interviews when asked how students define themselves and other engineers, they made comments denoting importance, such as…

Asking how I see an engineer is like asking how I see God. The difficulty is you have to be good at everything. Its almost as if you have too much to do (59)

In many ways engineers are egotistical. So if you sat through any of our IMechE meetings pretty much someone at some point will say engineers aren't respected enough and I think engineers do have this problem. They need to be wanted and appreciated. I think engineering is important but I think they do feel the need to be valued and that's what brings them together a lot of the time (69)

We are a doctor of the machines (76)

I imagine we are generally deemed as intelligent people (72)

Straight to the point, hard working, determined, embrace challenges, good at problem solving and analytical, effective communication from someone to senior to a labourer (65)

From the quotes, it is clear the superiority students place on themselves and others within the community. As can be seen in the above quote from 69, it is as though this superiority is something which is expected to be placed on them when entering the community of engineering. The engineering students appear to place themselves and the discipline on a pedestal within society. This was evident when they described their job role as engineers….

An engineer is a professional who will set standards who looks at solving solutions and looks at the entire picture. Not just the entire picture but they look for the simplest way to solve the issue, whereas a technician would just do whatever they are told (65)

I know it sounds big headed but an engineer is just someone who can do things the best way possible. Easier, cheaper (67)

Everything has been built by engineers, only human and biology not (66)

As is evident from the quotes, students not only learn their role as engineers through participation in the practices and regime of competence within the discipline but also gain an understanding of the importance of their role. Students place emphasis on being the best, setting standards, being in control and making an impact in society. Students placed emphasis on the importance of the engineering role and the authority, dominance and need engineers have over the development of the world….

Engineering is all about progress. I mean the IMechE slogan is improving the world through engineering and its always to improve what you have got (69)

Engineering impacts everything in the modern world. Everything is manufactured and the world would not exist without engineering because you just couldn't produce things at the rate they need producing. Engineering is pretty important, I would say that thought, I'm an engineer (69)

I think people take it for granted. Engineers are quite important in this world (75)

The qualities discussed in engineers such as 'solving-problems in the best way possible' and the precedence placed on the profession, create a structure which elicits the elite. Students within the discipline have this confidence which assures them that in studying engineering, they hold a high level of value in society. They believe, as a community of practice, they are intelligent people who hold a significant amount of control over the development of the world. This was a significant point I picked up on in interviews. Students not only demonstrated high levels of confidence in themselves and their ability to achieve in engineering but also emphasised how confidence was an expected trait, a norm, within the community. This was demonstrated in the student's interviews….

Engineers are so big headed, they think they are so superior and this is the thing that engineers should be paid as much as doctors and lawyers. There are t-shirts what say I'm an engineer, lets just assume I'm right (69)

I should always work to the principle that if I can't do it then nobody can (24)

One boy discusses a solution and says I am forever solving problems, just come to me and I can solve them all. Everyone is stressing out and there is just me coming up with the answers (32)

People who you would presume to not be very confident people are confident when discussing their ideas, they bounce ideas off each other (32)

I also noted from a lecturer in an observation….
Christian tells me he has got a paper back with no amendments to make which he says is really unusual, he said they only want the graphs making bigger but he doesn't want to take any words out because they said it was well written (47)

They say they are both presenting at the conference which is a big achievement because about 250 people apply and only 38 present. It's pretty big time and impressive to present there (47)

As can be seen, particularly in quote 32, in order for students to be successful within the discipline they must demonstrate levels of confidence. This confidence was closely coupled

with competitiveness within the discipline. From many of the quotes above, students strove to be the individuals who came up with the new innovative ideas, be the ones who wrote the best journal paper or who attended the most prestigious conference. The focus within the community of practice is centred around individual achievement and goal attainment. This enforces a very masculine culture, as discussed in the literature review, that values performance, competitiveness, mastery and achievement (Kim, McLean, 2013). I will now discuss elements of competitiveness in engineering which were spoken about in the interviews or observed by myself. Competition was something not only enforced by macro system influencers as it had to be incorporated into the curriculum in order for the course to be accredited (Engineering council, 2019) but was also something which students and lecturers exercised in the micro system of the HE community. Students spoke of how they acknowledged competition to underpin engineering as a profession…..

Engineering is a cut throat profession, there is always competition to be chief engineering, to be the boss (69)

Engineering is all about competitions, I mean I love competitions myself. It is a competitive profession, the bragging rights on things. engineers are primed to rip each other to shreds and it is good in one way because it about survival of the fittest and the best idea goes forward so you are primed to look at things and see if it is the best it come be. If you make a mistake you will be ripped to shreds. I liked being challenged and I don't mind criticism if it means I can improve but I do say this is a very harsh environment to people (69)

Competitive yes because everyone's team is trying to prove they are better which is a good thing but bad side is some are less willing to help. Cars are trying to beat rival cars to be the best (70)

In industry some would say this is the right way to do it and the other one would say another way to do it so its all about who is going to be the best (76)

Lecturers spoke of and I observed how competitions were put into practice in the education institute. For instance, students on a first-year module were split into groups and assigned a lecturer to help run a design project/competition…

One of the first year modules, in order for the course to be accredited they have to run a designing competition module (30)

Lecturer says to one of his groups, come on smash it. One of the lecturers groups makes it to the target and he jumps up and down shouting yes and gives his group a hi five (35)

As can be seen, practising members of the community demonstrated such competitive traits to first-year peripheral students. Students are encouraged to participate in this competitive way of being, prescribed by the community. This was demonstrated in a lecturer's comment regarding student competition in assignment grading…

Everyone is trying to get a good grade and this year I needed to teach some tutorial groups and mark some assignments and sometimes the students will come to you and ask for feedback and not because it is a low grade or whatever but because why my friends have a higher grade them me. They are not interested because they have a low grade but because it's a comparison (77)

Students, lecturers and even an engineering company spoke of how team competitions were something individuals were not fond of…

I ask if the students like teamwork and he says not because they don't like their grades being brought down by others but that's is what it is like in the real world. He says the students do hang out in groups, the smart ones hang out with the smart ones (36)

Christian on about a student who is entering a car competition but wants to do it alone as he has done all the work for it alone. Christian says he can't enter unless he has a team and nobody wants to be part of his team if they have no impact/input, but the boy just described them as cheerleaders (48)

Some people do work quite secretively, I send out newsletter to other engineering groups to let them know what we are doing. Encourage ideas and discussions from people what are only a few meters away from each other (3)

These quotes further support the value placed on individual success in the discipline. As students are apprenticed into the discipline, they learn through the regime of competence the requirements, valued qualities and culture of the community they are peripheral

members of. For instance, competition in something exercised in the engineering profession, this is a practice HE institutes have then implement into their education and as a consequence, becomes a trait students inhabit and exercise in their micro systems. Competition has become part of the engineering culture and the members within it. As discussed in the literature review, competition is seen as a masculine trait. Kim and Mclean's (2013) research suggests masculine cultures focus on performance, competitiveness, and achievement. The culture is centred around values such as money, success and competition which consist of a need for power, assertiveness and dominance.

Such traits and predispositions discussed above map out a culture for engineering that is masculine by definition. By members of the community viewing themselves as individuals who are leaders and who hold such value and importance in the progression and development of the world impinge particularly masculine qualities. This masculine dominance has created a culture in engineering which appears hostile in nature. By students appearing to hold such importance over themselves, by competitiveness and confidence being qualities valued and encouraged in the discipline and by the discipline being motivated by 'being the best' (individual goal-driven), a masculine culture takes precedence.
As mentioned previously, a masculine culture and the traits which encompass this can often be deemed as fairly hostile (Dutta, 2015). In students interviews, they discussed experiences when they felt the context was fairly hostile in nature.

When I first started they would give you no end of abuse and if you once complained about it they could call you a wuss, you were no good. It's a hostile environment, not just for women but for men as well. the women who do well are the ones who fit in with the lab culture. In engineering its that you need to toughen up and change your personality to fit in with engineering and you have to become one of the lads (69)

one man asks another man if he has got some work done yet and he says no, the man replies I could go to the zoo and get a monkey and he would do a better job than you (31)

one boy says well if someone had made the nose right then it would go on easier. Another boy replies in a sarcastic tone oh you've don't this wrong, you've done that wrong, take responsibility for yourself (31)

If you don't get it (placement) you're an absolute spoon (37)

Lecturers also discussed the hostility which was often apparent in the discipline….

Its male dominated and I do think that's a big difference to a lot of other disciplines and there is still an old boys network there with the institutions. I turned up to do a public lecture once at the IMechE and this man says oh where's the chap doing this lecture then and he thought I was his secretary so there is that kind of bias in it (94)

It could be quite intimidating and restricting to be the only women in a room of blokes who can be quite blokey (94)

When I go over to see the nursing they are all hugging me and I'm like get off me I'm an engineer. that might just be because it is male orientated, and they are not so chatty like women. It is sociable in areas but there is a problem (94)

I think it (engineering community) is reasonably friendly but it is a bit judgemental. When it comes to judging others work we are very hard critics. We are critical of others work, that seems to be a norm. The students like competing against each other. The less attractive side of the competition is career and prestige which is very pronounced in academic engineering (119)

The quotes clearly demonstrate how the masculine culture dominates engineering education. As can be seen, this culture enforces and influencers the behaviour of the members of the community. The culture has created a regime of competence in the discipline which causes its members to portray a certain image and act a certain way. This has constructed and influenced ways of being and belonging to the discipline. For instance, quote 94 was from a female lecturer, someone typically recognised as an outsider of the typical stereotype of engineers, yet appears to have developed and conformed to the ways of being of an engineer. It is evident from the quotes that this masculine culture has created a hostile environment in engineering education. An environment whereby performance is scrutinized, competition is encouraged and individual achievement valued. This hostile culture has influenced engineering education practices and expectations of students and their participation. Students spoke of the support they felt they received during their studies.

When I first got there, my first three weeks were an eye opener. It was a bit daunting. This is not to be boastful or anything but I've always been top in the class and I walked into a class and for the first time in my life I felt dumb like I didn't know what I was doing there. He was talking about mathematics like he could feel it, like he could touch it. I mean after that I had to do a lot of reading, a lot of catching up (55)

I once in my second year asked him (lecturer) a question after class as I didn't understand it that well and he sort of went through and afterwards said do you understand and I said sort of and he said well if you don't understand it you shouldn't be here. So I didn't complain, I didn't say anything and I opened up a book and I did it. That's how I think you should handle it. If you don't know anything go and find it out. Learning is a self-taught process (88)

As can be seen from the quotes above, the masculine culture of the discipline has created a community which appears to provide little support for students learning. From the first quotes, it is clear that students are expected to have a certain level of knowledge which is assumed by members of the community. This has created a community whereby if students require support in their learning, they assume the lack of knowledge is a fault on their behalf – supporting the student deficit model. This has consequently led to students gaining an understanding that they need to make it their own endeavour to correct their lack of knowledge. This is clear in the quotes provided and also in the vignette in appendix one. The masculine culture and the practices this has shaped within the community appears to disable learning, forcing it to become a sole endeavour. However, I make the argument that learning needs to be considered as a social enterprise which does not reside within the individual but in fact the social setting of the participant. I make the case that it is the 'old boys' network' instilled in the culture (as defined by 94) that causes the masculine culture dominance which is then perpetuated in the hostile practices exercised in the community of practice. I further make the argument and question how the strict regime of competence and culture within the discipline are the cause of high drop out rates, lower numbers of female students and students competence to fare in the workplace which might value more collaborative skills. I argue that it is the perpetuation of the rigid regime of competence and monolithic identity set by the community and influenced by the culture to be the cause of restricted participation.

Chapter 4 – Conclusion

The aim of this research was to explore students' experiences of studying taught engineering programs. The data was gathered using ethnographic methodology including observations and semi-structured interviews with engineering students, both taught undergraduate and masters, and lecturing staff. Theoretical thematic analysis was used to analyse the data and two key themes emerged. The first theme explores the identity of engineering students and the prescriptive traits students must possess to be recognised as an engineer. This theme explores how this creates a tribe in the discipline, a structured identity and mould for students to shape themselves into. The second theme explores the masculine culture of the discipline and how this impacts the educational community and student's micro system relationships within this. This chapter will highlight the findings of this research in relation to previous literature in the field and the aims of this research, provide a reflection of the research methods and process and provide recommendations and further research.

I will draw conclusions from the current research and consider these in relation to previous research in the field and sociocultural theories which were used to underpin this research. As discussed in the literature review, previous research in the field largely focuses on attrition rates and student deficit. The previous research argues that engineering students are required to fit into the rigid mould expected of them as engineers, regardless of any individualities. This research, however, fails to acknowledge how students negotiate their identities and participation within the educational community to enable successful participation.

Following is a discussion of what the current research findings add to the literature in the field. The first theme encapsulates the notion of engineering identity construction. Throughout the theme, I discuss students' and lecturers' suggestions of an engineering identity being formed 'from birth', with participants suggesting ideas of innate ability and a natural interest in the discipline. As in this case, students entering the discipline have developed an inbound trajectory which has been formed in them partaking in engineering activities before HE education. This inbound trajectory and initial identity formation appeared to be something which was required by the community's regime of competence. I make the argument this forms a monolithic identity in engineering education which enables students to successfully participate in the practices of the community. Although previous research has provided an understanding of the structured rigid mould in which engineers

have to conform to, it has failed to acknowledge the trajectory of this process and the practices and participation it involves.
The theme then discusses how such a monolithic identity creates a tribe in engineering. This incorporates a set way of being/belonging and a skill set which students are defined by to gain recognition as an engineer. An in and out crowd is created, whereby recognition to be an engineer and participation in the community becomes prescriptive. I argue the prescriptive identity which surrounds engineering education closes down opportunities for students whose identity extends beyond the norm. This creates an unsupportive community, whereby if an individual does not meet the 'requirements' to become an engineer, it is seen as a deficit on their part, not the restrictive community.
The last theme explores what belonging to the community entails. Students discussed how becoming an engineer was not receiving good grades in their studies but was a lifestyle choice they made. With this view in mind in the educational community, it is assumed that students will take a large amount of responsibility and independence for their learning. Students are expected to partake in activities in micro systems outside their education establishment. Lecturers also often assume knowledge which was sometimes a concern for students who had to make sacrifices to stay on track with their studies. In taking a sociocultural approach, I argue for engineering education to enable wider participation and less prescriptive identities and practices in the community. The current practices, expectations and assumed knowledge in students appear to disable learning. I also argue for a more supportive educational environment to be established whereby students and lecturers' understandings that deficits in learning are not a sole endeavour to be counteracted but one which can be constructed through social processes.

The second theme considers the distal process of culture and how this impacts the context and practices in engineering education. I provide evidence of how the masculine culture in the community shapes the identity of students and their behaviour to perpetuate the monolithic image of an engineer. I argue this is the cause of many of the disabling practices within the community. I therefore believe the masculine culture of the discipline needs to be analysed and modernised to create a more inclusive environment to enable wider participation. This theme highlights how the macro system of culture impacts the exo systems of taught material and the community in the educational establishment but, also how it impacts the micro system of relationships, activities and behaviour.

I drew on three sociocultural theoretical perspectives to analyse the data collected in this thesis. The first and main theoretical perspective was that of Lave and Wenger's

communities of practice theory which argues that's learning is the product of participation in the practices of a given community. I made the decision to use this theory as it not only draws attention to the enabling practices which support learning endeavours but also highlights the conflicts students can face which require negotiation, a point recognised in the analysis. The communities of practice theory discuss the notion of identity in learning, arguing learning is not about knowledge acquisition or performance but about understanding our identity. This theory has therefore enabled the examination of both staff and student's participation in communities of practice and how these influence identity formation. The current research indicates the prescriptive identity expected of engineering students which often takes the form of many disabling practices in the community. Many students discussed the demands, expectations, assumptions and lifestyles they had to negotiate in order to be recognised as an engineer by themselves but also members of the community.

I used Vygotsky's sociocultural theory, making use of the ZPD and MKO to consider the importance of relationships in learning and education. These models were used to explore the proximal relationships within the HE education community, particularly focusing on the relationships between peers. Analysis has suggested that students utilise the relationships they develop with peers to further their learning and engineering competence. Students appeared to form relationships based on the skills or knowledge they felt they lacked to be supported by peers who they felt were competent in such areas. I argue this further perpetuates the masculine individual achievement, goal driven, competitive culture of the community.

Bronfenbrenner's ecological systems theory was used to examine the historical and cultural factors outside the community of practice which plays a role in students HE experiences. The analysis has provided evidence of the distributed nature of learning and the influence of more distal practices from the exo, macro and chronosystems. The theory has also been useful in considering the connections between different systems and the influence they have over one another. For instance, establishing connections between the masculine engineering culture and the implications this has upon teaching practices and peer relations within the HE environment could highlight issues where practices need to be more enabling.

I will now provide a reflection of the research process and a discussion of whether the aims of the ethnography have been met. The aims of the research were as follows:

• Explore the culture and context of studying taught engineering programs in higher education.
• Explore engineering identity and participation in higher education
• Understand engineering identity and participation through the lens of sociocultural theories

The complexities of engineering education in the HE context and the ethnographic methodology employed means I have only been able to able to provide a small insight into engineering activities and practices which impact student participation. In attempting to focus on the main aim of the research and the first sub-theme, I reduced pages of interview and observational data into some thousand-word analysis. In aiming to explore factors which were associated with culture, context and identity, and in these being such broad topics, I inevitably overlooked other important factors. I can therefore only really claim I have partially met the aims of the research. I tried to ensure the choices I made in constructing the analysis did not reduce the richness of the data in that it was still recognisable. The exploration and analysis of my data is a reflection of my ontological position and I acknowledge that differing positions may generate different analyses and recommendations. I do not in any way state my theoretical position is 'fact' but instead as a contribution to an understanding of student's experiences of studying taught engineering programs. I attempt to highlight the implicit practices and cultures within the community and attempt to analyse these as influencers.

Being an outsider to the department where my data collection was being carried out had many advantages but also many implications. As an outsider, I was able to enter the field with no preconceptions and I was able to identify factors which may have become a norm for insiders.
I do however feel being an outsider to the discipline made me more critical in my analysis when comparing the practices within the culture and community. I often found myself comparing this to my own experiences of HE. However, I believe any community which is explored and scrutinized in this way will always reveal shortcomings. It was not my intention to be critical towards individuals within the community or the community/culture as a whole but to explore and consider how participation is shaped by factors which exist outside the individual. Conducting the ethnography enabled me to gain insight into and evidence of the practices and participation which shape student identity. In being an outsider, however, I did experience difficulties in gaining participants to take part in my research. As students had to volunteer to take part in my research, they were all, therefore, students who were keen to engage with their community. I therefore make no claim that

the students and lecturers who participated are representative of all departmental members but that the community and experiences they discuss does provide a good overview of the engineering community of practice.

To conclude, the aim of this research was to explore students' experiences of taught engineering programs. I believe the findings of the research highlight the deficit model of the students in the engineering discipline. The current study, therefore, recommends a critical examination of the proximal and distal processes, with a view of enabling successful participation, particularly increasing wider participation. I argue the culture of engineering and the way this is implemented into education needs to be addressed to enable inclusivity by addressing subject specialist support, shifting the competitive climate to be more collaborative and loosening the restrictive criteria which creates this structured tribe in the discipline.

I make the suggestion for further research to be conducted in the field of engineering education. In considering students' experiences who have made the decision to leave the discipline, will enable further understanding of the enabling and disabling practices in the community and how they shape participation. This research needs to be conducted to help support and improve the attrition rates in the discipline and widen participation in breaking down historical perpetuated identities, traditions and culture.

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Appendices

Appendix 1: Ethic submissions

THE UNIVERSITY OF HUDDERSFIELD
School of Human and Health Sciences – School Research Ethics Panel
OUTLINE OF PROPOSAL
Please complete and return via email to:
Kirsty Thomson SREP Administrator: hhs_srep@hud.ac.uk
Applicant Name: Tianna Myers

Title of study: EXPLORING STUDENTS' EXPERIENCES OF STUDYING ENGINEERING IN HIGHER EDUCATION.

Department: Behavioural sciences

Date approved: 5/6/16

Issue	Please provide sufficient detail for SREP to assess strategies used to address ethical issues in the research proposal
Researcher(s) details	Tianna Myers – MSc student.
Supervisor details	Dr Jane Tobbell – staff member (Behavioural sciences) Dr Lynda Turner – staff member (Behavioural sciences)
Aim / objectives	Aims of the research: • Explore the culture and context of studying taught engineering programs in higher education. • Explore engineering identity and participation in higher education • Understand engineering identity and participation through the lens of sociocultural theories Objectives:

<table>
<tr><td></td><td>

To provide insight into the enabling and disabling factors of the transition to postgraduate study which can impact upon the academic outcome of students.
Enable intervention strategies to be developed, e.g. improved supervision, to better academic outcomes and increase participation in postgraduate study.
Network between disciplines within the University.

</td></tr>
<tr><td>Research methods</td><td>
<table>
<tr><td>Activity</td><td>Rational</td><td>Outcome</td></tr>
<tr><td>Literature Review</td><td>To fully review the literature exploring education and culture of Engineering.</td><td>A theoretical and practical framework to inform data collection and analysis.</td></tr>
<tr><td colspan="3">Data collection</td></tr>
<tr><td>Interview 1:1</td><td>To explore student’s experiences and views:
First, second and third year Engineering students participating in undergraduate taught study
Masters engineering students participating in taught postgraduate study.
Lecturers and PhD teaching staff of engineering undergraduate students.
Graduate engineers: both KTP researchers</td><td>Transcripts providing factual information and self-report data about experience and participation in learning.</td></tr>
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		and industry working engineers.	
	Document analysis	To examine the documents provided taught students: • Introductory packs • Handbooks • Lecture notes	• An understandin g of the institutional context towards student participation and learning.
	Observations	To explore the actual activities which construct Engineering students' experience.	• Field notes of; activities, actions, feelings events and experiences which represent the students' experiences.
	Analysis	Merging of data for all data collection activities.	• Themes which represent generative mechanisms surrounding learning.
	Establishing intervention strategies	To meet the objectives of the project by combining materials and data analysis.	• Intervention strategies to implement in HEI's to improve engineering study.
Permissions for study	Permission gained from HoD Division of engineering school.		

	Permission gained from director of engineering company.
Access to participants	Participants to be accessed by working with Director of studies in Engineering department.
Confidentiality	All electronic data will be preserved in password protected files for five years. All handwritten data will be transferred to electronic form in a timely manner. The handwritten data will then be shredded and the electronic data stored in password protected files for five years.
Anonymity	All student's names will be changed. All information which identifies a participant will be omitted or altered to preserve anonymity.
Right to withdraw	Participants given the right to withdraw at any point within the consent form.
Data Storage	All data will be stored in password protected files on a personal laptop for five years.
Psychological support for participants	Psychological support will be provided to students by their teaching staff and the University of Huddersfield counselling service. Moreover, the research is guided by the following principles; • All participation in the research should be voluntary and participation can be terminated at any duration within the study, without any effect on the participant. • All participants consent to the inclusion of any data concerning them can be withdrawn at the request of the participant. • All participants will benefit from participation in the study; participants will work with me to identify a 'personal involvement plan' which will identify their goals for participation in the project, outline expectations on both parts, agree the parameters of activity and identify necessary support mechanisms.
Researcher safety / support (attach revised University Risk	Risk assessment attached.

Analysis and Management form if there are changes to this)	
Information sheet	Information sheet attached for: • Undergraduate engineering students • Postgraduate engineering students • Lectures of engineering students • Graduate engineering students
Consent form	Attached, same consent form for all participants.
Letters/ posters/ flyers	N/A
Questionnaire / interview guide	Attached for: • Undergraduate and masters student • Lecturers • Graduate engineers
Debrief	N/A
Dissemination of results	Dissemination of results will take place in two routes: • Written report issuing theoretical thematic results. • Written report expressing ideas to University of Huddersfield of how to improve experiences of engineering study. • Academic conferences • Journal papers
Potential conflicts of interest	N/A
Does the research involve accessing data or visiting websites that could constitute a legal and/or reputational risk to yourself or the	N/A

University if misconstrued? If so, please explain how you will minimise this risk	
The next four questions relate to Security Sensitive Information – please read the following guidance before completing these questions: http://www.universitiesuk.ac.uk/policy-and-analysis/reports/Documents/2012/oversight-of-security-sensitive-research-material.pdf	
Is the research commissioned by, or on behalf of the military or the intelligence services? If so, please outline the requirements from the funding body regarding the collection and storage of Security Sensitive Data	N/A
Is the research commissioned under an EU security call If so, please outline the requirements from the funding body regarding the collection and storage of Security Sensitive Data	N/A
Does the research involve the acquisition of security clearances?	N/A

If so, please outline how your data collection and storages complies with the requirements of these clearances	
Does the research concern terrorist or extreme groups? If so, please complete a Security Sensitive Information Declaration Form	N/A
Does the research involve covert information gathering or active deception? Please explain.	N/A
Does the research involve children under 18 or participants who may be unable to give fully informed consent? Please explain.	N/A
Does the research involve prisoners or others in custodial care (e.g. young offenders)? Please explain.	N/A
Does the research involve significantly increased danger of physical or psychological harm or risk of significant	N/A

discomfort for the researcher(s) and/or the participant(s), either from the research process or from the publication of findings? Please explain.	
Does the research involve risk of unplanned disclosure of information you would be obliged to act on? Please explain.	N/A
Other revisions	
Requirement for application to external body e.g. NHS REC	N/A
Please supply copies of all revised documentation electronically. If this is not available electronically, please provide explanation and supply hard copy	

Signed: T. Myers_____

(SREP Applicant – electronic signature acceptable)

Date: 18.11.16_____

Appendix 2: Participant information sheets, consent form and interview schedule.

Consent form

Project title: Exploring students' experiences of studying engineering in higher education.

Material gathered during this research will be treated as confidential and securely stored. Please answer each statement concerning the collection and use of the research data.

I have read and understood the information sheet.	Yes ☐	No ☐
I have been given the opportunity to ask questions about the study.	Yes ☐	No ☐
I have had my questions answered satisfactorily.	Yes ☐	No ☐
I understand that I can withdraw from the study at any time without having to give an explanation.	Yes ☐	No ☐
I agree to the interview being recorded and for the interviewer to take notes during the interview.	Yes ☐	No ☐
I agree that researchers can make notes about my activities in agreed contexts and that these notes may be used in the research (if applicable).	Yes ☐	No ☐
I understand that my identity will be protected and that all data will be anonymous and be kept for five years after first received.	Yes ☐	No ☐
I agree to notes of my activities and notes and audiotapes of my interview (in line with conditions outlined above) being securely stored.	Yes ☐	No ☐
I would like to see a copy of the data in which I feature.	Yes ☐	No ☐
I agree that the contents from the interview and/or observations can be used for research purposes and may be used by other researchers with agreement of the research team.	Yes ☐	No ☐
I agree to be quoted (by the use of pseudonym) in any published format.	Yes ☐	No ☐

Name (printed) _____

Signature _____**Date**_____

Feel free to contact me if you have any further questions.

The name of the main investigator, along with telephone and email contact details are:

Tianna Myers, tiannamyers@hud.ac.uk, 07800549839

Project: Exploring students' experiences of studying engineering in higher education
Information for Engineering staff and students' interviews and observations
My name is Tianna Myers and I am a MSc candidate in the School of Human and Health Sciences. For my research project I am exploring students' experiences of studying engineering at a higher education level using an ethnographic method, which may involve both interviewing and observing. I am interested in understanding how the identities of engineering students are constructed by their study environment and by the practices of the University (this follows Etienne Wenger's work on communities of practice). In order to do this, I will:

- Explore the subjective experiences, perceptions and learning in undergraduate or masters engineering study.
- Explore the culture and context of studying engineering.
- Explore engineering activities partaken inside and outside the educational context.

This research will hopefully assist in:

- Providing insight into the enabling and disabling factors of undergraduate study which can impact upon the academic outcome of students.
- Enabling intervention strategies to be develop e.g. increased participation in postgraduate study.
- Networking between disciplines within the University.
- Contributing towards engineering educational literature and understanding.

To conduct this research, I will conduct an interview (approximately one hour) to explore and reflect upon your learning experiences throughout studying Engineering.
Specifically, the interview will involve;

- Exploration of your experiences, perceptions and learning in undergraduate or masters study. (The data will be in the form of audiotapes and handwritten notes will be transferred to electronic format)

If you wish to participate in this research, please read the attached consent form carefully and note the ethical precautions of confidentiality and anonymity which have taken. Feel free to ask any questions or contact me if you have any further enquires.

- Tianna Myers, tianna.myers@hud.ac.uk, 07800549839

If you would like to discuss your concerns with an individual aside from the researcher, the University of Huddersfield student counselling service will be happy to do so.

- wellbeingdisabilityadmin@hud.ac.uk, 01484 472227

Interview schedule

Interview schedule for lecturers, supervisors and/or directors of engineering postgraduate students.

Questions:

Background to studying engineering:

- Why do you believe students are motivated to study engineering? Runs in family?
- Do you think an engineering student has a typical identity/ characteristics?
- Do you think students have to alter to fit in with the culture of engineering?
- Is there a 'type' of student what studies engineering?
- What are engineering students like?
- Do you think engineering students always believe they want to be engineers?
- What are the advantages of studying engineering at postgraduate level?
- Why do you think research in this area is important? As engineering is pretty industry focused discipline.
- Why do you believe engineering is important to 'global race' or economy, etc?
- What is it you enjoy about research and teaching in engineering?
- Is there a skill set needed for studying engineering?
- Do you believe there is an issue with attracting students to study engineering?
- How do you believe engineering in viewed in society? Old fashioned?
- How could this be changed? Starting at primary school? In what ways do you think engineering could become more up-to date and attractive?

Application process:

- What do you believe the application process to postgraduate study is like for student?
- Do you often approach undergraduate or master students to complete further study? – How welcoming are they to this idea?
- What do you think about funding in postgraduate study?
- What is the proposal system like?
- Why is it important to get students into research?

University structure:

- What are your expectations of students entering postgraduate study? E.g. independent, self- motivated etc.
- Do you think undergraduate study prepares students for this?
- What is expected of postgraduate students throughout their first year and towards the end of the year and how does this differ to progression expected in first year undergraduate.
- How often do you expect students to be in university/ be working on their PhD?
- Why do you think some students work from home?

- What is it like in the common rooms in the engineering school. Do you think students would prefer an office?
- Why do you believe the dropout rate in engineering is so high?
- Do you think enough support is provided to students? If not what additional support could be provided?
- Do you think postgraduate students feel able to ask for support? Stigma around postgraduate study and embarrassed to ask for support.
- Why do you think there is a notion of independent and expertise in postgraduate study? Where do you think this has come from?
- Do you think students are an expert? Do you think they feel as though they are?
- What do you think about students having to swipe for attendance?
- Why do you think only a select few of students decide to study at postgraduate level?
- How does the engineering discipline differ to other disciplines, e.g. the culture of it?
- How do the students differ, the way they learning, their mentality?
- How does the teaching differ

Other:

- What other aspects can influence postgraduate study?
- Does university policy and practice account for these?
- Do you think postgraduate students should socialise? How important do you think this is for studying or should a PhD be a sole endeavour? Do you think they should work with and talk to other students?
- How do you feel about students working while completing their PhD?
- What does it mean to be an engineer?
- What does it mean to study engineering?
- At what point do you think students identify themselves as engineers?

Interview schedule

Interview schedule with students

Background:

- At what part of your education journey did you decide you wanted to study informatics/engineering?
- Is it something you have always been interested in?
- Did you know you always wanted to be an engineer?
- Why do you want to study engineering, what attracted you to engineering?
- How would you describe an engineer?
- What persuaded you to study this in further education?
- What do you think the bonuses of studying informatics/engineering at degree level? As oppose to an apprenticeship.
- How will studying engineering influence you in the workplace/industry?
- Do you want a career in informatics/engineering? What aspect of informatics/engineering and what type of career?
- What made you choose this career?
- Can you see yourself doing this job?
- Does anyone in your family have a career in engineering?
- Did any of your family study in higher education? If so what degree and what subject?
- What were your perceptions of informatics/engineering? Old fashioned?
- Do you feel prepared to study at postgraduate level? Has your undergraduate degree enabled this?

Masters:

- Why did you choose to do a masters? Advantages, bonuses in workplace + peoples perceptions of you, will they differ?
- What was the transition like to postgraduate study? Any good or bad experiences?
- Did you feel overwhelmed with the project or use to it?
- How does masters differ to undergraduate study? Types and ways of learning
- How does involvement differ? Timetables hours, assessments, types of lectures.
- Do the types of activities differ?
- How have your responsibilities altered throughout masters?
- Would you say it is more independent?

- Do you feel you should be an expert after studying at postgraduate level?
- Has postgraduate study changed you in anyway?
- Do lecturers treat you differently?
- What did you expect masters to be?

Lectures and supervision:

- What has the workload been like so far?
- What type of activities are you involved in? timetable, working hours, working extra at university.
- Do you think engineering has a fuller timetable then other disciplines?
- Do you think the subject is harder than other disciplines?
- What are lectures like in engineering?
- What is the structure of lectures and seminars? Group work, someone standing at front giving answers?
- How have you found teaching and learning – amount of work, why so much?
- What ways do you learn engineering? – knowledge transfer.
- How do you demonstrate you have learnt it?
- What are assessments like?

Socialising:

- Do you meet/socialise with other students?
- Does interaction with other students aid your studies?
- What are engineering students like?

other:

- Do you have any other commitments outside your studies?
- How do these correlate with your studies?
- Is there a problem defining engineering?
- Would you describe yourself as an engineer? What makes you an engineer?
- What would you describe the engineering culture to be like?
- How would you describe a traditional/stereotypical engineer?
- Do you partake in any other activities inside and out of university? E.g. members of societies or linked in profiles?
- Do you feel as though you belong to the department or as though you just come here to study then leave?
- What does it mean to be an engineer? What do you see engineers as?

- What types of things do you need to learn to become an engineer?
- How important is engineering/being an engineer?
- How would you describe engineering? Objective, competitive, impersonal, masculine.
- Would you describe yourself as being an engineer in terms of being analytical and objective – how did you come about these skills?
- What makes a successful engineer?
- What other skills do you need to be a good engineer? How are you taught these? Team work, communication.
- Are you encouraged to have personal opinions, thoughts, feelings or is it just objective and factual?
- Is engineering just finding a problem and solving it or are there other sides to it. Project management.
- What did engineering use to be and how has it changed?
- What is the IMechE and how has it influenced your studies but also you become an engineer? How have the policies and practices influenced this process.
- Have your ideas of what engineering is changed while you have been studying?

Appendix 3 – Undergraduate participant: Chris P-W

T: when did you decide that you wanted to study engineering?
C: erm I was interested in engineering when I was in school. I'm 29, so I'm a mature student so I haven't done the typical follow the path erm I would say I never really thought I could do it because I don't have any a-levels. I had a job but I didn't really like it and I always wanted to go to uni but I thought I couldn't but then I found out I could if I did a foundation year because of my electrician background.
T: how do you think being an electrician before influenced you doing engineering now?
C: I don't really think it did. I would always watch every other trade how things would work so like lift engineers, I would always say how does this work, what happens and try and get my head round it. I always found myself to be more inquisitive, how things work and practical and its probably why I had more of an installation job. I'm more into hands on practical and its also a lot more problem solving, how you are going to do this and there is a physical outcome but I have always been that inquisitive way. Like building bike ramps out of wood, cant do that now a days without risk assessment. Now I understand the science behind how things work, I know the mechanics behind it and its more interesting.
T: why do you think it's important to study engineering rather than apprenticeships etc?
C: I think the term engineer gets thrown around a bit too much erm from what I would say is an engineer is not what another person may say. For example people who maintain and install lifts, they are not engineers, they are fitters. An engineer is someone who designs, specifies about that component to how it works. That's engineering. So I think going into that role you can do it, but you need the theory behind it. I have come back from my year at placement and about 80% I did use, I was in a manufacturing role. It allowed me to look at things differently from people who have been in the job for 30 years and its anatomies, it's the same route, they know it works so they just keep doing it. deep down if it is essential, pass, but it did help me.
T: would you be interested in postgraduate study?

C: yes I want to do my masters. The course I am on, the masters is part of your usual course to do your masters. If I can stay and do that is not in my entire control, it basically come downs to funding.
T: why do you think a masters is important?
C: for me a lot of the jobs I want to do, for the big end companies require a masters. I also want to go on to be chartered. Erm purely for financially, it's a lot more money and a masters is a massive step towards that.
T: do you think having a masters would influence peoples perceptions of you in industry?
C: yes erm I think straight away you get a bit more company recognition when you go into the interview, its like a tick box. It's something you can have that can put you in front of someone else, just having that paper may not mean you are but it's just about getting your foot in the door. One of the reasons I really pushed to go to university because in a lot of roles I use to get pushed back because they said I didn't have team management skills or project management skills and I did because I have managed my own jobs but they only read the job title so that's what pushed me to do it and pushing me to do a masters, more to just stand out.
T: do you want a career in engineering?
C: yes
T: what type of roles?
C: erm I like designing, the placement I did was manufacturing and I did like it but I only did one piece of the puzzle and it would be nice to see what else is out there. Obviously graduate schemes have a lot of variety so you can experience it all. I have thought about doing a PhD, it does interest me but it depends what on. I am interested in aerodynamics, it really interests me, ironically it is one of my weakest topics. I might possible talk about that, if you do a PhD, it's funded you don't take a lone out, but it is a 3 year impact, not just one year. But the PhD is more desirable.
T: were you good at maths and science and the fact you were interested in how things work interested you?
C: yes I would kind of say self interest. My dad erm potters a bit, if there is something brock he will fix it but he's not a mechanical wiz or anything like that. My uncle is always fixing the car or messing with someone because he is bored.
T: did you do anything to fuel that interest?
C: I never really have much time to tinker after school mainly. My mum use to childmind so we had lots of kids round all the time. I use to be methodological with certain things and I use to have hobbies and I use to play video games and puzzle games and figure it out how to win games and have you ever heard of war hammer. I use to do that and it was very methodological and you had to concentrate and pain the figures and it was maths based so

I think that helped. I was always interested in working things out in my head in terms of maths, god I sound like such a geek. I have always been interested in looking at numbers and making things better and looking at how to reduce things to improve it and things. That played on to my year in industry when I had to analyse numbers and identify patters and see when that would effect that, I'm definitely good at making things more efficient. Even when working, I was always looking at ways to find quicker more effective ways.
T: what has your workload been like so far?
C: erm first year for me was hard because the foundation year I did was not an intense as what it would have been here so it was a massive step up, especially for someone who has been out of full time education for 8 years. The actual workload wasn't loads, it was just catching up. Second year was easier. I found it easy to come in 5 days a week, 9-5. You would have a lab, write it in 2 weeks. Have another lab, write it. very methodological it was easy to manage the workload. This year is a bit more hectic because it was a bit sparse at the start and now its all come in at the end. So I have quite a big report due, another a week later, another three weeks later and then its dissertation, so it's like playing catch up.
T: is your timetable full?
C: erm its changed over the second term, I have 6 hours of lectures, that's it for the whole week. Then next week I have 6 hours of lecture and 3 hours of tutorial. This week is spare which is good as you have time to catch up but I find it a bit of a cop out when they say you need to do a lot of independent study. Especially some lectures you feel a might as well do this a home.
T: what are the structure of your modules, presentations, group work?
C: it depends on the subject. Erm each year we have had a group project to do. This year we have final year project, I am part of the drone team, so I am part of that, you are either independent or part of that. I have an eco report which is part of sustainability, which is a two person report. And then the rest are all individual reports based on subjects and then exams at the end of the year.
T: how is it working in groups with other students?
C: it depends who you are working with in the groups. If you are working with someone with a similar mindset and if students are more mature then they are more driven. I found it in the foundation year though, there were three groups of people and I spoke to others and they said the same thing. You have the mature student who has just come out of industry and they are really focused and they know they have to do this, you have the second group which is people who didn't do the right subjects at college and it is more of a top up for them and they don't take it as seriously and then you have the third group who are completely funded by someone else or didn't get the grades and they just don't care. The thing you have to remember is though when you are doing a report, you don't have to

be nice to people, you are not doing it with your friends. These aren't your friends, this is a business, you don't have to be nice with everyone you work with, you have to be civil. People don't get the concept of that, you have to be no I don't care, you pull your finger out or you are dropped. I'm not having my grade being pulled out because you cant be bothered.

T: what are the lecturers like in engineering?

C: short answer, some are good, some are very good, some not so great. I think with engineering in particular, the university are research research research. that's the biggest income to the university and the vice chancellor pumps loads of money into it but it means you don't get the best teachers. You get lecturers who are brilliant and they know their subjects inside out but because they know it brilliant and have done for so many years, they don't necessarily understand how to teach it another way and if you don't understand it they don't know how to explain it another way and necessary teach it. they just know how to tell you something and you can get anyone of the street to read a PowerPoint. There was one man in second year and nobody was understanding anything and he kept running ahead and we would say go back and he would plough through and lecturers would come and see the lecture and they would say yes there is some work to do. Then we had lecturer who came in and we understood the whole term in three weeks but he was let go because he wasn't doing enough research.

T: so do you meet or socialise with other engineering students?

C: I have a small group of students who I socialise with, I am not a massive massive people person. I know most people in the year and say hi and chit chat but I like a small group of friends. I think I can name them all on one hand and if I have more than that I will start looking who I can cut, too much maintenance.

T: when you meet up with them is the relationship just work level or personal?

C: yes we use to meet up in second year and every Friday we would have a couple of pints at the pub and when we meet up at uni it might start off as social but it will always go back to work but I think its because we are all driven by work. I have seen people who have come back and not done a placement and they are less structured but we will come in and we will sit there and start doing work and just chat to eat other and then the conversation will die off and then we might say what did you put for this. I would say we start social but then always go back to work.

T: what would say engineering students are like?

C: lots of guys, erm there are about 3 or 4 girls. I know university is actively trying to seek more female participation, there is an unproportionable variety. I don't think you can balance it, it is always down to what people want to do. I don't know many girls who say they want to do engineering.

T: why do you think that is?
C: I think it has been primarily portrayed as a manly job/interested. I think a job tends to portray a feel of more one than the other. Maybe its down to numbers, guys like working in numbers more than women. Maybe its because its more maths, science and numbers.
T: would you describe yourself as an engineer?
C: no
T: what would enable you to be an engineer?
C: when I have a job. When I have a job in that field and I am doing some form of engineering, designing, analysing, something towards task. If I have my degree, masters or whatever but if I was to work at boots, you wouldn't call me an engineer. To me it goes on the role you are doing.
T: what would you describe the culture of engineering to be like?
C: where I was on placement everyone would help out. I was working in an office where people had been there 30 years and people being there 6 months so there was a wide range of people in there and everyone knew their role and they would say I might be able to help but go and see Mark, he's been on this project from the start, he knows everything about it, go and see him and he would help you out. Everyone would have the coronary of we are one team but when you would speak to the production line, we would right the job cards and this is how we want you to build this part and give them the plans and there would be some animosity towards you and they would think they thought we were better than them and it was like I'm not trying to trip you up, I'm trying to make it better and easier for you. But like I want to know how long it takes you to build this part, what is taking the most time, if we reduce that we can make the process easier for you but you will still be getting paid the same. But they see it as you are trying to see how slow I am so they would go to the trade union and say we are timing them and you are not allowed and they would come in and say we couldn't and we would explain we are trying to develop a process to make it quicker and easier. There was a culture of this and them. There were departments and it was like that's their job not mine and its like you are the same company, if it doesn't go out of the door we don't get paid, you don't get paid, you lose your job and it did get very like that but I think in engineering it was the same. You would have engineering team for one office, there is a problem here, oh it happens in sheet detail, find out what they do, they wrote it. we go to them and say we have had a problem here, it happened in this stage and they try and ping it back to you by saying no it's in your bit now it has pain on it. yes but the metal under the pain in damaged, it happens at your end. It's like you know the answers better than us, just write the process and it did become very clicky.
T: how would you describe a stereotypical engineer?

C: I wouldn't say like Howard Wollowits. I think we are just like everyone else. Society think you are a right little anorak, calculator in pocket, swatty, brief case, but it's not what we are like. In our office we had one guy turn up who looked like a typical mess and his shirt was never ironed and his desk was a mess and then there were people who's desk was very methodological. I mean we would go and play sports, about 20 of us a week and hire the AstroTurf and it would be a combination of everyone from the company and when outside the work environment there was none of that clickyness. We did have a couple of charity matches where it would be office staff v shop floor and the winning team would buy them all a round. It was fine but in the workplace there was clickyness. You go to work and they would help you no end but in work no.
T: do you do any activities inside or outside engineering what link in with engineering?
C: I am on grad cracker looking for work and I do follow some engineering companies of facebook.
T: what kind of things would you say you need to learn to become an engineer?
C: you need a good understanding of physics, you can break that down to mechanics etc. maths is imperative, good maths skils, IT skills and a lot of program based and you need to develop the program you will us. A methodological way of working, if you are scatty you wont get it done and this developed a lot in my placement year and in my electrician job they just wanted me to get it done but in engineering it has to be right, it doesn't matter about the time. Its about structuring time, if you set a methodological route of doing something and then a time limit but that's all manufacturing engineering it. making something quickly, easy and simply.
T: how important is engineering?
C: its very important, everything is designed and made by engineers. What don't engineers do, you have the basic ones, F1 cars but then there's the kettle what makes your cup of tea. That plastic has been chosen because it does alter due to the increase in temperature caused by the boiling water but its not the best material because you need to keep costs down. Like the coke can it has three different metals in it for structure but to keep costs down. Everything is made by engineers. They are a real world problem solver, its not theoretical problems. Can we take the problem we are given, break it down into quantifiable values and then take that and do the maths and then take that to fulfil the role.
T: can you see yourself as being an engineer?
C: yes
T: always?
C: yes I have always enjoyed solving problems. How easy can I make this, in video games how can I solve this problem easily. I've always enjoyed that.

T: how would you describe engineering? I have read a lot of papers on it being objective , competative, impersonal.
C: very objective based, engineering is black and white, this is what I want to do, this is what I am doing to do, this is why, this is what I got. If your results don't meet that is the only grey area and you go back and see why, you don't leave it. so yes if you have a problem, the object is to solve it. competitive yes because everyone team is trying to prove their better which is a good thing but bad side is some are less willing to help. Its like the whole industry, cars are trying to beat the rival car to be the best.

Appendix 4 – Undergraduate participant: Matt C

T: when you kind of decide you wanted to study engineering?
M: I spent three years at college and at the end of my second year I actually applied to do physics and chemistry at another uni and I didn't get in and one of the heads of year took me into the office because I was feeling quite dejected and said instead of going for this why don't we go for something else and she suggested mechanical engineering and showed me what's it all about and I thought do you know what this is probably more me than what I was actually applying for. So I spent another year at college and then applied to come here.
T: so is like maths and chemistry and physics and things always something you've been interested in and good at?
M: erm yes and bit of both really. At high school I did triple science award and I did well at them, I think I got AAB overall so it was something I was good at and I quite enjoyed it as well. the content of the course was about everything around you and that's what I kind of like. Like knowing how things work and how things process and stuff like that
T: is that something you have always been interested in since you were little?
M: erm yes pretty much. I mean obviously with technology no a days. When I was a kid if something broke, instead of going to my mum and saying I need a new one I would be like oh I broke it how can I fix it. so yes it's something I have always been interested and good at to be honest.
T: when you kind of knew what an engineer was it is something you wanted to be or could see yourself doing?
M: well to be fair especially when growing up through high school and college you think of these engineers as men covered in dirty on their face and working on machines all day. I never realised there was a step behind that where people were working in an office doing equations and calculations and stuff like that but to be fair either would I could see myself doing. I don't mind getting my hands dirty and doing something manually and I don't mind

doing some equations and modelling on software and stuff like that so. Both sides of engineering really.
T: what attracted you to study engineering? What aspect is it you like?
M: it's more the physics more than anything. Out of all of them I was best ay physics so that kind of attracted me to do that and to apply the physics I learnt at college to a bigger wider world.
T: erm how would you describe an engineer?
M: somebody who makes or manufactures or repairs things in the world. You have design engineers who make stuff on the computer and then manufacture it. then you have maintenance and quality engineers who measure and maintain machines and produces so yes that's kind of my definition.
T: what persuaded you to study engineering rather than apprenticeships and things like that?
M: erm well I kind of went through the standard route, high school, a-levels then university and it just never really appealed to me to go into work and then way it was portrayed in college is that it is split into a-levels and BTEC and the ones who do BTEC tend to do apprenticeships and I know a few who went on to do a degree and like vice versa with a-levels. I think it depends on the mental background you have had, because I have always had exams so I did university but if I was more hands on like a BTEC student then they would be more likely to go into a practical role.
T: do you think there are advantages of studying engineering?
M: yes definitely. When I went away on placement last year and I was in a factory with guys who had worked there 10 20 years or so and they were obviously practical based, they did their apprenticeship, they were very hands on. But there were a few times in projects, they didn't know how to get over a boundary but me with an academic background and with some of the stuff I learnt at college and uni and I said well maybe you could do it this way and it worked and they would say we never would have thought of that. So yes I think so.
T: how do you think studying engineering will influence you in the workplace?
M: erm well when you talk to people, people in industry they said people who come in from university are more academical, they are not really practical. And sometimes I have heard people are a bit snobbish about their educational but I knew that before my placement so I wanted to do. These people who have been here for 20 years and you show them respect, some of them have been doing it for longer than I have been alive and so you know that's the guy to talk to. instead of doing it fully his way or fully my way you sort of integrate the two and see which is the best option.
T: I'm taking it you want a career in engineering, what type of career are you thinking?

M: I think I am definitely going to go into industry because when I got a job last year on placement I enjoyed the day to day life of engineering. To what actual role or job I am split between a few different disciplines but hopefully by the end of my degree I will know yes that's what I want to do.
T: has anyone in your family studied higher education or engineering?
M: no not one
T: what did they say when you said that's what you want to do?
M: my mum always said are you going to build bridges for some reason which I never understood. Yes it was things like that, they didn't understand engineering themselves and they just said if its what you enjoy then just go for it.
T: do you think your undergraduate degree has prepared you for your masters?
M: oh yes definitely. Because the stuff you learn on your undergraduate degree is taken to the next level in your masters degree. I have looked at my modules for next year and I think I have static analysis and aerodynamic analysis which are a step up from two modules I am already doing this year. Obviously when I go there next year I will have a basic knowledge to work off.
T: is that something you have seen in engineering, you build on it throughout your degree?
M: erm I think it just depends. Erm cos I think we did build on stuff, especially in first year we did basics in maths and mechanical science and CAD work, design work stuff like that. Then in second year you doing a bit more in depth and you go into thermofluids and you can still apply stuff from mechanical science into that and then in third year you do applications of CAD. When I went on placement I used stuff and then I came back this year, especially this year because you model stuff a lot more than in first and second year and it has actually helped me because I feel like I can do it.
T: how has your undergraduate degree been so far?
M: there are a few lectures that are tedious and there are not getting their point across so you need to go away and get some external sources from the library or what not and try and make sense of it all. That has been the only problem really. There has only been one module per year like that, all the rest have been quite helpful and stimulating.
T: what about assignments and things?
M: to be fair the step up from second year to final year the workload must have tripled but once you get your head down and realise what you have to do and you know what you have to crack on with at what time. There are a few assignments where the brief kept changing a few times but that's the only real problem I have come across.
T: do you think there is a problem in engineering admitting you need help or that you ae wrong?

M: yes because I've come across people who think they are never wrong and again going back to my placement I asked for help a lot because I knew I was in industry and these are real being used and I wanted to make sure they were right and if the slightest little thing was wrong I wanted to double check. I didn't get a bad report of the end of it and he said one of the only downfalls was that he asked for help a lot and guidance when in my view I don't mind that I'm just making sure its good for you. I don't mind passing that on but if its wrong at the end of the day its going to come down on your heads. I don't mind asking for help and admitting I am wrong if I am just tell me. in my second year only about half gave comments back on assignment feedback so I was like right I have obviously gone wrong on about 20% of it but what have I done wrong, I never knew. That it pretty much the only problem, I don't mind admitting I am wrong, its how to progress.
T: how often are you in university?
M: everyday
T: timetabled every day?
M: erm not in final year, first and second year either from an hour to all day. But final year I think we have Wednesday and Fridays off. Monday is our busies day I think we have 10-4 and Tuesday the odd tutorial and Wednesday if day off and Thursday a lab but I always come in because the spare time is the only chance you get to crack on and get some work done. I come into uni to do work so I don't get distracted.
T: what about the structure of the modules, is it lectures, seminars?
M: for us it is mostly lectures, tutorials and a few practical sessions here and there. In a class we have a sheet of questions relating to that weeks lecture and we sit and work through it. kind of like apply so you develop your knowledge that way and practical's are where you have computer software and then the teachers are always there if you need help but you have a set guide of what to go through. And we have lab sessions every so often where we do an experience and we write it up as a lab report and it is classed as an assignment.
T: what about team work, do you do team work or projects?
M: in first and second year we did, we had about three of them overall. This year not so much. The only reason I haven't is because I haven't done a team project, I decided to do my own research project. I did do an eco design assignment which requires you to work in pairs.
T: how do you find working in teams in engineering?
M: erm sometime sits difficult, sometimes it is ok. It depends who you get and some people do doss about but I know full well in a job that is less likely to happen but at university when your assignment depends on it but we do have peer reviews so we can just slate them. I remember in second year we had to build a paper bridge, I ended up writing the

report myself and my peer review was 5 pages long because I single handily had to do everything on my own. Other than that working in groups is fine and you have different backgrounds so you just bounce off each other and get there in the end.
T: why do you think engineering has a fuller timetable than other disciplines?
M: I think in engineering you have to cover a lot more basics. Especially our degree because it is accredited, they need to make sure once we graduate and get that job they need to make sure we can do that job so they have to try and cram it all in. I know some people in final year who are only in 2 days a week, engineering has a lot more to fit in.
T: do you think its harder than other degrees?
M: I cant really say because I haven't done other degrees but if I look at my friends who are at the same stage as me I would say probably. Because my housemate the other day because she had 3000 words to write and she was panicking and I was sat with her in the library and I was there doing my eco design assignment and it was 8000 words long. I didn't say anything because I don't like downgrading other people. If someone from another discipline came onto our degree I would like they find it hard. We do have a lot of essays, CAD assignment, experiments and write ups. It could be the broad spectrum of different types of learning and assessments.
T: I have heard a lot about lab reports but I have never heard anyone mention that you get essays.
M: yes it's a weird one because every assignment we have we have kind of done something first. The eco design assignment we had to research a project, identify three components and modify them to make them more sustainable. Even that meant researching them, putting the stuff like research into a software and then get the numbers out of that and then discuss them. Everything single one of our assignments we have to do something and I know a lot of essays require research and they just write about it and their opinions.
T: your opinions and thoughts and things, are they accounted for?
M: no because we have an opinion, we have to back it up with numbers and our numbers come from software's and research. in respect it is the same to other degrees but we have more quantitative data.
T: what would you say lecturers are like in engineering?
M: erm well our lecturers are fellowships of higher education and stuff and they are good. They are always there if you need help but some struggle to get their point across in lectures. I think some of the lecturers teach how they learn or how they understand it and they don't realise we are not PhD students we don't understand it because obviously if you have a full slide full of equations you are just like no I cant read that, I cant make sense of it so you go away and try and make sense of it.
T: what would you say you need to learn to be an engineer?

M: erm it depends what type of engineer you want to be
T: ok well what would you say you need to be good at?
M: ok you need to be good at maths, logic, communication because its all well being smartest person in the world but if you cant talk to someone or get your point across then there is no point. Communication is a special one.
T: how would you say you demonstrate that you have learnt engineering?
M: in my assignments, going back to the software we use because its all industry standard. So if I can do it in an assignment and get a good grade then who has been marked by a lecturer or professor who has been in many sides to engineering then surely when I go into employment I can actually do it. the only difference is I wouldn't have to write it up so intensely as I did it here.
T: do you meet with other engineering students?
M: yes pretty much every day. inside the design studio then obviously when you go for a drink with your mates, some of them an engineering students so.
T: would you say engineering students are sociable?
M: yes definitely. Obviously you get the stereotype that engineering students are nerdy and things like that but I cant really think of anyone who's an introvert. Everyone is happy to go for a drink and quite out there.
T: what would you describe engineering students to be like?
M: hard working pretty much. All of my friends and everyone I see. You go to the design studio and you see someone there at 8 o clock in the morning then you go home at 8 at night and there are still people in there. So they put the effort in definitely.
T: would you describe yourself as an engineer?
M: not at this stage no because I don't have any qualifications. Its ok going into a company and saying I got part way through a degree but I don't actually have any qualifications yet.
T: so would you say when you have that degree you would be able to call yourself an engineer?
M: yes
T: what would you describe the culture of engineering to be like?
M: I think the basis of working alone on a computer is that it is an assignment, your assignment but what I have found that is you are stuck and the guy next to you who you have never spoke to but is doing the same thing is happy to lean over and show you how to do things. They are always happy to help and they know they are in same boat as you and they will have been stuck where you were like two days before you they think fair play. So they are really helpful and I think that's part of engineering when its communication. You need to help each other out and bounce ideas off each other because that's when at the end of it progress.

T: would you say engineering is competitive?
M: again I haven't seen that much that year. In second year when we were doing the paper bridge we were obviously in groups working with people against other people so there is some competition there. If you look at team HARE and team HAWK at the end of the year they have to race their object so they do need to be competitive. So yes engineering is competitive.
T: what about competition between students?
M: no not really. We got two assignments back in past two weeks and one everyone more or less got 90 and then another one what ranged a bit more and I got 76 but my mate got 90. There is no like showing off or anything like that. It was more picky when everyone got 90 because I got 91 and he got 94 and he was like ha I got 94 and its like its 3 marks mate calm down. Its because at that stage is everyone has high marks it doesn't really matter. It depends on how hard to assignment is. If people really struggle with the assignment there is an understanding in engineering that this is hard so I'm not going to rub it in someone's face if I get a good mark, its quite respectful that way.
T: do you do anything inside or outside university what link in with engineering? Like societies or facebook pages.
M: erm I like a few engineering facebook pages and I think the only really hobby I have is making stuff out of mikarno. I got a big box for Christmas where you could make loads of models out of it and once I did all those I took it on myself to kind of start making other things that weren't specific on the box and I watch a few YouTube channels about engineering.
T: what does it mean to be an engineer?
M: to basically make a product that will at least help people or provide a service that will help people. So you could be an engineer on the production line what makes milkyways. You are still an engineering, people wont get the milkyways if you are not that. Or something what I hope to do is be a medical engineer to make implants or prosthetics which will directly help a patient to have a better quality of life so yes that what it means to me.
T: have you thought about doing a PhD?
M: I did but I don't think the research side of it is for me. spending 4 years producing a thesis, I am more hands on I want to get out there and provide a service, that's more me, that's what I would enjoy and progress more in.
T: how important would you say engineering is?
M: its imperative really. If you just look around that settee, that plug socket, they have all been engineered. Someone say down to build this table and thought we cant make it out of this metal because its too expensive and we cant make it out of this because it will be too weak. I think people take it for granted. Engineers and quite quite important in this world.

T: I have read a lot of journal papers to say engineering is objective, competitive, masculine, impersonal. Is that something you have seen?
M: no masculine, there are quite a lot of women in engineering. Competitive yes because there are a lot of companies working towards the same goal, obviously you have to be the best but at undergraduate level you don't really see that competition other than the group projects. Objective erm probably yes because you have to look at a product and you have to think how it works, you cant think this is going to go into a land rover what does x y and z. you have to focus solely on the gearbox. What I see mostly you have to focus on the task in hand not the bigger picture.
T: what would you say makes a successful engineer?
M: someone who is level headed, down to earth, understands different disciplines. Understanding like in placement when the technicians have been there for 20 years don't disregard them. You need to get your point across, your communication skills need to me good. If its talking over the phone, face to face or over email. All the work the communicate, all the CAD draws etc. if you put all those together someone will make a good engineer.
T: are there any other skills you would say you need to be a good engineer?
M: teamwork yes because any job you go into you are going to be working in a team. Erm I don't think so much analytical because unless you want to go into a job what is focused on that not necessarily. Yes so I think I don't think there are any other skills you need.
T: what about creative?
M: erm again there are some engineering roles where you do need to be creative but I think on the whole some roles you don't need to be creative. Like if you are going to be a design engineer.
T: do you think the different roles in engineering attract the different people?
M: yes I think I saw that when people are going for placements. Some I read I was like that sounds like there is no practical work involved what so ever. Like you basically say behind a desk and mine was practical and theoretical as well and then when toy heard about who got the very academically ones, I think I can see that because he stays in library about 20 hours a day so no wonder so yes it does attract different people depending on different skills and their work ethic.

Appendix 5 – Undergraduate participant: Rob N

R: pretty much the only reason why I chose engineering as a degree and a career path to follow was just my academic background you know, I've always been good at maths, sciences and so I think of it sort of the default pathway for academic people who don't want to study pure sciences. For me it was a choice between engineering, maths degree or a sciences degree and neither of them interested me so that's why I chose mechanical.
T: so when you decided to study mechanical engineering, had you studied that before?
R: never, literally never
T: so if you'd not studied it before, what have you that idea to want to study it?
R: it sounds really cliché but for me, nobody in my family is an engineer, nobody in my family is an academic, I'm the first one in my family to do to university erm so it didn't come from environmental influences it was just through my perception of mechanical engineering and putting things together. Like I've always liked to build models and like lego and it sounds really cliché but when I was searching through UCAS for degrees and universities to apply at but it was just my perception of what a mechanical engineer was that purely influenced me. I cant really define it because it wasn't like oh my friends was a mechanical engineer and that persuaded me, it was literally gears and metal, but you know as you said its such a diverse career path to follow, I had to idea to extent of the career paths you could follow. It was purely just my perception.
T: what did you think engineering was when you applied for it?
R: probably what I now term design engineering, so designing mechanical objects. But its so much more, there's manufacturing engineering, production engineering, so much that I could go into that I didn't know about. To be fair, I don't know if telling a-level students all the different things what come under mechanical engineering would be useful because it's not as if a 17 year old would really think I want to go into manufacturing engineering. You really need to do the degree to understand where you want to go.

T: do you think there's a lack of connection between understanding what it is and what it actually is? Like if there was an a-level or BTEC in engineering
R: well I think to be fair because I don't know enough about it, my route into engineering was typical a-levels but I think there are BTEC qualifications what go into more the practical side of engineering. Erm a lot of my friends at Huddersfield came into engineering through a BTEC qualification so I think those routes are out there but I literally was never told about those. I'm pretty sure there is an a-level in engineering but then again that is purely down to the school, if there's not enough interest in it then there not going to run it. They wont run it if only 5 people want to do it but I think the government or educational bodies should do more, even if it's just one part of physics a-level, dedicate it to engineering or similar to what you do in final year or let a-level students choose a few modules to make up their a-level.
T: why do you want to study engineering?
R: erm for me its because of the broad range of opportunities this door opens for me, you know its getting a secure career erm, a job that's well respected and well paid as long as you fit the criteria obviously you don't just get given a job but yes I would say for me I'm most likely. You know how everyone says if you enjoy your job you will never do a days work, for me I have the biggest chance of getting that job through engineering because that interests me the most. You know I don't have to try and like lectures, you know I'm genuinely interested so yes that's the reason.
T: so why did you decide to study engineering at higher education rather than getting a job in it or an apprenticeship?
R: I suppose what persuaded me to study mechanical engineering at university was because you cant really get a job as a mechanical engineer without having a degree in it. You need that further education so for me it was a no brainer. So after a-levels I took a year out and did a pre-university year in industry, like a pre-uni placement through a charity called education development trust, EDT. Erm they came into my school and gave a presentation on what opportunities they offer so I was luckily enough to get a place at singenta just down Leeds Road, a big chemical manufacturing plant erm and so I got a taste of engineering before I committed to a degree and whilst there pretty much all the engineers had a degree. It wasn't a problem 20 years ago because you could sort of work your way up through the ranks you know, manual labour, apprentice, then into management and so on so on but in todays climate you sort of need a degree, it's just one of those things.
T: so what do you think the advantages are of having a degree?
R: erm well to me on paper an apprenticeship is much more appealing, you are not paying 9 grand a year, you are getting paid and you are doing work for a company as well as

learning but for me you become a much more rounded engineering through university because you just learn so much more. As an apprentice, ultimately your working for the company in the specific area so you will never get exposed to something outside their remit. They will never train you on such and such a process, ultimately you are a worker for them. And because doing an apprenticeship you are sort of obliged to work there afterwards. I've got some friends who did pretty substantial 3, 4 year apprenticeships and they have to work for that company, sort of like doing service in the army like if you get sponsored. So higher education and university, you are not restricted and you are not limited and like I said, you become a much more rounded engineer because you learn about so many sub-topics.
T: what made you decide to take that year out and do that placement year?
R: I would say one of the main influences was that I was quite excited about the prospect of experiencing industry before committing to a degree and it did give me that opportunity and I'm pretty sure they marketed it as that as well. you know if your not too sure you want to commit to a STEM degree and the money really. It was a paid internship so coming out of a-levels and a part time job to that allowed me to get a car, you know it allowed me to do some nice things in that year but mainly the freedom of exploring that before doing a degree.
T: do you think that influenced your degree in anyway?
R: 100%. I don't know anyone else that has done one erm at Huddersfield and I would love to see because I don't know how many people do it every year. Firstly I would love to see a-level leavers do a year in industry and then how they perform in their first year at university because it's not even like I'm claiming to be more intelligent, I'm not. I'm just more drive, I'm more motivated. I can see the end goal, where as the problem with going straight from a-levels to university is that you just never see a point you know. Because I'm in second year, we are apply for placements now and so many of my friends from a-level and BTEC are like I don't really want to do a placement, I don't see the point and I'm like you really need to do one, you become so much more driven and you actually see the point. It helps everything, I don't think I would still be here doing a degree if I hadn't had done it because I would have just lost interest. I would have wanted to earn money, it's so hard being a student.
T: so are you still going to do a placement?
R: well I'm not sure. I'm in a pickle because I've been given a summer placement at BA systems up at Barrow where they make the submarines erm so that's a 12 week summer placement so I'm debating if to do another placement to coincide with that. You know everyone I speak to on campus is like go do a placement because that's the default response but I don't think that they take into account I've already got that year of professional development, I'm not sure I would get much out of doing another year. I'd

rather just graduate a year sooner and then getting into a grad. Role but it's all about keeping your options about but I think BA systems are good at recruiting into their grad. Roles from their placement system but I wont be guaranteed a job but as long as I perform well there over the summer, hopefully that opportunity will be there for me. but if I was to do another year in industry it would be purely for the money but it's sort of false economy because if I'm going to delay my degree for another year for, what's a typical salary for a placement engineer, 17K, that's false economy because I could finish a year sooner and be on like 25. So I don't know, it's a tricky situation.

T: do you want to do a masters or PhD in engineering?

R: I would say I definitely want to do a masters but I don't really know much about PhD's to be interested in them. I have spoken to a few engineering postgrads. That are doing PhD's now and the reasons why they took one and also at a grad. Fair last November and they were advertising their EngD programs and as oppose to PhD's they are much more, you are sort of partnered with a company who want a bit of research completing and it's research for a real world company and you get because of a government incentive you get 20K a year default, tax fee. I think they call it a steep end and I think the company also top that up as well so you could be earning quite a lot doing postgraduate study so that did seem quite appealing to me as well. but I don't know if anyone has expressed this to you before about STEM subjects but I was talking to Christian Young who is a engineering PhD student, he is in is final year now and I was like what are your views on a postgraduate degree and he said it was good but what he found in his placement year that a lot of the engineers who worked there who had doctorates didn't tell anyone because they were thought of as like a boff. Like they had no practical skills, just a brain. So and there is the argument is the problem with postgraduate engineering degrees is that they are so focused, like investigating the material structure of this certain alloy and I would love that and it would really interest me but when I came out I would have to get a job in that specific area so that's why a masters year is much more appealing to me because it's only a year.

T: so would you do a taught masters or a research masters?

R: erm a taught masters, I never really realised there was a difference. A taught masters would be my preferred study route, purely because the doors it opens and the access to chartership. I think with a masters in order to become chartered by the institute of mechanical engineers you have to show 3 years of work experience, where as if you only go to bachelors it's 10 years so you can become chartered much quicker through a masters. So the most appealing option to me is masters.

T: did you always know you wanted to be an engineer?

R: erm no. like I say it pretty much started in the second year as a-levels but up until that point I had never considered it as a career path.

T: what were your families perceptions of that when you said you were going to study engineering at university?
R: erm to be fair neither of my parents have explicitly said this, I've just inferred it. I think there intimidated by what I do. It's as hard for them as it is for me. because I still live at home, I commute to university, I just drive in. erm even through a-levels I couldn't come home and talk about what I've been doing because they didn't get it and that's not a criticism, you don't show interest in something you don't understand. So I'm not criticising them but their opinions when I said I wanted to do engineering, they were supportive because they just assumed I would go down that route because I've always been academic. It wasn't like I randomly came home one day and I said I want to go to university, they weren't surprised by it, I think they sort of expected it.
T: what were your perceptions of engineering before you started studying it?
R: mucky hands in overalls. I don't really have an answer to that, I didn't have an image in my head of what an engineer does. It was just sort of machinery, putting things todays, I didn't have a clear perception.
T: what are your perceptions of postgraduate study?
R: quite a lot of independent work, well all independent. Erm in terms of a research degree I am curious as towards the structure of one, like how do the years break down. I don't know, I think I would find a research degree hard to stay motivated. I would like to find out how people changed their study technique. Surely you become much more organised. I would be intrigued to find out how the years break down. I'm not sure about a PhD but I think with an EngD, I think in your first year you do taught sessions and then for the remaining 3 years you do your research but who like supervisors you, who makes sure your on track, you know all these questions would need answering before I considered one.
T: do you think undergraduate study prepares you for postgraduate study?
R: probably not. I suppose in your final year you do your final year project which is sort of, you can think of what yourself through your placement year or you can get given one and follow that through but in terms of the independent, you sort of get a bit of experience but I cant really comment because I don't really know what a PhD involves.
T: do you think you have to have a certain ability or be a certain type of person to do a PhD?
R: yes I do. Erm yes sort of personal issues come into it as well. it would be hard for me to commit to another 4 years of study when like I want to move out with my girlfriend, all those things have to be considered because ultimately influence your life. I think for people who don't have that they sort of want to move out, move away from university, get away from it all so you have to be a particular type of person to want to do a research degree. I was speak to Christian Young and his PhD is funded and was offered to him and he wasn't

even considering one but when Professor Liam Blunt went to him and offered it, that's says to me it was funded that sort of swayed him. I think you would find the really mad people, like the cycloptic people if you made people pay for it because there would be even less but yes you definitely have to be a certain type of person.
T: do you meet and socialise with other students on your course?
R: erm yes about 8 of us re-set up the engineering society this year so we do socials, we do trips. Outside of that I do a lot of events with the IMechE so they do lectures, technical visits so you go to a company and look round the facilities and stuff and it's not necessarily a good way to meet students but it is to meet professionals and network in that sense. Erm but in terms of erm yes so far there have been plenty of group projects so I could socialise with other students on my course.
T: how do you think that's influenced your studies?
R: it sort of makes you feel less isolated. Speaking to other people who are in the same position is sort of the best way of feeling more comfortable and yes the group project we have done so far has been a useful feature. And doing all the extra-curricular stuff through the IMechE, if anything it's good to experience different industries and see what they are all about and even get talking to someone who has a job going and just getting your foot through the door that way.
T: how often are you in university?
R: in terms of timetable or just how often I'm in?
T: both
R: ok so timetabled sort of Monday whole day, Tuesday whole day, Wednesday free, Thursday whole day, Friday half day. Erm but I opt to come in at half 7 because I miss the traffic on the M62 and I get a close parking spot and it gives me an opportunity to do all the work I've got on. When I say whole day, a typical Monday would be 2 hour lecture 9:15-11:15 then a one hour tutorial till 12 then two hours off and then a tutorial and then another lecture.
T: do you think you have more timetabled hours than other disciplines?
R: definitely yes but I would like to see the timetables for other mechanical engineering degrees around the country because even though it's quite a full timetable, I would be happy to be in more. I've thought this a lot, I would rather do the three years back to back and finish in 2 years, instead of having an 8 week holiday. I've not pushed for time really as long as I'm willing to come in earlier and stay later.
T: why do you think the timetables so full?
R: I would say the biggest % of the timetable just comes from lectures and content to get through. You know the exams and the modules demand that about of taught content. We

don’t really get taught anything irrelevant, so it’s just seer amount of information to absorb, that’s why it’s so full.
T: do you think an engineering degree is harder than other degrees?
R: that’s ambiguous question though because what I find easy. I would find your degree really hard.
T: but do you think the majority of people would find it hard?
R: probably. Just because quite a lot of the stuff, not first year. If you have done your basic sort of maths, physics, chemistry a-levels you are sort of grounded for first year. First year is just to sort of get everyone up to the same level. But in second year, so far things have been conceptually difficult to get your head around, especially analysis of materials. Like actually looking at the microscopic structure of metals. That would be challenging for someone who just took a punt at engineering, it’s like what do you want to do, I just want to do engineering.
T: have you found a few people to have dropped out of your degree or are struggling?
R: yes a lot of people struggle. In terms of dropping out, they haven’t dropped out, they’ve just not passed first year. So they have to re-sit a couple of modules this year. I would say about ¾ of the people from last year are still doing it now. Not loads of people dropped out.
T: do you have any other commitments outside of your studies?
R: no I did have a part time job last year in first year because a lot of the people I had spoken to. like a friend from placement, he was in his sandwich year at Huddersfield so I could ask him about how much to expect in first year and so I did get a part time job but I quit it before my first year exams so I could full concentrate. Even though the money would be nice, I don’t like being split, I don’t like my time being split. Like even if I was on top of everything, I hated having to finish a 3-4pm lecture to rush home to a job. For me the sacrifice of that extra money its not worth it for me. even if I go home and sit and chill with my girlfriend in way better than working a part time job especially in second year. Quite a lot of people are like why did you quit, they didn’t understand, I don’t think I should have to work while studying.
T: would you class yourself as an engineer?
R: no because in the textbook sense I’m not qualified yet but I don’t feel like I’m rounded enough to be an engineer yet?
T: what will enable you to become that term?
R: completing my degree, studying all the modules of final year, completing the modules I am doing now. Erm I think that would be it for me because like I said to you I don’t see the point in me doing another year placement because I think I’ve got enough professional development, enough personal growth out of my placement, it would literally just be for the theory. For me it is literally the taught content and finishing my degree. In terms of walking

into the workplace and feeling confident, I would be quite happy to do that now, I just don't have that little bit of paper says now I have a degree.
T: so you think that bit of paper makes you be an engineer?
R: yes and I don't agree with that. That's another thing, at singenta there was quite a negative attitude towards graduate engineers who had just come straight from university who were getting paid more than the technicians. You know the control technicians who actually open the valves and do the labour. There was quite a negative attitude, he's just all brains he doesn't know what he's doing and I totally agree with them. My year in industry taught me more than anything to respect anyone at work, there's no point going into a workplace and thinking your better than someone else because you have a bit of paper. But to get there you need that bit of paper, I get that but I developed my maturity enough to understand there is a lot more to engineering that just your degree but to open that next step, you need that. Going back to when you said do you have to be a particular type of person to do a research degree, maybe by the time you graduate and you don't have much direction. A research degree allows you that extra time, maybe the people who have done a placement don't necessarily want to work there so they have ruled that industry out. Maybe quite a lot of PhD students don't know what to do, so instead of taking any job, they just stay in academic. Or maybe they do have that burning desire to stay in academic forever, but that doesn't appeal to me. if I was to do some research it would have to be industry focused because I don't want to stay here as a lecturer.
T: how come?
R: for me its clear the lecturers who have been in industry in their life and then come into academic and they have a much deeper understanding of industry and can share personal experiences what they made of industry rather than just staying in academia and just doing it out of a text book, its real world but I might consider it further down the line.
T: how would you describe people in the engineering department?
R: I would say they are all academic people, they are focused, they're competent that's the main thing. But yes I don't really have anything else to add.
T: when you discussed you were going to study engineering did anyone warn you it would be hard?
R: no nobody made any negative comments on doing it but just really enthusiasm and persuasion to do it really. I didn't get any negative opinions off anyone.

Appendix 6 – Undergraduate participant: Rob N (observation)

I first met Rob in the design studio. He says I am just going to speak to a lecturer about getting a grade back because we did a group project and have got a group grade but we do peer reviews so I am thinking we get an individual grade as well and I wanting to know what I got. Lecturer not in office.
He then says I am just going to go to the workshop in the technology building to pick something up. We go to the workshop and he picks the part up. He talks to the technician about the car part and the technician discusses things which have altered in the drawing/design what Rob gave him to the finished product. He says the whole object has shifted but there was nothing I could do because of the way it was gripped onto the machine – technician language used here.
I ask what the part if for and Rob says someone has brought a race car over from the college because the apprentices there were working on the pain but they couldn't do anymore because of their ability so one of my mates asked if they wanted to bring it here so we could do all the mechanics on it. So this is part of the suspension and he explains how it works and demonstrates with the part. I ask how he got involved and he says because one of his friends is basically running it, he said he would help out and he said plus he really likes using cadworks and there is a lot of that involved.

Lecture – Liam Blunt
We go into the lecture and Rob shows someone sat behind us the part, he looks really excited about this and is looking at it in a lot of detail. Another boy says its like all your birthdays and christmas' at once this. the boy looks at it for a while and they discuss what they are doing to do with it to fix it onto the car.
All the boys have workbooks what they say Liam gave them at the start of the module. They are ring-binded with all the lectures in for the year – throughout the lecture I can see

Rib adding things to the slide what Liam has on his PowerPoint but what he has not printed the students off – incentive to come to lecture.
Most people sat together, about 50 boys, 2 girls. Some chatting before lecture starts.
'you wouldn't really have the time to do it on this degree'
Real life applications, justification of why materials used in certain situations. Plays video to further discuss uses of materials, displays objects and says what they are used for.
'I am going to go through loads and loads of applications as people don't really understand ceramics'
Passes out replacement hip joint to pass round
Boy asks two questions, Liam answers. Boy says really I thought it would have been heavier and Liam re-answers question as to why the replacement is the same weight as bone.
When talking about ceramics being in glass he says 'someone smart should say well why is it transparent'
'remember that, you've heard of that before' Assumption
Someone asks question in break because of something other lecturer has said to them.
Liam answers the question and then shows them a video of it. he then says if you want a bit of background this video is good on the BBC iplayer. Even you lazy ones have no excuses because we don't have time to cover everything in here.
Covers what ceramics are for in first part of lecture, second looking at processing ceramics, what they are made up of.
Someone asks Liam a question and he answers in detail about how they would take excess material off ceramics
Uses images on slides to demonstrate things he is saying to students, e.g. a microscopic picture of porcelain
Does just stick to slides, really explains + expands on things from PowerPoint
Works through ceramic processing production
We do all our calculations based on a super pure product
Always start at the easiest white porcelain produces and work through to the more difficult ones advice
Nobody talking throughout lecture, if someone walks in late they have to apologise to him
Keeps re-capping of one process and he says that process is great but we can also do this…
Says why alternative processes is good and what it is used for
Discusses other not so good methods, quickly brushes over there – however we way we process the powder will influence the type of ceramic we get
When we come back next week I will talk about this process
Leaving the lecture I hear Rob talking to another student about placements and he says he has decided to only do a summer placement, not another year one.

Design studio observation

11:16 Rob says hi to someone sat near us

Around 12 people on the computers at the top of the room, nobody talking

A boy comes in and sits near a girl and boy, they are chatting. Two boys also come in together + go on the computers next to each other, they are also chatting

11:18 a boy comes and sits next to us, he does not speak

11:20 another man sits at computer but also does not speak

11:23 two men sat near us and they are chatting, along with two Chinese girls + one boy and two boys + one girl

Rob is working on an assignment, he is looking at the 'detailed marking system'

A number of people coming in to the room, not enough computers for them all

11:29 same people chatting as mentioned previously. Group of people chatting over other side of room stood up, all gathered around one computer

11:34 John Baron comes in and says students who should be practicing SVP, there are some spare chart sheets here – a number of students get up to collect a sheet, he places them on a table.

John is then talking to Josh Brikett about getting the engine running on the F1 car this week, josh leaves and John walks into team hares working space.

Team Hudrail work area is behind where we are sat and I can hear them chatting about work

Groups of people chatting on/off about work – all about work

Rob looking at pics on computer. He is using these for his assignment – a lot of things are visual – is this for justification/evidence.

11:47 he asks me how it was observing team hare and I say it was interesting – he mentions his intentions of his final year project. he says he is not doing a team one.

He talks about the report he is writing at the minute and he says its about taking a component, altering it and then getting it to the stage where it can be taken to a manufacture to be designed/built. He says the report was suppose to be a group one but when he was at his caravan he walked past this company what specialised in agricultural machines and he wrote to them and went to do a two week work placement in the summer and they wanted this new product creating (describes this to me) and so he has decided to take this on as the report as the company set the task to him as an assignment to do so he can do bot in one together, rather than doing a group assignment. He says he realises the project is too big and so he is only doing one bit for this, he says he might consider finishing it at his dissertation.

We go for lunch and he chats about his girlfriend, what she does and where they are thinking about buying a house etc. he talks about how he is servicing his own car this weekend to not only save money but also experience of how things work.
We then go to the workshop again to see if another part is ready and it is not. His name is not on the sheet for who the object belongs to, it has someone else's on it so he writes his name on there as well.
We then go back to the design studio and he logs onto a computer. One of his friends comes in looking for a computer – he sits behind Rob and they start talking about an interview he had for his placement and Rob was asking who was there for their cohort etc. talking about what he had to do in the interview – team projects and that they had to think about all the problems they could think of about why a certain part wasn't working on a machine and they had 30 minutes to do so. He said they thought of all of the ones the company had thought of but it had taken them three months to figure it out and them only 30 minutes.
Rob asks more questions about the task and they talk about it in detail explain what the machine did etc. the use terminology.
They then start talking about the company, Rob asks if the factory was clean and what the fuel tanks looked like and talking about the moulds for them and why they are like they are etc.
Rob says you should have got it then, the boy replies yes I did pretty well I think. Rob says if you don't get it you're an absolute spoon.
There are 4 more people apart from Rob and his friend in the area we are sat (about 10 computers), two of the men are chatting on/off.
They talk about interviews and the best ways to get a job. Rob says yes exactly, its your time to shine.
Rob's friend says I've never been in a proper engineering environment before so it was interesting to see.
Two of the boys sat near us chatting leave the room together.
The boy says a man from the company told me about one of the projects I will be doing, boy explains it. Rob says oh yes that's like logistics in engineering. Rob's friend says they also have a lot of stock what goes out of date and they don't know about it and they don't know where all their stock is they were telling me. Rob says yes that's a typical engineering environment. His friend says I could take it upon myself if I get that placement to try and sort that out in my own time.
Two boys come sat near us and they are both working on an assignment together, they discuss what they have done so far and what they need to do next.
Rob is still working on his report from previous.

A boy comes overs to speak to Rob's friend and they are chatting about an assignment and lab session which corresponded with this.
They are complaining about a lab that was not very good and that the lecturer did not explain a lot and one boy says he has no idea what he was doing in that lab. They then say some labs are really good and they really explain things.
They talk about the lecture this morning because one boy was missing in it and he says that's the good thing about uni, if you don't want to come in, you don't have to.
Rob pops in and out of conversation while he is doing his report
The two boys are now chatting about getting up early for a paper round when they were younger – talking about the rounds they use to do/experiences they had etc.
There are two other boys sat near us talking about work/assignments.
They ask rob if he did a paper round and he said not but he discusses a job he did have and then gets back to work.
1:36 Rob is still working on his report, the two boys are still chatting
The two boys are on about how they think a boy has dropped out. He says I thought he wasn't a bad student and the boy replies yes I just think he didn't like it.
One boy talks about how uni are trying to kick him out saying they if I don't do this, this and this then they will kick me out.
They start talking about another boy who dropped out in exam period and he said he thought that they were hard exams though, he can see why.
Another boy comes over to the two boys and they are chatting about the assignment they want more clarification on. He says I will email the man I need to.
Two boys in 4th year team hare are chatting about work and one has a question so I hear him say he will go over and ask someone from the team hare work space – he comes back and tells the other boy the answer they just said to him.
1:52 boys still chatting about general chit chat.
Two team hare boys not chatting, two boys chatting about assignment one/off still. Rob still working on assignment
1:57 one of the boys says I should go and work on the assignment but I think I will just say here and talk shit for a bit
Boys discussing the assignment ask each other questions about it and what they have put for each part of it.
They go back talking about the boy who dropped out and they say that he just ignores them now he has dropped out (clearly embarrassed).
2:07 two more men come and start chatting to the two men working on their assignments – they are still talking about the assignment.

Me and rob leave the design studio and go to see if the man who he went to see this morning about his grade is there yet – he isn't. he says they got 92 as a group but there is no way he thinks all the group members deserve that. He says that he wrote and submitted the report so that is why he got told the grade. He says he thinks he should not have told the group the grade because the peer reviews will bring some of their marks down and they will want to know why but he says all his peer reviews can be justified.
We go back up to the design studio and he tells me about the trip to China at the end of April wit the engineering society from the Santander fund to see a few museums and things. He said they are looking at getting hoodies with logos on as he thinks that would be a nice thing to have.
He says the trip is just before exam period so he thinks that has put a lot of people off but he thinks it will be nice to have a rest just before the stress.
We are sat in the hudrail area and there are 4 other boys there. They are all working on computers in silence. Two of the boys keep talking on and off about work and one sometimes leans over to the others computer.
Rob is working on solidworks and looking at making a tool which he appears to have found online.
Nobody in our area chatting
I can hear one boy at the other side of the room chatting about assignment deadlines – saying the way he wrote things up in his assignment and his justification for this.

Lecture – John Chai
Start of lecture boy goes up to ask a question and lecturer answers and a boy sat near us asks this boy after if they can meet up to go through the answer John just said as he is struggling as well.
Says they have finished part two of the module, now they will move on to part 3 – he re caps what they have covered in part 2.
Starts by writing notes on paper on projector of previously covered concepts
He asks questions, nobody answers, he says you now how to do this bit by.. so how do I do this? he starts going through the answer.
Still nobody answers so he goes back to equation sheet – he says these are all here so you don't have to memorise them/
Provides students with alternative if they don't like the first method of how to solve the equation.
Nobody has lecture slides, some people making notes
He provides equation and says previously 'h' has been given in equations, now we will learn how to work it out.

Goes over 3rd part of module – looking at flat plates. He says I know what you are thinking, you may never use these but let me explain later.
Content moved fairly quick, lot of terminology to learn.
He says the middle bit is not understood yet and we do not have an equation for it so what do we do if we don't understand something, we ignore it and substitute it for something we do understand.
'this will come with experience'
'you don't have to remember these for the exam because you will be given an equation sheet but in the workplace you will'
Provides + works through equation for one object (flat plate) and then demonstrates how it can be applied to other objects
Discusses something and says I bet you are asking what this has to do with engineering, he says this has everything to do with engineering because in engineering you will be following orders. When you look at something you have never come across before, don't look at it and think I don't know I have never done it before. You need to figure it out because in engineering that's what you do – we are all engineers.
As engineers if you don't know fundamental units there is a bit problem, converting… to… is big thing for you because you are going to go out and work as engineers.
They think we have trained engineers to think, solve problems etc – that is why bankers grab you up.
Not many people look engaged.

Appendix 7 – Undergraduate participant: Ryan T

T: at what part of your education did you decide you wanted to study engineering?
R: to be honest engineering was an accidental choice, in my first year I wanted to be an electrician and then in my second year I asked to be put on the same course but they actually put me on engineering and because I wanted to do it later on and saving time I will just go into it now. I wasn't going to actually go to uni and as the course went on the more and more I saw I liked engineering.
T: so was this at college?
R: yes
T: how come you only wanted to go into engineering later in life?
R: erm because growing up I thought being an electrician is an easy and good choice because its quite well paid and my uncle use to be an electrician and he sort of built up to being an engineering so I thought that was the best way to do it. I thought using the real life experience of being an electrician would make it better for me to become an engineer later on. Now I realising what it actually is I think its best to start as early as you can in engineering.
T: so what choices did you make to enable yourself to study engineering?
R: I've never been great at maths and even now it's something I struggle at but I know I've got to do it but physics has been one of the things that's always come naturally to me. not that it's easy but I get a grasp of it easier. That's why engineer is a better course because I understand the theory of it easier because it comes to be easier.
T: so what makes you want to study engineering?
R: erm at first it was just because it seemed a good role to have because you could be a manager but also work on the tools in a sense so it's a good mix of both but not I've looked at a more higher degree and I started looking more at research and what a degree in engineering can do for you. When put together engineering and inter-disciplinary engineering and see what it can do for real life.
T: why do you think it's important to study engineering rather than just getting a job in engineering?

R: I think many ways, I know someone who's gone into the RAF like apprenticeship scheme and if I don't do well I would go into it because I do want to be an engineer but I think doing an apprenticeship you are capped to what you can become because you will only be at best a mid range manager of just some technicians. I don't see that as a bad thing but I have aspirations of being up to doing to designs and you can only really get that with studying because another thing I've learnt only being here a few months the difference between a level three BTEC and these past few months and I just feel the overall degree would benefit just any engineer.
T: what differences have you seen for college to now.
R: at one sense there is the fact that at college there are not that bothered about the course and they are like my dads an engineer so I will do this course and get the same job but at university you want to know about the research, you're interested in it. Like at college I would tell someone about something going on and they would not be bothered but if I tell people here they want to know more detail and they want to know more and they probably go away and look it up.
T: do you think that after you have finished your undergraduate degree you might want to look at postgraduate study?
R: erm yes the course I've actually chosen is integrated masters, it's a five year sandwich degree so as soon as I finish my bachelors I go straight onto my masters, if I've got the right grades of course.
T: so what made you have that choice?
R: erm I think it was because growing up, it was intention to go to uni and although it sounds bad now I have sorted slated people for going to uni because where I've grown up in high school it wasn't a thing to go uni, it never happened but when I thought I want to go to university, this is what I want to do. I thought if I am doing it I want to get a high degree as possible. I don't see a bachelors as pointless or useless but like if I'm doing it I want to do it to a higher standard as I can. I don't know about a doctorate I think that is a too higher standard for me but if I think that it might be possible for me.
T: why do you think it would be too much for you?
R: I think one thing is the fact that looking at my lecturers and what they have been to profession and stuff but the mathematics they can do. I know I'm only at the beginning of my studies but to them it's just fluent, it's like they have been doing it their entire life. But like I say maths has never been a strong point for me so if I was going to do it I would have to try and get a high and good at maths as I can and I feel if I get to that point I may consider it. I feel like a doctorate is something I would like but I wouldn't go for it in case I was certain.
T: do you want a career in engineering after your studies?

R: yes
T: what type of career are you thinking?
R: erm this is the one thing I've never been certain. I know its engineering I want to go into and around electronics and electrical but it's not a real known thing specifically what. I've always wanted to be in the design process, creating things and designing things. No matter what job I've always been the one making the things. I'm not sure really, I've looked at a lot of things but specifically for electronics and electrical I've always thought about working in power, like if other jobs aren't available I can go to it and say this is something I can do.
T: so how do you think you have a masters and then going into the workplace will influence you, having that level of knowledge.
R: I think straight away it will make you more confident going straight in because when you read up about the transition from study to industry engineering it's a completely different format. Erm I'm not too sure why but every article I've read says it's a massive different and it will take a few years to sink in so I think having a masters and having that knowledge, straight away you will have a more I know how this works stance on it rather than doing it and someone saying that's not how to do it and you thinking oh well he has had more experience but with a masters it proves you have higher than a bachelors and you can say no I know this works because my studies prove it.
T: do you think peoples perceptions of you will be in the work place?'
R: I don't think it will be overly different, I think it shows I have the higher knowledge and that I have gone out and researched and knowledge through my own research and it's not just taught information I have been told and had to write down and remember myself it shows I have developed knowledge through my own study and it has provided my own studies have worked out be to fine sort of thing.
T: to you what does it mean to be an engineer?
R: erm when you follow pages on facebook there are jokes about things what an engineer can do. I feel like an engineer really, I think one of the best things I've seen is an engineer is a job anyone can do, it's just an engineer can do it faster and easier. I know it sounds big headed but you are going to do something. A well known subject in a sense but because you have studied it you know how to do it easier and cheaper in a sense. Its about knowing how to do things in the best way possible they know.
T: do you think there is a problem with defining what engineering is?
R: yes because there is a thing in Britain because there is an organization call the IET which came at the beginning of the year and they said that anyone can call themselves an engineer, like a pizza man can call himself a distribution engineer but in a sense it is a word but for an actual engineer because it is not trade marked or specific enough so everyone

wants to be it because it an a well recognised thing to be but because everyone wants to be it, it sort of dilutes it for a real engineer.
T: does that annoy you?
R: it does to a sense like I know when I was an electrician, there were positions called engineers but what it was was just like a, not even really a higher level of electricians but you just did more than a domestic electrician. I think it was more to lure people in but you were only a bit more than a house electrician so it does in a sense. If you tell someone you are an engineer it might not feel the same because it is diluted in a sense.
T: what were your perceptions of engineering?
R: to be honest before college I didn't really know what engineering was and because it wasn't really a well known thing. Because like I said everyone was seen to be an engineer so I never really know what it was I just knew it was good and well paid. It wasn't clear what an engineer was but when someone would say engineering I never really knew what it was I though it was just bending and welding metal because through college and stuff and high school that's what people said they were but all they were really doing is creating metal cabinets and got paid for it sort of thing.
T: what have you found your workload to be like so far?
R: it's not a big as I thought it would be but in a sense it is a bit overwhelming. Not that I can't do it but like at the moment I have a 11 week project to do but what I'm creating and working with at the moment because I've never worked with it before and I think what if I cant get it to work I feel like I am going to struggle so the workloads not much it's just what I have to do in a certain time I think I will struggle.
T: do you think there are expectations of being an engineer?
R: yes I think so because even at college if there was a problem or there was some sort of thing that needed to be sorted out and not sort of maliciously but they would joke like oh your studying engineering and you can't do it but your sister or someone you work with can and they aren't doing engineering so I think because you are studying engineering they expect you to be able to solve everything or be able to do anything that should be able to be done.
T: what about your timetable and how much work do you do and things?
R: erm the timetable is pretty full days to a sense, its not that I'm here constantly here 9 till 5 but compared to people out of my flat, it's much greater. I know one person I live with she's only got I think 7 hours of study a week but I know just on Friday I have 5 or 6 hours.
T: what about the whole timetable, how many hours study is it?
R: erm I am not certain off the top of my head, it might be around 20 hours. I've never added it up when I have work to do, some days because they are mostly spread out its difficult to get work done. Like I will say I will stay at uni all day today but because the day

it broken up, it fragments the work I can do because I work of have an hour there, two hours there, by the time I've finished by last lecture it's 4:30 so then I just go home.
T: so how much extra work do you put in would you say?
R: at the moment, I would say not near enough. But I feel like that's my own fault, its not because of other responsibilities but when I have assignments and exams to do I really do knuckle down and I will sit for hours on end just doing the work. Erm when it comes to studying I am disappointed with myself because I am not doing as much as I want to do.
T: why do you think engineering has a fuller timetable than other subjects?
R: well I know the person who has 7 hours, she is supposed to read for 40 hours on top of her study so I understand hers to a sense but for other people is because engineering is just work and what you study. It's more than just studying electrical because I also have a professional skills which is making a report, managing work load, making a presentation, giving a presentation so it's more than just what you actually have to do as an engineer, it's also learning the other jobs you have to do so I've been learning the professional side to it and also the log books I would have to do and keeping notes of your own work and yes as well as learning the general study of going into it, it's doing the general maths of it, it's doing the professional side of it. I think that's why I liked Huddersfield because you are learning the full spectrum of what it means to be an engineer in the workplace. They don't let you forget that's this is what it's like in the workplace and we are not doing it because we are cruel, it's for your own benefit.
T: what kind of advice have you been given advice on what it's like in the workplace?
R: in professional development it does sort of tell you, he says like if you are working on a project and he was reeling off like someone could get injured, someone could have a baby, someone could get a disease and he says this is not just examples but I have known this happen many times. And that's sort of the thing, he has taught up that things do go wrong and it doesn't always work to your plan as much as you plan for it.
T: do you think engineering is harder than other disciplines?
R: in a sense I think it is but I've always said that you go into what you want to do and obviously I'm not going to go into biology because I cant do biology so you will always go into what course you find a challenge but I always believe that engineering is harder than most other courses but that's more because of the generalist of what you do. I also live with people who do music and music is all they do so, they spend all day doing music and the course is on music but I also do report writing, log books, presentations and then just maths is general. even though engineering is largely maths based, they do just teach us a general maths as well for when we need it.
T: what are the lecturers like in engineering?

R: I think they are all great really. I've been to other unis and none of them have really impressed me to a sense that Huddersfield have because as well as them all been really experienced and have knowledge of the course but they are all really enthusiastic because when I came to the open days they were all happy to talk to you and about engineering and you could tell it wasn't just a job to them, it was their life passion.
T: when you came to look round and things did anyone kind of warn you of how hard engineering is and things?
R: yes the head of my department and talked to me a bit and an undergraduate was talking as well and he said it is hard but if you put the work in, he said it is what you want from it. And sort of also the undergraduates were saying it is good but it can get hard. One of them was in their second or third year and one of the modules, I think it was electro magnetism and they said it does get very challenging but it is worth it and good to study on.
T: what are the structure of your modules like? Lectures, seminars.
R: it's a mix of both, they do give the lecture and he will explain the subject we are learning and he will give us in class examples and he says you have a go and then I will go through it and he always says if anyone has a question please ask because there probably another 20 people want to know but don't want to ask.
T: do you meet or socialise with any other students?
R: erm I do to a sense but I wouldn't say I have seen any of them outside university but in the classrooms and in the lecture rooms and I will sit with them and if you have a question or want some notes we know we can go to someone in our class, we can help each other like.
T: what are engineering students like?
R: it's a bit of a hard one this. they are not what I thought the stereotype is like, I thought they would be quite, didn't speak much, they would run away or avoid interaction but all the people I have met they are the complete opposite. Its not what I thought the stereotype was, they all want to do well and are out there.
T: do you have any other commitments outside of your studies?
R: erm not at the moment but now I feel like I have got into the course more I feel I could start looking for a job and join clubs and things like sport teams but I couldn't do it straight away because I feel it would be too much.
T: would you describe yourself as an engineer?
R: I would like to but at the moment I don't think I have the skill set to do that. I have always thought I have always been availed to solve problems relatively easy but that's not what I think an engineer is so I don't think I can class myself as an engineer just yet, it's one of the things to work towards.
T: so where is the point you think you would be able to say you would be an engineer?

R: I don't think I would particular have to finish the degree but I think when I have passed I can say I've done the degree, I passed all the tasks, I've proved to myself I can do it so that's what I need but I don't think that's what you need to be an engineer because if you can do stuff you don't need that to make yourself an engineer. You do need the degree because engineering is not just I can do maths and I can solve problems but the degree sort of solidifies and proves that you can do that.
T: do you do any other things inside and outside university what link in with university?
R: I follow pages on facebook what show new technologies and new research things and something I've started to do is read up on my lecturers and reading up what they do and what they are interested in and then going on from what they are doing I read up on it and extend it on to other things and also try and base it on what I am doing now and try and base it all into one thing.
T: do you feel like you belong to the engineering department, do you feel a member of it?
R: erm yes the lecturers make you feel welcome to the course, they sort of don't make you feel like your only a first year you don't deserve my time. They don't overly make a lot of time for you. I think that's because they have other things to do but no lecturer has not made me feel like I can't ask for help. Even if we feel its basic and we don't think it's worth their time, they are there to teach us above everything else so they make time for it.
T: what would you describe the culture of engineering to be like?
R: there are a lot of stereotypes but there is not one true engineering because there's mechanical, electrical so I feel like there are a lot of serotypes in one genre a but at college like you can't tell who is who. But there definitely is a community of engineers but if you know someone is an engineer you will try and help you but its vice versa if you know someone is an engineer you can ask for help. Engineering is we are all here and if you need help we are all here.

Appendix 8 – Undergraduate participant: Seb R

T: when did you decide you wanted to study or be an engineering?
S: I guess my dad was an engineer in the merchant navy so I just wanted to follow that kind of route
T: so did you ever think you wanted to do anything other than engineering?
S: no
T: so did you go to college then?
S: yes I went to college and did AS levels but I didn't really go to college
T: so then what did you do?
S: well I already had a placement so I was just wasting a year at college before I went to join the navy
T: ok and what was that like?
S: interesting
T: in what way
S: I didn't like it really, kind of boring I thought
T: was it an apprenticeship?
S: yes three years studying with a year in industry
T: was it what you expected engineering to be like?
S: yes it was what I expected engineering to be like it was more the lifestyle that went with it.
T: what persuaded you to come back into education?
S: I realised I wasn't going to get a proper job without a full degree
T: when you were doing your apprenticeship did you see you realise you needed that you needed that level of education to achieve in engineering?
S: not while I was doing my apprenticeship, it was more when I got out and I was unemployed for about a year and I couldn't find a job anywhere, nobody would take me so I thought I need a degree.
T: why do you think its like that?
S: erm I think because everyone does the same route, everyone does the same thing, its college and then uni but was I did was different and nobody really recognised it.
T: what do you think the advantages of studying engineering are?

S: you would have a more grounding kind of knowledge of what you are doing rather than learning on the job. You kind of have an understanding of what you are doing.
T: do you think people's perception in industry of you would be different if you did have a degree?
S: from an employer's point of view, definitely.
T: do you think you will end up doing a masters or a PhD.
S: I would do a masters if I was offered it but not a PhD.
T: how come?
S: I don't know if it's right it's just my opinion. If you look at someone who has a masters, they are well qualified, where as someone with a PhD I would think they were more theory rather than practical ability. Old view of engineering being 'hands on'
T: would you want to work in academia or industry?
S: industry, I don't like, I only came back because I have to.
T: how have you find it then, doing your degree?
S: a bit like being in high school I guess, a bit weird after working.
T: for you, what does it mean to be an engineer?
S: I dno, a life ambition I guess.
T: did your dad ever persuade you to go into engineering or was it your decision?
S: it was my decision based on the stories he had told me and stuff
T: what did you like about engineering?
S: it was just the subject I found interesting, I'm not like into art and English and stuff
T: so were you always good at like maths and physics?
S: yerr it was like a natural kind of grasp I think
T: what has your workload being like so far?
S: horrendous
T: in what respect
S: just a lot of assignments. At Christmas I did more work than just relaxing
T: is that what you expected it to be like?
S: yes I knew it would be like that
T: what about your timetable, it is quite full?
S: its ok I guess, I'm not timetables a lot but I have a lot of meetings with different teams and stuff. Like last term I was in every day. This term is a little bit easier.
T: do you still do work when you are not in university?
S: yes all the time.
T: in comparison to other disciplines why do you think engineering has a fuller timetable than other disciplines?

S: I suppose, I don't know it's not something you can just pick up from a book, you need contact time from lecturers and stuff.
T: do you think engineering is harder that engineering is more difficult than other disciplines?
S: yes I guess there is a kind of stigma that engineering is difficult but then I would find art really difficult.
T: what are the lecturers like in engineering?
S: nice enough
T: what kind of ways are you taught in engineering, lectures, seminars, group work?
S: most of the time just someone stood at the front. Slideshows. Occasional group work, very occasional.
T: what is it like working in groups with other students?
S: its easy enough I guess
T: do you meet or socialise with any other students?
S: I try and meet people when I'm in uni but outside of uni I don't really see them
T: so when you meet them in uni and stuff, is it more like just a working studying relationship?
R: yerr we don't sit and have coffee and stuff, we just talk about work.
T: do you think its important to have relationships with other studies or do you not think it influences your studies?
S: yerr I would say you need working relationships because when you are stuck on work you can talk to people.
T: how would you describe the people in engineering?
S: pretty similar to me, we all have the same sort of interests.
T: when I have been doing observations there is not many females in the environments, do you think that influences what engineering is like?
S: when I was working in industry, on ship people were actively against having females on board.
T: you are joking
S: yes it was mad
T: so what kind of things would they say?
S: nothing pleasant, they just assumed they wouldn't be any good at their job and it would be dangerous to have them on board sort of thing. They had a lot of loud opinions.
T: do you have any other commitments outside your studies?
S: yes I do army reserve. That's about it.
T: how does that fit around your studies?
S: it doesn't at the moment.

T: do you find it hard to fit other things in?
S: yes
T: would you describe yourself as an engineer?
S: I would like to think so
T: what do you think makes you an engineering?
S: probably my last job
T: do you think if you hadn't done your last job you would class yourself as an engineer? Like if you had only been to uni?
S: no I would only say you are an engineer if you have worked in industry.
T: what would you describe the engineering culture to be like?
S: its hard to say because the industry I was part of what was like old opinions, like they were all like old sailor boys. Erm so they kind of considered anyone who wasn't white British to be appropriate engineers.
T: have you find that at uni?
S: no they are a lot more normal opinions
T: do you think there is a problem defining what an engineer is?
S: yes because you can say you are an engineer but you can say you are a chemical engineer but that's more chemistry. And then you get like project engineers and maintenance and there I would say there is a cut off point with like a car mechanic which I would say was an engineer is like someone who's doing large scale engineering operations.
T: why do you think there is that difficulty in defining engineering?
S: I guess it's down to personal opinion I guess. I wouldn't say a car mechanic is engineering because I've done a lot more difficult stuff than a car mechanic. But that's I don't know
T: do you do anything inside or outside engineering what link in with your degree?
S: erm no I'm a member of the IMechE
T: what is that then?
S: well I know what it is but I don't know why I have to be a member of it.
T: what is it then?
S: institute of mechanical engineers. I don't really know the point
T: do you not do any activities with it or anything?
S: erm no you can get like affiliated with it, so when you apply for jobs you can say you are an affiliated member and there are different levels. It's kind of like saying you are of a recognised standard, I wouldn't say it was a club or anything like that.
T: what type of things do you need to learn to become an engineer?
S: maths I would say is the main thing, I would just say maths. It's all just applied maths in my opinion

T: why do you think engineering is important, why is it important to become an engineer?
S: personally I kind of look at it as British heritage, we have always been a country of engineers but that's just like a personal thing. I don't know I think you need trained engineers in the country to build industry sort of thing.
T: did you always recognised yourself as being an engineer?
S: I don't think I ever considered, I guess I always wanted to be an engineer, I always wanted to be in the navy so I guess so.
T: I see you have a team hare top on. I said how come you decided to do a team project rather than an individual one for your dissertation.
S: because I was old it looked better on me and that at the end of it there is a big do and there are lots of employers there so hopefully it will work in my favour.
T: how is it working in a team?
S: different to industry. I have a big problem with the way students do things.
T: I guess its more relaxed here.
S: a lot more relaxed, I'm use to consequences if work doesn't get done.
T: so do you work with the masters students?
S: were supposed to but it doesn't really happen, its more us and them.

Appendix 9 – Undergraduate participant: Yousif

T: when did you decide you wanted to study engineering?
Y: around 5 or 6 years ago
T: is it something you have always been interested in?
Y: yes I was really passionate about science, always learning new stuff so I just thought I would continue. That's why I decided to go and study engineering because it has physics and chemistry and all the science there is.
T: how come you decided on engineering and not just to study physics at university?
Y: my mother is an engineer so that helped me out. They said to study whatever I wanted.
T: why did you choose to study engineering rather than just getting a job in engineering?
Y: now a days if you want a good job you have to get a degree in it.
T: what do you think the advantages are of getting a degree
Y: having a better job, if it want to work for companies around the world, they won't accept me without a degree.
T: how do you think having a degree will influence you in industry?
Y: I think some people will look differently at me. if two people are working on the same thing and one has a degree and one doesn't, the one with a degree will do better.
T: did you do things at home based around engineering at home?
Y: yes I have always read articles for NASA and how that discovering new like stuff every day and I use to work in a small garage fixing cars and I loved it so.
T: what are your perceptions of postgraduate study?
Y: yes I mean to be completely honest if I didn't need a degree to work I couldn't do. I mean 4 years is a bit much just for a degree. Only thing I have gained advantage of is working in teams and groups. That's the only thing I liked.
T: so what year are you in?
Y: second, so two more years.
T: how do you think your placement year will influence you?
Y: gaining experience as most companies want experience as well as degree.
T: have you got any previous experience of working in industry?
Y: no I just worked in the garage its not proper.
T: what do you expect working in industry to be like?

Y: I'm pretty sure I will have a desk and responsibilities to be in control of.
T: do you want a career in engineering?
Y: yes
T: what type?
Y: aerospace, building planes and stuff.
T: how come you like that?
Y: since I was a little child I always loved the idea of planes and a huge object can get off the ground.
T: what is engineering?
Y: it is basically building, building cares planes. Everything is engineering.
T: what makes an engineer different from a builder or a technician.
Y: an engineer is just a general name for these. Like this chair, an engineer designed it and thought it needs 4 legs and the way they are shaped.
T: would you say the person who designed the chair is the same as the person who built it?
Y: no that is a builder.
T: do you think there is a problem with defining engineering?
Y: yes if they don't study the concepts behind it they are not an engineer
T: what has your workload been like so far?
Y: yes ok its been quite easy, all the assignments they gave us were easy actually, they weren't hard at all.
T: how often are you in university?
Y: 4 days, two full days
T: that's quite a full timetable compared to other subjects, why do you think that is?
Y: because there is so many things to learn about, it is such a broad subject. I mean it's just this university, others are even harder on their students and they give them more assignments.
T: so what do you have lecturers, seminars, group work?
Y: lectures and one lab a month. They give us as well group projects.
T: how it is working with other students?
Y: that's the best part
T: how has it helped you?
Y: its better than working alone like writing 4000 words alone, in a group its much easier.
T: when you are working in a work do you just discuss work or other things like hobbies?
Y: no mainly work
T: do you think engineering is harder than other subjects?
Y: erm in general I would say yes. A doctor had to work a lot to study where he is, I think this is the same as engineering. I think these are two of the most difficult majors.

T: what are the lecturers like in engineering?
Y: boring and they don't teach us much to be honest and most of them start speaking and nobody is listening to them. I mean I am being completely honest with you. I mean they would help if you ask them and they can help a lot with your problem and they don't speak a lot and they just speak speak speak.
T: so do you have to do a lot of work outside the lectures then?
Y: depends if I have an assignment or exam, I just start a week before the hand in but I still get good marks.
T: what kind of marks do you get?
Y: erm last year I got 72
T: do you meet any other students outside your lectures?
Y: no I've only really spoken to 30% of the 150 students and the rest just mind there own business so.
T: what would you say engineering students are like?
Y: unsociable and there is only two girls in our mechanical engineering
T: why do you think there are only two girls?
Y: they don't want to get dirty I think
T: would you describe yourself as an engineer?
Y: not yet
T: so what would make you be able to call yourself an engineer?
Y: building something or making research
T: do you think at the end of your degree
Y: yes yes final project, nobody can call themselves engineer till they have a degree
T: what will it mean to be an engineer to you?
Y: I dunno erm to be a maker, to be an scientist.
T: do you think engineers are viewed as important in society?
Y: yes I think so, everything has been built by an engineer. Everything, only a human and biological things, everything else is engineers.
T: do you do anything else inside or outside of university related to engineering?
Y: I joined the engineering society but they haven't had any activities in the whole year, they have only done one thing which is about placements for industry year. I am upset actually because their job is to create activities for students and they haven't done anything. Its sad. Bring students together – community.
T: so do you do anything else?
Y: yes I really like 24 hours, articles on the new concepts of stuff. Every day like there is loads of new stuff, like the scientifically things. I just read a lot, all related to engineering.

T: do you feel like you belong to the engineering department or do you just come here, study and go?
Y: come here, study and go. No sense of community. I mean the tutors are really trying to be friendly and stuff but other than that nothing.
T: has your mum told you want its like working in engineering?
Y: she said its fun and you can make friends.

Appendix 10 – First year undergraduate observation

Students sat around testing area working on their cars.
Leigh at front on room on computer making a table of all the teams.
One boy joking around saying that he is going to gamble about which team wins etc and Christian jokes around saying you can if you would like. The boys laugh saying this has become much more interesting.
Christian puts the three targets on the run way and one boy jokes saying that's not in the middle of the board, Christian says well that adds to the challenge. One boy then makes excuses up of why his car doesn't work and Christian jokes saying you are just like the formula one team making excuses up.
Christian laughs are says to the other lecturers we are all precise engineers, those targets should be exactly where they should be (laughs).
Christian jokes saying that if one student car doesn't start he can bet it will be his fault not the students.
Leigh still checking people in
Christian walking round chatting to students about their cars. One student points out a fault as some students have built their cars differently and put the datum in different places.
Christian points out that on the IMechE sheet it says it has to be put on the back but some students have put it on the front so Christian has to account for this and change the line.
Christian then has to alter the target distances on the board because of this and take 30cm off them all. One lecturer starts working this out for Christian and shouts the answers out, Christian says I know.
Christian goes chatting to a few teams and talking about their design, he says you race car drivers make all the excuses up.
One team working on some calculations for the car
Christian goes through rules and at the end says is anyone feeling particularly confident and laughs, a few people shout yes.
Some of the run way is not flat and a boy laughs saying they didn't account for speed bumps in their car, the boy then says if anyone hits the target he will be impressed.
Christian says its is a test of accuracy, not a race.

The students who just raced said their battery has run flat so a lecturer goes to get him a new one.
One team managers to get their car into the target and another team start calling them names and laughing.
They had been shouting one group for a while to come up to the runway and they still hadn't, he says we are all wonderfully organised as engineers.
One lecturer starts taking photos of the students racing their cars
The group from before still hasn't come up after about 3 minutes of waiting so Leigh says they will be time limited now and have one minute to come up to the runway.
When students miss the targets they either get DNF, DNS, over.
One team go over and they say don't worry about it to each other, we got this.
They shout who the next group is and one boy gets up, the people he is sat with say ohh you ready, he jumps around as if he is getting ready for a boxing match.
One car doesn't move and Christian says driver belt off (elastic band)
One car goes off runway and lecturer laughs, one of the boys racing it says that's not my car that (laughs).
Someone created body kit out of paper for their car and make it look very professional and one boy laughs and says it has aerodynamics and everything. Christian laughs and says to the team do you think the spoiler will make a difference.
One of the lecturers' groups cars make it to the target and he jumps up and shouts yes and gives his group a hi five.
One car goes off the runway and onto the other runway, they laugh and say you don't get a score from other runway you know.
Boy laughs at someone else's car saying the friction from the motor will just stop it (car not very high off floor). Christian says its an interesting design. the car did not start and the lecturer is still taking pictures of this and the boy says done take a pic man (embarrassed), everyone laughs.
Every time the cars race, the whole team come up to race the car (team spirit).
Leigh says the next round is 2.8 so you should have modified your cars to account for this.
Boy laughs and says nobody likes a sore looser
Team comes up and leigh says I can see some confidence in that face to one of the boys
One team make it just past target and leigh gives them the points, they all say ohhh no that's not fair – she looks at the score board and says we have had to lower the standard because we overestimated your ability.
When they win some points they jump around, dancing, cheering, you can really tell it is a big deal.

Christian asks one team how the car will even stop and the team say oh we just hope the band comes off at the right time. Christian says very sarcastically, oh very scientific. Lecturer says good job this is not an Olympic event, the other says more like Paralympic and they all laugh.
There is another team what cant get their car started and Christian says this is a clear example of needing bearing.
Lecturer says to one of his groups, come on smash it.
Groups still working on cars in between breaks. Some students are clearly proud of the cars as some have not put them down the whole time.
One of the teams had a none standard elastic band (not the one given out in the pack) and Christian points it out and the other boys go boo and laugh. They ask if they have to remove it and Christian says the judgement of your peers is enough to answer that I think.
One car falls to bits and some boys cheer, another boy laughs and says I didn't know we were playing battleship.
I hear a boy saying that they stayed up last night doing measurements and calculations for the car or they wouldn't have got it working.
Students hung around talking about their cars and some carried on testing them while the lecturers were adding up the scores.
Leigh was scoring the cars on their design, she says if you win you will have to bask in the glory and laughs.
Leigh test the cars when scoring them to see the mechanics behind them. On one of them she says it runs really nice.
Leigh shouts out 3rd, 2nd and 1st place and everyone claps and cheers. The winning team celebrate.

Appendix 11 - Graduate engineers working in industry: Ben I

T: when did you kind of decide you wanted to study engineering?
B: it was probably after GCSE when I was trying to pick my a-levels. Erm I decided that maths and sciences were the things I liked studying. I wasn't necessarily that good at them to be honest, I was probably in the lower set in maths. Erm but I just liked well tinkering with things really. Basically as a kid I would always take my toys apart and not be able to put them back together or you know I just enjoyed doing things round the house. When I finished my GCSE's and I had to think about where I wanted to go, that was the kind of road I could see myself going down. I didn't know what type of engineering but I knew it would be along those lines so.
T: is it always something you have been interested in?
B: yes taking stuff apart, cars, I was a fan of top gear and stuff like that. So it is orientated around that, going out and doing stuff rather than staying in and watching tv.
T: have you done any activities inside or outside school what kind of link in to engineering?

B: erm not necessarily, it is mainly just around the house like DIY and stuff like that. Erm I mean that is it, I did a couple of things with school like in sixth form you could do a crash course in car mechanics and stuff like that. You could choose what you wanted to do so there was astronomy or whatever but cars was interesting really.
T: when you knew what an engineer was, is it something you could see yourself doing?
B: yes I would say, knowing what an engineer was was quite hard to define because you know you can call anyone an engineer from being an academic to being a plumbing engineer so it was hard to nail down what an engineer was. Erm but yes it was hard to kind of decide which one to go, mechanical seemed the most obvious one as it was so broad but when you started to look at uni and the courses and grades you needed.
T: how come you chose to study engineering over an apprenticeship for instance?
B: I kind of wanted to carry on studying. Erm I felt like apprenticeships weren't worth it, you get a lot of experience but I had heard horror stories that apprentices kind of get abused because they are cheap labour. Erm something I witnessed later on when I was doing placement, a degree seemed like the best thing to do at the time. It was also the last year before they put up the fees, it was just the norm really.
T: do you think having the degree had advantages?
B: we did go through it with career advisors and they said we would have more chance to progress.
T: did you do a masters as well?
B: yes
T: how did the masters differ to undergraduate?
B: the masters added a bit more management style courses, you got a bit more choice on the courses you could do as well. I specialised in a bit of metallurgy as well as I found it interesting. There was also the group project, so you do a single style project in 3rd year then in 4th year you do a management style project. And then you manage a second year group to do a competition style project so it was more management and kind of what you wanted to specialise in.
T: what was involvement in comparison to a lecturers involvement in your masters?
B: it was heavy, more say you had to go away and learn on your own a bit more. The lecturer would give you a tonne of notes but you kind of had to get your head round it which had been similar to undergraduate but there was more coursework involved and you had to kind of go away and do a bit more in your spare time really.
T: would you say the masters was hard?
B: erm no, purely because I think I managed to choose the right modules that suited. I have the mentality that if I find something interesting I will want to work towards it. When there was the undergraduate course there were modules you had to do and they weren't

necessarily that interesting and what you wanted so I probably put less effort into those and easier because there were more group projects so people on my course grouped together a bit more and it was easier to learn really.
T: did you think the lecturers treated you differently doing your masters?
B: probably because it was a smaller group of us and you have a bit more one on one and it was easier to ask questions and it was more debate stuff rather than here is the lecture stand in front of you for an hour and death by PowerPoint sort of thing.
T: is all that what you expected the masters to be?
B: yes I think so, it was quite well kind of portrayed when they were trying to get you to go onto it and you instantly knew what you could select as modules and what you would be doing.
T: how come you decided to do the masters?
B: I did want to leave uni really. It was the lifestyle choice really. Quite attached to university, didn't feel like I wanted to go and get a job but also the masters appealed to me because it just had that edge over. Its gets competitive applying for jobs so it was like what else can I add to my CV before I leave that gives you that edge and I think a masters definitely did.
T: so how come you chose not to do a PhD?
B: PhD was going to be a lot more money, you do get partially funded but that depends on who you end up working for. A lot of the PhD's were aimed towards aerospace industry so it was impact is the scheme between a few universities. If was just the fact that after doing my PhD will I get a job? If you don't get a job with the people you have been working in industry with will you end up in aerospace. It was limiting the field I could go into and it just seemed a long time on something and I might not even get a proper job and also the fact that most PhD people end up in academic jobs and I wasn't feeling that, I wanted to go into industry so.
T: has anyone in your family studied higher education or are any of them an engineer?
B: none of my family have been to university. Erm I would say my uncle got degrees later in life but that was part time. None of them are engineers.
T: how come you chose this career in engineering?
B: I spent a long time looking for jobs before I graduated and then I kind of applied for a couple and you go for the top graduate schemes so I applied for rolls Royce erm BA systems and stuff like that. They all have long winded schemes to get you down to 5 people to interview and it just became frustrating. I went to a couple of interviews for smaller jobs, not necessarily graduate schemes because I wasn't sure, I had no idea what I really searching for but basically my aunt found out there was a job going here and managed to get hold of Tony's email and basically started from there. Come in for an interview and a

look round and that's how I ended up here. The thing that appealed to me was the travel and that it was purely different. Everyone gets to go down a mine and decide equipment was it. It was a bit of an adventure, still really technical stuff and I get a broad range of stuff as oppose to graduate scheme. They seem to shift you round to different departments for a few months and then you get pigeon holed into one place and you are designed a spring for an engine but you don't get to see the full thing were as here its kind of you get asked questions about everything so it is interesting and different every day.
T: what was the workload like at university?
B: it was a lot of hours, to being with it was like 24 hours a week in first years. But a lot of it was you turn up to lectures, make your notes and then you cram for a few weeks before hand. But I wouldn't say there was a lot coursework. Obviously if you compare it to a history degree that was about 7 hours but not too bad, it didn't seem to faze me that much yes.
T: do you think it is harder than other disciplines?
B: I think you have to want to do it. You have to have a certain mentality to want to find out why things work because you can see people get frustrated. Definitely you have to get into it at first year and want to carry on with it otherwise its you know, it can get frustrating.
T: what were the structure of the modules?
B: erm so we had core subjects so stuff like mechanics, maths and a few others like fluid dynamics. You would have labs as well and they would try and link in with the modules. So you would do an experiment that kind of proves a theory you are learning about it. Then you get marked on your reports and things like that. Then also later on in the degree were projects, so in the second year you would do a group project that was managed by a 4th year.
T: what were the assessments like?
B: your lab and experiment reports and you would get a % of that as so many credits, it wasn't as much as exams. Exams were the main.
T: were the reports fairly factual or were personal opinions accounted for?
B: mainly yes. There was a clear answer but it was how you got to it. Showing how you worked the problem through wouldn't get you marked down if you got it wrong. Nobody got 100% marks which everyone found frustrating.
T: how would you say you demonstrate you have learnt engineering?
B: that's a difficult one. In general I think it is how you approach a problem. You wont necessarily know everything about something you are working on. Its how you approach it and how you think about it. Its your mentality, like right ok what do I need to know. Probably a lot of it is management of how you go through the problem really. They say

there is no wrong answer, there probably are. Its just been systematic and creative because a lot of the stuff we learnt at university and projects and you might come up with a few solutions, it is how we are taught to think.
T: when you were at uni did you meet and socialise with other engineering students?
B: the engineering society wasn't that great. We would have a bar crawl every year but not many people went. I tended to do other sports and stuff so I joined those societies instead. They did have a formula racing team but again it wasn't very well managed I don't think. It just kind of didn't appeal.
T: do you think engineering lacks that social element?
B: not necessarily no. if it was managed better it would have been a lot better. I know there is a perception it is mainly male orientated and some people think you are nerdy and all that. I think it is on the person. A lot of people like to get their head down and study. A large proportion of that group would just go out and play sports and they just didn't socialise with other engineers, it just wasn't that popular.
T: how would you describe engineering students?
B: erm if you go down the main perception. Guys you know, just very hard working and just devoted to studying. That is the generic perception. I would say just like any normal person, maybe they like to think about things more, technical. That's my perception really.
T: how do you think studying engineering has influenced you working in industry?
B: erm specialising in metallurgy a bit has helped a lot. Coming into an engineering office, you don't know about the products necessarily to being with. You know the theory behind all the loadings and it is very theoretical at uni, you don't have the experience of being in industry which hasn't helped but by doing stuff like placements has. It prepares you a bit for what it will be like. But yes you have the theory and you learn to apply it and that is the key thing of coming into a job after being a graduate.
T: did you find that hard?
B: not necessarily, the guys in the office have helped a lot so that's a think is a key thing. How the company takes you on and how they structure what you start working on and I think the benefit of this role I have come into, I have managed to do a lot of things in a short space of time. I've kind of learnt how the company works and how they approach things but yes it is definitely how the people in the office react to you and how they guide you.
T: have you had any training, how did you go about learning the role you are in?
B: so you start off learning the systems and how the office works and then I had training in stuff like project management style things and I went on another metallurgy course and I got trained in how to use to CAD software because I had never used that type. How to use SAP and other systems, I had a lot of training in that respect. The structure, I was kind of

given a project where I needed to speak to a lot of people who I had never met before. So that got me to learn everyone on this site and people on different sites and then how you know, who to ask for help because it was very much a project management style thing to start and then I fed in the stuff I learnt in in uni like technical. Also my manage said I had to speak to everyone in this office for half an hour and learn what they do, that was like oh. When you are not feeling confidence, it is unnerving at start but it was ok because I get to know the person as well and what they do.

T: do you think you have that level of knowledge from your degree, that it influenced people's expectations of you when coming into a company?

B: yes and no. I think to begin with I imagine people look at you and think uni guy, he thinks hes knows everything and he doesn't kind of thing which I kind of didn't get the feeling here but the general perception is you go into a job where people have been working and not necessarily gone to uni, I mean there is only a handful of us in this office and why does he get to that level when I have started off lower. There is probably that perception at a lot of places. I talk to my friends and they get that feeling too. When you get talking to people and break down the barrier they know you are not just some know it all from uni and that you are here to learn and get the experience too. Might be able to do all the calculations but it is how you apply it so. Once you get to know people they realise you are still learning.

T: were there any skills you learnt at uni which you have used in your role and were there any you wish you had learnt which would have been beneficial?

B: ok erm so obviously there is all of the theory and stuff like that. Then there was project management we learnt you know, how you go about approaching your problem. A lot of it was erm you didn't necessarily get taught what it would be like to work. Being a student is how you imagine it, you don't have a structure, you are not working 9-5. You don't get taught how to interact with people in a professional manner, you don't know till you experience it. There are loads of things like just generally working in an office what you cant learn at uni. Erm but I think what I would have liked to have learnt is how to look for a good job and what to expect for it. If I hadn't done a masters I would know how to style a CV and what to put on there and how to portray yourself to get the job.

T: do you feel like your masters helped prepared you in any way for this role?

B: yes I would say project management and it just prepares you a bit more. Like we did one module on ethics and development, it was you know, prepared you for what's coming ahead a bit more.

T: what was the transition like for you from education to industry?

B: getting up earlier was probably the main one. It was kind of like starting uni again where you go in and don't know anyone. But then you get to know people and you just get

interested in what people are doing. I wanted to know everything want went on. I just wake up and I wanted to come into work, it was interested and I wanted to know more more more. Erm yes the transition was different, longer days, longer hours.
T: in the workplace are personal opinions accounted for or is it still objective and factual.
B: yes I think more erm you kind of have a bit more of a platform at work. You know you can, say you are working on something and you know all about it where as you would have to get someone in to make a decision. You have more of a platform and you have more influence and you can sway the vote but you recognise more than someone who knows the same thing because your more of an expert in it because someone else is working on something else so they would have to know different things basically.
T: is this what you expected working in industry to be like?
B: yes and no really. I didn't expect to be travelling so much, I thought I would get a 9-5 job and stay in the office and do everything in the office but it has definitely met more people than I thought I would. Speaking to suppliers and clients, customers as well. I expected to be a cog in the system rather than here there and everywhere meeting everyone. It is definitely more interaction than I thought.
T: what kind of things do you have to do for your role?
B: basically I am project managing developments. So new products development come through our team. We start the project, we plan how long it will take, how much is needed to bring it through. You assemble a team, get everyone on board erm kind of delegate the tasks and define the tasks that are needed to create it. I am also kind of metallurgy trained, so I can offer expertise in that and I can also offer expertise in mechanicals calculations and analysis so I can do that. Erm yes and I can also do testing, I can plan and conduct testing for certain things so I have a wide scope on what I can do, it depends on what the project is really.
T: how many people tend to work on a project?
B: it is normally around 10, you know you pull in subject matter experts then you need like manufacturing quality to be on board. Just depends how far down you want to go down the chain.
T: how is that working in such a large group of people?
B: it can be difficult because we are technically not working for orders, we are working to develop a product to then sell. You don't get the time people give for contracts. It's a lot harder to say I need you, its more like you are asking for favours sometimes. It can be difficult but once someone has got interest in what you are doing then they will try and help you if they can.
T: did you expect it to be more of an office environment or more hands on?

B: mainly office yes. Well you go through university you got the impression it would be office based but the benefit of this job is that you get to go out in the field and go underground and see stuff working. It is hands on sometimes because if there is a problem you have to go out and see it to understand what is going on. We work a lot with the customer and it is actually a system we provide, we help them maintain it and advise them on the next one where we can make changes a stuff. It is not like we are waking out 3 million bottles a day, it's a bespoke product and it is quite interesting.
T: so the role you have does it make you feel like an engineer?
B: depends how you define an engineer I would say.
T: do you think there is a problem defining what an engineer is?
B: yes I mean my perception is that I would define myself as an engineer. Erm a partially a project manager as well. I mean we went through this a uni, how do you define an engineer. A lot of people say it is by if you have a degree or name, if you are a member of an institute or if you are chartered. I think anyone can be classed as an engineer, but a professional engineer needs to be chartered I would say, that's my perception. Engineer can be anyone working who is problem solving I would say
T: is that what you would say an engineer is?
B: yes if you are a problem solver, you are probably an engineer. Just depends what form if it be electricals, plumbing.
T: do the people who you work with here differ to the engineer students at uni?
B: I would say it differs very little. You know same social kind of thing, go out to the pub or go play sports or go on weekends and do things but in terms of thinking as well, same approach.
T: how does it make you feel working alongside other engineers?
B: I think it improves confidence, you have someone like minded who also has a good opinion and idea about what they are doing so you don't feel on your own kind of thing when you are making an decision which is the main thing, just keeping as a team. You know big decisions you don't do on your own you get everyone round you who you need to help you. It is a team/family environment really.
T: how would you describe the environment you work in? does it tend to be working on your own then when you come to a problem you ask someone?
B: yes it tends to be that because there is quite a large erm scope of people in the office. It goes from quotations to technical publications erm to like problem engineering, application engineering to us, we are development engineers. We try and work, people are experts at different things. if we are working on certain parts of a machinery we will go to that person and get them involved, you can see it through the system. I have probably managed to work with most people in the office on one project because you just manage to do that

cycle, from developing it to technical experts, getting it built, getting it tested, people writing the manuals for it and in the end people having to quote it.
T: at what point did you describe yourself as an engineer?
B: erm probably after I graduated erm yes.
T: what was it was made you an engineer after you graduated?
B: it is having you know, having the degree and also being able to you know, how you approach things. being able to systematically plan out how you are going to solve something. It is probably the eureka moment when you can probably work out how something is or how to solve it sort of thing.
T: what would you say engineer is? Has your definition changed of what you thought it was at uni in comparison to now?
B: yes originally I thought it was just say you know you would say an engineer is kind of based on what you are working on be in mechanical or aerospace but it is more like the mind set of you know, you could be an engineer in mechanics or you could be an engineer in aerospace, its you know the two cross over because it is just how you think about it because the theory still applies. Its how you approach things.
T: what would you say makes a successful engineer?
B: erm basically being able to way up the problem and work with other people. You know be creative, be innovative, erm be open to other options from other people and be able to work with other people. Team work is quite a big thing I think. I think that is more of them
T: how important would you say engineering is?
B: very. You know, you look at how things have been built and somewhere in there an engineer has done it. the creators and innovative people are key to society I would have thought.
T: what would you say engineering use to be and how has it changed?
B: I would say engineering use to be looked at a kind of hands on job where you would get stuck in and it would be seen as a manly job where you would need to have a bit of brawn. I would say now it is seen as more technical and professional. I wouldn't say it is seen as a manly thing now, just a professional job really.
T: one thing I have seen is that engineering can be fairly competitive, is that something you have seen?
B: I wouldn't say its competitive here. Erm it is more of a team. Ok we are competitors in industry but I would say it is abundantly there all the time. When you win or lose orders you will be like oh yes that's good for us. I wouldn't see it as massively influential. I didn't see it at university really, yes some people always wanted the highest grades and stuff but they wouldn't necessarily show competition with you, they may be a bit stubborn to work with but that's it.

Appendix 12 - Graduate engineers working in industry: Craig B

T: how did you come about getting into engineering?
C: I have been here since I left school so erm while I was in secondary I was always interested in woodwork and metal work. I have always been interested from way way back. I got into it and it just seemed a natural progression from school. Apprenticeships seemed the natural progression for anyone wanting to go that route which was a 4 year apprenticeship. Well it was three and you got selected to be a technical apprentice as it was then. I did some qualifications and then I have just done this degree. So it was just my interest really and that is where I ended up.
T: did you use to do this outside school to do with engineering?
C: I always have an interest in technology. My dad was a plumber so I use to help him a lot, he was always very practical. It was always the technology side what came to me more.
T: when you kind of knew what an engineer was, was it a role you could see yourself doing?
C: yes I always say there were two teachers going back to secondary school that took me for metal work that just sparked my interest. I tended to mess around with the tools more and it just grabbed me. I think you have to be a certain mindset I think. I would always say with engineers, there are the practical guys and ones that would be more innovative,

thinking up the designs and the third set is right someone has dreamt up a solution and it has been made practical and now make it work. I think this is sort of the mathematical side of things. you don't have to be able to do it all, you can do the bits you are good at, you cant spread yourself across the beast. You don't have to be good at the mathematics because that's the hard bit, I always say that's what scares most people. When we started at uni we went straight into second year and I always wondered what maths they get taught in the first year. I guess it is difficult because you are not taught it in a way which it is applied then. Like we are doing it now and you will get your head round it in 2 years two, it doesn't make sense. I remember on our first lesson, it was mechanics and he was going through something then jumped from one equation to another and he had done it in his head and maybe that was something we would have learnt the year before and we hadn't done it for 30 years. That first two to three weeks was a massive shock.

T: how come you decided to go back to university to do an undergraduate degree?

C: we do an annual review, within the review for probably even two, three years before I decided to bite the bullet and do it I had been asked to do it. it didn't interest me at the time. I always thought I can do what I do why do I need something else? That was my opinion for 2-3 years and then this company changed and then your recognition was split into two streams and they wouldn't call you an engineer unless you had a degree, you got called a technician. If we wanted to go forward we needed that recognition. I have since then looked at doing a masters but I always enjoyed maths since school and did well at its so it never scared me I always knew I would get my head round it.

T: what do you think the benefits of a masters would be?

C: well again I think the masters would be a personal thing. To have that accreditation for me and again it comes down to career paths. I am not into man management, I want to deal with products. I have half convinced myself the masters will keep me there. What I want is chartered accreditation, IMechE stuff. That was one of the good things from the bachelors we did.

T: do you think it would give you additional skills which might be helpful?

T: I don't know to be fair. When it is individual I can do it but when it becomes group stuff it becomes complicated. I would say it is something they are trying to push more. I mean even here I will say we have designed more by committee than alone. Group stuff needs to be the next step. Even the IMechE accreditation said you have to have more group stuff to get the accreditation so.

T: was your undergraduate degree what you expected?

C: erm I always thought it would be more applied to the physical world and more applied to practical side of things. it was all very much here is the theory and we will show you examples of the theory and then what I do think sometime lacked is here is what it is used

for. The link was never really made at any stage. How does I use it in reality? There is still another level of you have another 2 years before you are actually useful, you know all this but how do you apply it? I would say I expected more of that but maybe wrong expected of me.
T: what about the assessments?
C: we sat exams and did two of three assessments throughout the year. They weren't overly difficult. Almost 50% of the module was how to push buttons on software, you can be taught it in two or three days and we were taught it over 6 weeks.
T: how would you say you demonstrate you have learnt engineering?
C: I would definitely say it has expanded on what I knew. I know how to write a report now for definite. What it has taught me I don't know, but I do feel my skill set has increased.
T: in what ways?
C: I can look at a problem differently now and I will more happily bound into try and look at the mechanics quicker than I use to and I have more confidence in what I am doing. The skills have always been there but it has brought them forward and tuned them for me.
T: do you think since having the degree, the expectations from others has changed now?
C: erm yes, without a shadow of a doubt.
T: do you think having that degree and that level of knowledge has influenced you in anyway?
C: erm that is the side it has done. There is definitely a level of confidence you get in having that bit of paper or whatever letter after your name. it gives you a boost in confidence in what you are doing and what you are saying people are listening to you.
T: what kind of role do you take here?
C: my new title of many of the years is principle of chain products, prior to that it was engineering, senior engineer and so on. I am in charge of the future of the new products now as oppose to previously you were given a product that the direction has been decided and I had to come up with the product. Now I am the idiot which has to decide the spec. and that is a change I will say. I am in charge of three main product lines.
T: how it is working alongside other engineers?
C: it is fine I don't mind that. The higher you go up, the fewer decisions you make but the bigger the decisions you make. That is just how it is. I have no problem with working with other people actually.
T: what would you say engineering is?
C: I guess it was those three I was talking about earlier. If you can have a mix all three you are doing well but that is rare.
T: what makes a successful engineer?

C: I guess with me I am more analytical and because I am bias that way I would always look for that.

Appendix 13 - Graduate engineers working in industry: Robert S

T: why did you kind of decide you wanted to study engineering?
R: probably a-levels, two years before going to uni
T: why kind of attracted you to it?
R: I studied product design and it would have been the way I liked design technology at a-levels and high school and having that creative allowance. That's probably what it was, something creative and something interesting
T: is that something you have always been interested in?
R: a bit I think I was open to whatever I sort of would develop a liking for in school. A-levels was going to either be business or design technology but I decided to go that way because of the creativity.
T: so would you class yourself as an engineer now?
R: yes
T: when you kind of knew what an engineer was is it something you could see yourself doing?
R: it's a pretty open job title, engineer. Here I have been a mechanical design engineer and now I manage a team looking at new product innovations but since I have been here I think

having been in industry and I had a placement year and all these potential pathways, I definitely wanted to become more technical.
T: what is it what you like about the role of engineer?
R: probably the multitude of avenues you can go in to. the specialities, my placement was with defence forces and that was really cool and then coming into Joy and working on heavy machinery. It is nice to be part of that story and seeing some of the machines what are so vast and powerful that you have designed and played a part in that design and getting feedback too. It kept me in engineering rather than put me there but just the multitude of options in an engineering forum.
T: how come you decided to go down the study route?
R: it was just considered the norm at my high school and hand in hand that's what most of my friends were doing and locally that didn't seem a significant option. It was something I wanted to do, carry on studying a little longer.
T: what did you perceive the advantages of that to be?
R: to hone those skills. At high school it is low level broad brush study and then three a-levels which were pretty different means that you know I still have option to move into any of those three sectors if you like. So to choose one and study in more detail made me think I would be better set up for a job in that area
T: so did you do a masters?
R: no just my BSc
T: what is your perception of postgraduate study?
R: it is something I am likely to start actually this year in professional engineering so it is an MEng
T: for what reason?
R: now I am in a management role it just sort of suits what I am doing a bit better. I am involved in new innovations and new technology, so having a good working system and process is vital really in being not only efficient but not making that many mistakes along the way and if you do they are fairly insignificant. Just having the right process and approach. Just to develop those skills a bit better
T: has anyone in your family studied engineering?
R: yes my dad has a PhD in cosmic rays. My mum was university level
T: has that influenced you in anyway?
R: probably to go to uni yes.
T: when you were doing your undergraduate degree, what was the workload like?
R: it was heavy because it was pure coursework so you couldn't sort of ease off and then cram for an exam. It was a consistent workload

T: were you involved with other activities inside or outside of university what were linked in with the course you were doing?
R: erm I cant say I did during uni. Anything I did was not linked to uni and there wasn't any option really.
T: how often were you in university?
R: we had maybe 4 hours a day of lectures but because it was so coursework intensive we had our own time and space to do our own research and manage our own workload.
T: how come you decided to go into this side of product design?
R: it was purely the industry and job potential. I felt in a much stronger position with a BSc rather than BA, I don't think I would have a job here with a BA.
T: how have you found it working with engineers rather than product design students?
R: when you talk to people in the product design field everyone specialises but engineers have technical nowise but something which I felt we have a uni was a good process. Something I even use now what I learnt at uni.
T: do you feel your degree enabled you to do your role better or do you feel you lack skills you would have got from doing an engineering degree?
R: erm well what I did do a few years back, maybe two or three years after I graduated I joined a course at Aston university to do erm a mechanical engineering degree. I did the foundation degree and it was pure maths and science and it just bolstered the things what Huddersfield didn't teach or at least didn't teach on the pathway I did.
T: did you feel like you were lacking skills in that area?
R: yes the course I was on wasn't maths and science and not engineering intensive as an engineering degree would be. Industrial product design isn't an engineery as an engineering degree. I think it worked really well.
T: what was that like in terms of workload and assessments?
R: the further leanring. Erm well I took a couple of hours off every week and it was an evening course where I would go to a local university and study there and it was a long night, you would finish at 9. Joy at the time wasn't very forthcoming in letting me have a study day, even when I was quite junior. It was hard doing part time study with a full time job. I just has to put more effort in
T: how would you describe the engineers who you work with?
R: everyone in here has a speciality and they are very good at knowing their product. They have the technical details about their product. There are a few people who know the system and application knowledge of the system in the field and know their own little piece. Everyone in here lacks having a good development process, significantly lacks that and that is only just been acknowledged.
T: how do you think doing that foundation course influenced you in the workplace?

R: erm well I think I was doing a lot more technical analysis, development and mathematical based problems. Problem solving. It was something I wanted to do for personal reasons, I wanted to bolster that knowledge but by doing that it didn't help me in promotions.
T: do you think it gave you any skills?
R: well yes prior to sort of university study in terms of maths study would have been GCSE. I went to a bit of an elitist school and I didn't do a-level maths because you had to get an A in it at GCSE to study it and I only got a B so I think it was that limited by choices at uni. Having to do a product design BSc rather than an engineering qualification.
T: so would you have rather picked engineering?
R: yes but because of my school I wasn't able to study that before hand. So that is probably where the whole thing started. My skills have now morphed into purely engineering skill set and bringing some of the product design processes and methods, I think that is why I am managing a new product innovation team.
T: how was that coming into an engineering coming now having that engineering background?
R: I was sort of part way there. There were a couple of people who have studied product design in here as well but study the BSc and having that more technical substance to your products and knowledge. That's what I realised I had to demonstrate coming for an interview here.
T: do you think there were expectations placed on your, coming into a company and already having that degree?
R: yes I think so. I mean they did do apprenticeships here but there are certain expectations in terms of grown up professional and your approach to problem solving would be made better. That is probably what the expectation was, that you were good at problem solving and creative thinking and things like that and that is what is asked of us here all the time.
T: did you feel you should be an expert in a way?
R: I do now, not when I joined the company. So when I joined I had a few months in a certain department getting to know the company. Learning my way round, the people, the process, the acronyms what come with any company erm but certainly now because I have had a few different jobs in the company but the role I had now I couldn't have got without all this prior experience. I have to be an expert now, people rely on me to answer questions.
T: what skills did you learn in university which have been valuable in industry?
R: I think it is the approach to problem solving and having a good erm sort of a robust process to follow and if you are problem solving and risk assessments and things that has

been helpful. Here I do a bit more analytical problem solving. Working here is so diverse, I mean I am a mechanical engineer I would class myself now but I am heavily involved with the electronics group or software development or service engineers. I think studying product design you are in a bubble and you are aware of stakeholders in a design project and others coming into play but there was not enough focus on stakeholder interaction and exploring their responsibilities. I imagine you should be prepared for that as that is something you would be doing managing any project.
T: how was the transition from university to industry?
R: fine, It was just like any transition into a new company. I wanted to bolster my maths and physics study but I had a good comprehension of but it was only stuff I tried to learn myself or do in my own projects.
T: so in your product design course would you do a lot of reading around engineering for your work?
R: it was more around material engineering. Stress and strain and physics and those things I was reading extra.
T: what were your expectations of industry?
R: erm I expected it to be more challenging than uni and also more erm specialist. So I would end up going into an area, a finite branch of engineering. Both of which has happened. Also meeting other people with different skill sets.
T: what was the application process like for this job?
R: there were the minimum entry requirements which was a science based degree. It wasn't specifically a graduate but I think they actually wanted industry experience so I wouldn't have been able to apply for an interview if I hadn't done the placement. I knew when I was doing university I had to do that to get a feel for the real world.
T: what kind of things do you do now in your job role?
R: I am managing a team so there is a lot of personnel management so you need a lot of soft skills for dealing with people and their aspirations and making sure they have the right exposure and skill development. We have independently developed a pathway for them to develop skills, soft skills such as presentations and that sort of stuff and talking to people and meeting new people and going underground. I have to look into a lot of field issues, I did that for three of four years, if something fails you had to play detective.
T: so the skills you use on a day to day basis, where would you say they have come from?
R: I would say most from industry. Maybe at handful at Huddersfield, maybe a few more in the mechanical engineering degree but a lot has been developed in the workplace as it has to suit the workplace. These sort of systems or procedures or methods and I am trying to get the guys to do some analysis. You need to pick the problem apart, completely out the box sort of stuff and that was a process I learnt at university. I am implementing the stuff I

did at uni. And I saw the engineering degree and just mathematical skills, rather than a process.
T: how it is working alongside other engineers?
R: when I first came into the business a bit daunting because in your eyes everyone is an expert and you are learning. You are learning the product range and the business but you pick up a lot from so many different people but now I feel rather complete. I am still focusing on personal development skills as I go, I'm not that cocky. I realise I can always expand my knowledge and get better at dealing with people. Working with engineers is fine as long as everyone is on the same page and agrees to specification.
T: when you came into the company did you have any training?
R: there wasn't a graduate development program. That's why I chose to do that further study on my own because there wasn't an opportunity to jump on a program here so I sort of made it happen myself and also moving between groups or departments. I did that myself to help me get these skills and exposure to the industry. I sort of made it happen myself because there wasn't anything here
T: would you describe engineering to be competitive?
R: it is cut throat, absolutely. Commercial agreements and things like that, it is fascinating really. If your not doing it the next person is so there is a big push for us to as soon as we come up with an idea, we talk it up and we apply for a patent straight away. We sometimes do that even to just stop someone else doing it.
T: have you seen competition within the company?
R: we all work well here but I think some do work quite secretively. It is a crying shame, it is strange. I try to be as inclusive as possible, I get my team to send out a newsletter to other engineering groups to let them know what we are on with and to encourage ideas and discussion but people only a few meters away from me are so closed in. just a crying shame because every time we get together and we always try and create a big forum when we are tackling a big problem or field issue or whatever it might be. Together we are strong in a group than one individual, maybe it is just characters.
T: at what point did you feel as though you were an engineer?
R: probably when I made the transition from the first group I was into to the second. I had a stronger insight into the product, the detail that went in and the products we sell and a new awareness of the system. A lot of people know their products in a lot of detail when they don't appreciate the whole system. I thought I knew enough at the time and that sort of made me feel way more comfortable as an engineer doing an engineers role.
T: what would you say an engineer is?
R: erm someone who can completely understand a challenge and have to capacity to break down something which may seem complex into bite size pieces and then be able to

systematically tackle one of those to come up with a solution. But also coming up with the right methods, that analytical approach to make sure they have the best chance possible of taking on that challenge.
T: what type of things you need to know to become an engineer?
R: erm I would start with sort of a small maths background and a heavier physics background. Some effort spent in creative thinking techniques. You might have the mathematical understanding or appreciation of how something works, fine but unless you have the right processes to following in putting all these ideas together. As much as you have these hard skills you definitely need the right approach
T: do you think you can learn to be creative?
R: yes like lateral thinking and debono, his books and things like that are really good. It is picking things apart and looking at things from a different perspective. It is using the right approach for the right problem or challenge
T: what would you say makes a successful engineer?
R: having all of those, its having the right approach. I think someone even asked Einstein an equation and he said why do I need to know that when I can just go to my book and read it. you know as long as you have an understanding where you can get information if you don't know it off the top of your head. You know you don't necessarily need to be hugely skilled in that field as long as you know how to access that information or the people who do, pulling it all together which I think is the key.
T: do you think anyone could be an engineer?
R: with that background and schooling absolutely.
T: how important would you say engineering is?
R: the most important.
T: how would you describe engineering? Journal papers say objective, impersonal, competitive, masculine.
R: I think any industry has to be competitive I am sure. We have one female working for us and she's coming to work for me soon so I am excited about that because she is smart. There is a bias in terms of male orientated field. I see that everywhere I go, if I got underground and there may only be one or two women, in the states there is a lot more. Objective, it shouldn't be because it is sort of right or wrong. It will either work or it wont. If it is objective is hasn't been broken down enough. People count on you in your area to make sure your assumptions are right based on whatever evidence you have worked out for yourself or first hand research.
T: would you say engineers need the other set of skills, like soft skills?
R: 100% yes. We have a couple of different groups in this one office. We might have one group who has a manage with all those skills and can report up and down but he can

manage people who are purely analytical but he is bringing those things together and he is the ones delivering it. so you can be purely technical and long as you are feeding into someone who isn't. to be an all rounded engineer, which is why I want to do professional engineering as a masters because the approach to everything and the way you deliver a project and manage a project. to be an all rounded engineering you 100% need all of those things. you need technical people and all rounders completely.
T: would you say the technical people have different roles?
R: in the company we have two different pathways. One was a technical arrow and one was a managerial arrow. Up to only last year the technical arrow only went so far erm director or something like that but the other arrow went to like CEO or something like that. It is only now you can get further being purely technical but to me you don't have the skills to engage with people properly. Sell an idea, have that communication and sort of win people over. Those interpersonal skills. If you want that all-rounder you will find it easier going up there. I think you would be personally limited if you were purely technical in terms of your career, you cant get past a certain point.
T: what did engineering use to be and how has it changed?
R: it has changed for the positive because now it is more inclusive. You know your erm required to call on subject matter experts and getting a wider opinion on things. you still have technical experts and managers directing people in the same way so I wonder if it has really changed. Technology has changed but the culture being it probably not but why would it need to. if a business is flexible enough to respond to different markets or whatever find but I think the engineering behind developing products and problem solving hasn't changed a great deal.
T: is engineering something you have always been interested in?

R: I have always been interested in wanting a career, job or life that is creative. Or coming up with new ideas, creative right. That is why I don't want to do history, I focused on the engineering side of product design as it was better career prospects. It is just the creative outlook I wanted and still do now

- Saying how they are merging with a company and they got actors in to tell them how to deal with this transition. Why can engineers not tell engineers how to deal with this transition – because engineers are socially awkward and don't know how to deal with situation.
- He was saying how you need certain sets of skills to become a manager, some people are just technical and they are happy with that role, they don't want to expand. He says these are not all-round engineers.
- He also said that a lot of the engineers are very secretive and just hug their computer. He said he doesn't understand why they don't share them. They could improve them much more as a team or if they discuss them to bounce ideas off each other.
- Real social element lacking
- He was then saying that he recently went down to the electrical department and he has been in the company 5 years and he was saying that are having an open day down there so people can see what type of things they do and meet them – why does it take an open day in the electrical department for people to go down and chat to them.
- He was also saying that have PIP for individuals – personal improvement plan. Where managers pick out who they think would make good managers – finance, project management, communication with customers effectively, ideas, costs.
- Says only just set up football team and he has been there 5 years

Appendix 14- Graduate engineers working in industry: Robert W

T: how did you kind of come into engineering?
R: obviously been an older student, I went to education as everyone does, I went to an engineering college and then I went to do my HND and after that there were not many jobs around in engineering. I got a job at a gearing company and I just enjoyed it. I just had a knack, it was something I could do naturally. It was just something instinctively I knew I could do. Once I got the job I just enjoyed doing it.
T: when you were at school and you went to the engineering college, is it something you have always been interested in?
R: when I was 16 years old, I hadn't a clue. I was good at technical drawing and I was adequate at maths. I was useless at English. I knew roughly I wanted to go into engineering and I knew I didn't want to work as a mechanic in a garage, I was more of like working things out and creating stuff.
T: is that something you have always been interested in, even when you were little?
R: I had mecharno, lego so yes that type of thing.
T: when you knew what an engineer was, is it something you could see yourself doing?
R: erm post 15/16. Once I went to the sixth form college.
T: how did you come about going back to university to do engineering?
R: erm obviously I did a HND so I was an engineer. In industry now, unless you have a degree you are not going to get into management.
T: why do you think that is?
R: I think perception of upper management that you need a degree to be intelligent or do a job. I think its because a lot of companies are run by accountants and you need high qualifications. You need high skills like management and accountant skills to go up the ladder because you have to do budgets
T: what do you think the advantages of studying engineering are?
R: you get to learn basic engineering, what is right what is wrong. It teachers you all the fundamentals you need in engineering. You cant just go into the workplace and suddenly become an engineer, you need foundations. Its different to learning to operate machinery. You learn the building blocks to turn you into an engineer.
T: how has doing the BSc influenced you in the workplace?
R: I would say it's a piece of paper but it has added to the knowledge. It is a reminder. I forgot stuff from college but there are technical publications what come along, they are aids to doing your job. Doing the degree was just another aid, it refreshed a lot of the stuff I already knew. There were a couple of things I've not used and I had to go back and learn them but that was it.

T: how come you chose not to complete postgraduate study?
R: I am 55, that is maybe not a good excuse. At the moment doing a masters is very specific. Having a masters sets you on a path to becoming a manager. You are learning more about a specific subject or arm of engineering. PhD you can really specialise. If we went to do a masters here we would have to do accounting and marketing and I don't mind doing a bit but its not the be all and end all of my life.
T: when you were at university what was the workload like?
R: when I did my HND I had to do a hell of a lot of work, more than for my BSc. You do learn an awful lot in your workplace. Throughout your engineering life you make notes. You always have to do calculations throughout your working life.
T: when you were doing your BSc did you do a lot of reading outside the subject areas?
R: no, only if I would have to. I retained a lot of information from my HND so I didn't always have to.
T: what about the assessments?
R: I think they are a very good way of learning. Self research, you have to do research. any information we needed, there was always time to go and research or find books.
T: so what were the assessments based around?
R: mainly lab reports, in groups.
T: so were they mainly factual and objective or could you put person opinions in for instance?
R: you write it up and conclusion and observation.
T: are the structure of the lab reports still the same in the workplace?
R: its more long winded I had to do at uni than the workplace. People are only interested in yes no in the workplace. Its more relaxed.
T: how would you describe engineering students and how do they differ to engineers in industry?
R: the engineers in industry are the people who pass the degree. If you want to complete engineering you have to really want it, half measures don't work. If you have the drive to complete the degree, you have the drive to make a success of your career.
T: do you think there are expectations and perceptions of people who have degrees in the workplace?
R: yes but at the same time some people come in and cant do the calculations what me and Craig have always do
T: so are there any skills you learnt at university what you don't think you already had?
R: no because these days if you need to learn how to do a calculation you can always find it out, the theoretical side of engineering. What I did learn, is to look outside the box. Other ideas and ways to solve things. that was worthwhile. Engineering is called innovation really.

T: do you think the graduates lack any skills when they first come into industry?
R: your degree is large and the industry is specialised so even though you may have covered some of it. you cant come in here and product the whole product like that, you use the skills at uni to do that. Ben has his own project to do and they are pushed out of their comfort zone and they have to communicate with other people on a social basis. Most colleagues will help you out if you are stuck, that is a good engineering environment.
T: at what point did you describe yourself as an engineer?
R: erm when I was young, when the first products I designed were put into metal and sold. When you see a whole product, that's when you become an engineer and when you solve it when it goes wrong, that's when you become a double engineer.
T: what would you say engineering is?
R: I always think if you took away engineering where would we be? Engineering has been around forever because you naturally make things, learn from mistakes. It just takes us on. Engineering is all around us.
T: what type of skills and knowledge do you need to become an engineer?
R: you started off by saying did you build things when you were a kid and I think if you are not interested in building things or seeing how things work. You need to want to do something.
T: what would you say makes a successful engineer?
R: I don't know. There isn't enough of a pat on the back for engineering, they are all successful.
T: what about the skill set?
R: you need to be analytical, you need to be creative.
T: how does being creative fit in with solving a problem or fixing a product?
R: you can design a product and that is great, you have to be creative in how we manufacture it and stuff. You get one person who is creative and then there is a supportive network who says we cant quite to that but if we do this does that still give you the same buzz and when you jumped out of bed and designed it? and he makes the decision yes or not. You cant teach creativity.
There are so many ways of doing things. it can be regimented but that is normally after it has been developed. When developing the product you need to go do every avenue. There are constrains you need to put on it.

Appendix 15 – Masters participant: Alex G

T: when did you kind of decide you wanted to do engineering?
A: ive always since childhood make things, build things, so it just flowed on from there. How things work, take things apart. I think I finally decided to go down engineering in college, it was either product design because I liked wood work and stuff like that or engineering and I preferred electronics so I chose electrical engineering.
T: what is it what attracts you to engineering?
A: I liked computers and again how things work so its like this trying to understand how thing work and being around computers is sort of becoming more electronic so it sparked my interest.
T: what would you say the differences between electrical engineering and the other types of engineering are?
A: erm some of it is more theoretical, mechanical is a lot of practical and physical testing and things like that. Erm it is more of a small scale thing as well, mechanical deal with meter, kilometre and civil engineers do buildings and things, where as electronic is much small, stuff inside your phone can be smaller than your fingernail. That's the main difference, the mentality of thinking, you cant actually see everything. Erm I think mechanical engineers see a gear box and they can see what is inside it erm but electrical engineering you tend to have the black box effect and you don't always know what that thing is going to do and how it kind of works as a generic part. You kind of shove things in and see what happens, you do a lot of prototyping because you don't know how things will get on. You can guess but you don't always see how it comes out because like down in the lab especially in second and third year. Everyone has this weird mind-set that if it works first time there is something wrong because its not supposed to work first time, you need to work out the kinks but I think mechanical engineering study everything at the start and they know all the dimensions and then they kind of choose properties from there for the exact result. So it is not opposite but erm different work flows. Other than that is it just maths so.
T: did you kind of always know you wanted to be an engineer?
A: kind of, it was always about making things.
T: were you always good at the typical subjects associated with engineering?
A: yes but I am not the best but I work hard at it I guess. I guess some people have a talent and some have to work harder for it and I am one of those. I have the talent but I still have to work for it, just making sure I get the practice in.
T: what attracted you to engineering?

A: its about making things and understanding how things work. I have always been curious. When I like computers and technology, having a degree in it, I can guess and do finer research to product the result which satisfies the curiosity.
T: what persuaded you to study engineering as oppose to apprenticeships?
A: erm it was a 50/50 choice. I was open to an apprenticeship but I wanted to do more of the electronics side which meant in the local area there wasn't any available which meant I either go to university or I do I different field to do an apprenticeship but I really wanted to do electronics so. I was always good at academics but it was annoying I didn't have the choice to do the apprenticeship if I could.
T: what do you think of got out of the degree?
A: my written work has come a long way because I have dyslexia and stuff. Communication and stuff have all come out of it as well
T: how come you decided to stay on and do a masters?
A: erm it was more about. I was thinking to myself get it all done at once because I can go out to industry and have my masters degree and then rather than coming back later on and interrupting work. A lot of people on my placement justified that again, you wont go and do your masters when you start working because you have commitments and stuff like that. Other than that seen as it is accredited, I can get onto the chartership path a lot faster as well. rather than one or two years break then do my chartership.
T: did you feel prepared to do your masters?
A: erm yes and no its like erm. The way the masters has shaped it, it is more management stuff, it is more technical stuff. You are learning technical aspects and then you apply it to more managerial projects and you learn to manage your time better and stuff like that. Which is stuff you don't learn at undergrad. Like the USA project, we have to handle BEng students and obviously people who are meant to be technically on the lower level of the scheme. It did prepare me to think outside the box, especially on a group project everyone has different opinions and stuff even though they have all been taught the same, everyone comes up with a different solution so it has taught me to think differently or approach things we a generic mind-set.
T: do you think you have got anything else out of doing a masters?
A: I am not sure yet, once it is finished I will be able to review it all in my head. Erm but it is just mainly about the group project and that kind of stuff should be benefit because obviously in industry you will have a small project to yourself or you will be in a group so hopefully it has prepared me for that.
T: so have you had any good experiences or bad experiences in your studies?
A: erm bad experiences is always leaving things to the last minute when I shouldn't but I have not had anything academic wise that is really bad but it has always been acceptable

within reason. On a whole good experiences is just learning new things. I do a lot of the same thing as a hobby so its good to take things forward what I learn there to use a home.
T: what kind of things do you do at home?
A: erm a lot of is mostly programming because it is easy to sit at a computer and do a load of programming. I am building a 3D printer from near enough scratch so I have control systems which you learn here on my course and the dynamics of how that works. I am also building a robot arm and using a kind of board which most people don't use on such thing.
T: how come you decide to do all that sort of stuff at home?
A: erm I like robots and new technology like 3D printing so I want to expand on what I know by learning from that. I choose to do it at home as it kind of cements what I do at uni. All you do, especially on a masters year you do 6 months but you only do a small segment on it as your not a specialist or research in that area so I take it home and I can develop my knowledge on it and develop something cool.
T: do you think you will end up doing a PhD?
A: erm its on the cards, I would prefer to get industrial experience but I have not really looked into the PhD option just yet. It depends what they can offer me if I say I want to do this and they say I can.
T: do you think having your masters when you do go into industry, it will give people sort of expectations of you in a way?
A: erm it should do because you obviously you have earnt that level and you should be expecting that to happen and it will also depend where you are from as people will be. If you have a MEng they expect you to be more managerial and to manage things a bit better and I think it is more of an indicator you want to go into positions a little higher. There is an expectation you know more and you have experienced more, it is just making sure I meet those expectations.
T: when you were given the project, how did that sort of feel?
A: erm there was a choice of three erm so I chose the drone. I expected it to be a bit more complete and ready for us to get on with the work with there been a lot more management work, setting up websites and getting the finance in place which the other teams turn up and start doing the technical work so there was a lot more admin work to do but there are a lot more masters so there is not too much individualised work. Things seem on track and we seem to be communicating well
T: how are jobs dished out when you first start?
A: after we read all the rules and the criteria of what we have to do, we can split it up into general areas then. We split it into the basic criteria of what we want to meet and then those groups go away and see what criteria needs to be met for their section and it goes

down from there. My individual work is batter and batter management. Just making sure all my calculations are written up and it is correct.
T: in what ways would you say masters differ to undergraduate?
A: there is a lot less lecturer help, generally because it is more management, it is more on you. You get the work done, you learn more project management stuff or a couple of research things as well, I think mechanical still learn technical. We have done a couple of new things but it is more about getting down and making sure we know the management side and getting down on that. More of the soft skills
T: what about timetabling and how much your are actually in uni?
A: erm obviously at this stage you should be doing 40 hours weeks but it depends on the module. A lot of modules this year have been half year and not full year. It has been a lot less student lecturer involvement. It has ended up being more like here is the thing you need to do, go away and do the research if you need to. before Christmas it was like 6-8 hours and now this year it has halved. UAS has one timetabled meeting and you make up your own timetable which is sort of nice.
T: do you feel like your responsibly have altered then?
A: yes I have to make sure I am doing my work. Meeting commitments of the meetings and like I said the drone has two meetings on a Friday and we have sub group meetings, making sure everything is scheduled right.
T: do you feel like you have changed while you have been doing your masters?
A: not so much yet, I have been better with group work and management of other people and making sure I don't overstep boundaries, I have to have trust that people are doing their work as well. more of the soft stuff
T: do you think lecturers treat you differently?
A: some do. Some have always been like they are super busy so they help you when you can. Other sit down and help. When it was BEng you say what you have done and then they give you something else to do and you go away and do it, MEng there is more of a discussion. Some lecturers have always been lovely with everyone but they give you a bit more respect. Some of them are more like to let down that professional boundary. They see you more on their level.
T: how often were you in university in your undergraduate degree?
A: I was in quite a lot. I was in 9-4 everyday. final year dropped down a bit but only because I was doing my dissertation
T: why do you think your were in so much in your undergrad degree?
A: erm it all varies with each subject because with humanists you get told what you have to read and you go away and research it and you cant do that for engineering. There is a lot more maths and theories you have to go through because there is a defined right or wrong

answer. Where as business if you can justify it you are correct in your own case so you have to have principles. I also think most people don't remember there is a safety case with it. you can go into industry and safety can become really important so you have to make sure all your principles are sound.
T: would you say it is harder than other degrees?
A: in some regards yes, I don't think business and law or even history. Anyone who has to read a lot of books and I couldn't sit and debate about if an answer is yes or no for hours so in that sense it is easier, there is always a correct answer you can go through your working out and check it again but at the same time there is a yes and no answer so you cant come up with your own idea. You have to go through and make sure each step is correct because you might have the right answer but you might not have done about it the same way. You have to produce something and learn the theories behind it.
T: do you like that way of learning, with the right and wrong answer?
A: I would like a balance but it is nice in the fact that you know there is a correct answer at the end of this and you can type it in your calculator and be happy in the exam. Where as business you have to go through the point of explanation and back up your evidence and justification. It is just that. It would be nice if it was yes no or in-between.
T: do you think having the flexibility in the project was difficult to adjust to them?
A: erm yes it is in one regard and I think it falls down to everyone has their own correct answer and you just need to find a fit. It is just making sure everyone answers line up.
T: what about the assessments, what are they like. Do they link in with this whole right wrong answer sort of thing?
A: some do and some don't. especially undergrad stuff, when I am doing programming, you can do programming in many different ways and get the same result. Those assessments are ok. Bit of a mind melt when people ask questions and they have done it a different way or if you are stuck and you ask someone to help and they say you shouldn't have done it that way.
T: do you have to justify the way you have chosen?
A: sometimes yes and sometimes no. it depends how in depth you want to go, not really at this level but in industry it would be a case of optimization. You can do things right but you can do things the optimal way. In programming there are many ways to do things. When it gets to flexible answers they can justify why things aren't the best and you might be able to justify why it is.
T: do you meet with other engineering students inside or outside on uni?
A: the UAS project we try and organise nights out and things like that. When I am hanging out at uni I am usually doing my own work because everyone is doing their own work. Just typing away at PC's

T: what would you describe engineering students to be like?
A: erm usually focused erm detailed driven, usually look for a correct answer. It is hard to say because when you are on the outside you can see the generic stereotype. Nerd is generally a stereotype but when you actually talk to people you can see different characteristics. I think the main type is dedicated to what they have chosen because there is rivalry, here it is between mechanical and electrical. There is chemical but we don't usually see them. I think improvement would be a good word, they like to improve and optimise things. we always criticise something and each other's ideas
T: are you members of any societies or other hobbies what are liked with engineering?
A: I have the official accreditation stuff and they do tours of cool places. I am part of the 3D printing society which is nice, we don't meet up too often.
T: would you describe yourself as an engineer?
A: yes I usually say I am a student of engineering
T: what do you think makes you an engineer?
A: I would generally say you are an engineer if you have the degree but other than that I do think you need to the degree. I would say you have an engineers mind set.
T: I have read a lot of papers on engineering being objective, competitive, impersonal, masculine. Are they things you have seen?
A: yes erm yes those sound like the generic terms. Not necessarily all positive.
T: why would you say engineering is competitive?
A: erm it is not all competitive. University level you get a competitive but collaborative approach. It all falls down to yes or not answer, when you get a grade. When things get quantified and especially because we do a lot of is this better than this, so when we get numbers we compare things. we do compare grades and a lot of us calculate things randomly and how much it is worth on the course etc.
T: what other skills would you say you need to be an engineer?
A: yes you don't get taught too much at uni but it is the soft skills. Communication, written communication. How well you replay information, presentation skills, especially for industry. Those are the ones what done get taught but are vital. Its communication in different ways, in teams, communication of what you are doing. Time management, work load management. Scheduling and communication are the ones you need.
T: when you do engineering is it quite hard and demanding and you have a large workload. Why do you think people stick it out?
A: erm I think its because especially when you start and when you get past your first year and you see the challenge, because a lot of us do like a challenge. Once you have got past your first year you tend to be quite driven by it. A lot of us go there is no point leaving your degree at 50%, you are wasting your time sort of thing. Why would you do a process and

leave half way through, why would you not evaluate it before you started it. It is hard but erm like I said we like a challenge and we have become very devoted of it. The assignments as well you kind of fall into a mind-set, I cant really say what type of mind-set it is but you do get sick of it but you just say well it needs to be done. A lot of us say that, you see the result and you know what result you want, it just needs to be done. it might just be the just do it mind-set, you want to go there and have to go there which is the driven kind of mind-set.

T: what would you describe the engineering environment to be like?

A: it can be hostile but it is weird because, it might just be a stereotypical male thing but we go from banter, rip into people, take the mick and sometimes we don't leave the joking side behind and someone might present a bit of work and we are still ripping into them. Then it kind of gets diverted into ripping into them because of the problem. And then sometimes because we prefer yes or no answers, correct or incorrect and when the answer is a bit grey and everyone has their own correct answer and they all start arguing for it. When it comes to maths, as long as we follow the same calculations we will all get the same answer but when it comes to meetings and stuff. In industry there is chain on respect, but here we are all on the same level so you cant show them that type of anger. It just falls down to yes or no correct or incorrect and trying to justify it. I tend to be quite in the meetings and do it person to person afterwards. I would rather not raise a problem in a meeting if A I have thought of it randomly and it needs to be thought through a bit more and it is just a stupid thing so I would rather think on it a bit and go after the meeting because the meeting tends to flip between personalized stuff and sorting problems out with the UAS.

T: is there a level of embarrassment?

A: there is yes, it depends how bad your question is. If you say 1+1 is 3, everyone will rip into you for that but if you say the answer is 1.5 are we rounding up or down then people will start justifying the case for it. It is not the worse question as long as you justify why. It is when stupid questions get stupid answers and it is like hahaha. When people give you a joke answer, when you ask a genuine question, I think that is what people try to avoid and being made small, belittled. That's when people don't want to raise questions.

T: why do you think its like that?

A: especially with our meetings, A everyone is on the same level and you can be correct, everyone can be correct in their own way. There is no chain of command, plus in the meeting everyone shouting out and it sort of becomes anonymous. I think it is a similar mentality, keyboard warrior. Which is why I prefer one on one and you can have a discussion.

T: was it like that in industry?

A: no because there was a chain of command and a process for sorting problems out. If there was a problem in industry the people who related to the problem would all meet together and define the problem and a solution, if not they would then pass the problem down the chain. So them obviously it gets passed down the chain of command and someone has a work package for them to do and then it gets reviewed by someone on a similar level. Other people would come down and give their review from different perspectives. I think that is one problem here because everyone is coming from the same place so there is no perspective on things compared to industry which is why it gets bad because everyone shouts for their answer which is why it gets bad. They say I know its this, they just shout for it. At least if everyone is shouting and if they get their answer heard, they get the credit sort of thing.

Appendix 16 – Masters participant: Cale J

T: when did you decide you wanted to study engineering?
C: this was going back to primary school age, roughly around 9 because I think before that you don't really have a sense of yourself and what you want to do in your future. Now the thing with me, the interest really came from my dad and a lot of members in my family because they worked in engineering, especially the oil sector so for me becoming a teenager and later you understand the work environment and the industries and you start to get glimpses of what certain careers have and for me getting to see my dad working in the oil sector, for me a just see it as a great opportunity to have a great career. I mean the rewards financially, hey speaks volumes.
T: did you ever consider another career or is that what you always wanted to do?
C: erm for a couple of moments in time I contemplated medicine right but later when I finished high school it was IT. This thing with medicine is I couldn't really deal with that blood factor because its not for me, I thought I would just stick to engineering. With regards to IT when I finished high school, I thought about it but when you look at the last 20-25 years that industry has changed so dramatically you would always have to be keeping up. Keep re-tooling yourself a lot. I thought no I don't really want to do that and you know changes in the sector what companies would offer employers, it was not feasible. I guess family routes and I just wanted to come into engineering.
T: did you work in industry before you come into studying?
C: I did for a short moment, roughly about 18 months when I was younger. I worked for an oil company and they would make what it known as Christmas tress and simplified, they would make a contraption with a number of valves what would sit on the oil well with the BOB and these would control the flow of oil from the oil well to the pathway and I was responsible for assembling the Christmas tress and making sure there was no leeks because any leeks or anything can be potentially catastrophic.
T: why do you think its important to get an education in engineering?
C: in hindsight I do see the apprenticeship route as important as going through the conventional route erm I think the drawback with that is, from my perspective and speaking to guys who went through say that people don't really want to commit to that work environment and such a young ages to they see the uni option as more relaxed way and a chance to party but depending which section you want to look at and how far you want to go up the corporate ladder but the education system is essential now because you know if you want to become a manger in the engineering section, apart from a good technical grounding you need to have an understanding of the business as a whole and having that foundation of an education background will make you that all-rounded engineer.

T: did the members in your family who work in engineering get an education?
C: yes my dad studies a little in the US for some time and he went to school and went to school and got his degrees and all the members of the family got some sort of technician diploma, I think they were fortunate to get into a job but this day and age you really need to tool yourself up.
T: how do you think studying engineering will influence you in the workplace?
C: my technical knowledge and ability has certainly developed a lot more because if I had stayed working, I wouldn't have encounter some of the things I have seen at university, so it will help me become a better engineer but the downside is just the cost. It all depends what you as an individual wants to get out of your career because if you want to just stay at the lower end you may not need a degree, just a HSC and call it a day.
T: do you want to do further study?
C: well I am currently doing my masters, but PhD, I don't think so. Not at this stage, certainly. In the event someone says here is some money to do it, why not because it's a win win situation. I think it depends what you want to do with your career because if you do a PhD you will be specialised in that one area as well and it's a sort of double edge sword and it sort of restricts you to that area. If you go for a managerial role and they may say you have spent all this time doing this, where do we sort of fit you in. funnily enough I have a good friend who has a PhD in physics I think and she has been working for a company for about 2 years now and she doesn't do anything related to her PhD, she works in the labs. I don't see it appealing, spending another 3 years doing a PhD.
T: how was your undergraduate degree – what made you carry on to do a masters?
C: I thought it was just an easy transition to you know, just get it out the way. You don't have to come back and do it 3-5 years down the line.
T: why did you feel it was beneficial to do a masters?
C: it does from what I have seen over the past couple of years, in certain roles it can be beneficial. One of the modules on the masters course is finance for managers where the knowledge and stuff I have gained from that will certainly be beneficial in the future and for my own personal reason it has helped me understand, like financial reports from companies and so on. So it is you know, when you look at the MEng course, the timescale it not much.
T: do you think having a masters will influence peoples perceptions of you when you do go into the workplace?
C: I can see to a small extent because people will know from colleagues you would work for in the future, they would assume you know certain things, especially if they have not done academia to that level before so they would view you in a different light and they would expect certain things as well.
T: would you rather go into industry than academic?

T: erm I have thought about it erm because my initial thoughts and plans are to get into industry because that's where the money is. Staying in academic, there needs to be something there in terms of financial rewards for me personally to stay there. We will see.
T: money aside which would you prefer?
C: it's a tough call, it depends which company you work for in industry you may not see but in academic there are things you can see what you don't see in industry. It's a tough call but I would have to say industry to sum it up because the potential is there as you may not be stuck in an office doing the 9-5 and travel around different sites and different countries and whatever. That would tip the scale.
T: for you, what does it mean to be an engineer?
C: erm wow, taking a step back, having done by degree I don't feel any different and probably completed by masters, I don't think I will feel any different but the biggest thing for me is I will be following in the family footsteps. I know that sounds a bit cheesy but from my dads point of view he would be proud and then for me also I can know I am in a profession and I can go anywhere in the world and have a good chance of employment. I think its an achievement in that sense.
T: what makes you want to be an engineer?
C: I do like the innovative side, the way you can design something, make something, that pushes the boundaries. Whether you are designing a piece of carbon string that can hold 200kg and that wow factor what draws me. I see it as challenging, its not like other careers that can be mundane and repetitive. That what draws me to become an engineer.
T: I guess you always had an idea of what engineering what, is that what it is for you now?
C: sort of, yes pretty much yes. Unless you will be in a role of where there is a lot of designing and stuff, I sort of had a good idea of what engineering entailed from a young age.
T: what for you is engineering, what does it entail?
C: engineering is all about pushing the boundaries, having a creative mind, being part of a team what delivers solutions whatever the problem is. Whether its from you know, a bottle, to a hip implant, drilling to extract something, delivering solutions to meet our needs. When I say our needs I mean mans needs. It's a feel that there is so many variations to each role and each sector and to say you are restricted, no. you are multi skilled, transferable skills that can apply to so many different aspects and you can use these skills to just manage people or come up with the next best thing.
T: so do you think there is a problem with defining engineering?
C: yes to answer that question. I think in the UK there is definitely a misconception because how can you class a bin man as an engineer but also the guy who comes to fit sky TV. I always knew these as technical roles. There is a clear divide, not only what you need to do

but also what you need to study to achieve that status but also what is involved when you get there so for me if someone says that.
T: what is an engineering for you – what is their role?
C: it is a professional who will set standards who looks at solving solutions and looks at the entire picture. Not only the entire picture but they look for the simplest way to solve the issue, where as a technician would just do whatever they are told. There is a clear divide, I think here in the UK its cloudy. Where as if you go to Germany or the US and if they tell someone you are a professional engineer they will shake your hand.
T: what has your workload been like so far, has it differ to undergraduate level?
C: it is a bit more intense in the sense that erm well for example we have a group project and everyone who is involved in the group project needs to deliver in order for us to get a grade, so if someone doesn't deliver, we wont get a grade on the project so there is a bit of pressure when you have to rely on colleagues or your peers. But when if was Batchelors the dissertation is down to you. The way they structure the semesters for the masters, it's a bit more hectic because you have semester one, so you get some modules and then when its finished you have exams and mid way through that there were exams for finance. But at bachelors there was just exams at the end of the academic year. I mean in that aspect it's a bit more hectic, but on the other side of the coin, because we have finished a few modules in semester one, they are out of the way so there is less to concentrate on and more time for the group project so it is more or less the same. But you sort of from year one, to year four, you get use to a certain structure, exams at the end of the academic year but then in masters to come a switch it up, you are pressed for time to really deliver, not just exams but reports as well.
T: so your undergraduate degree was for 4 years?
C: yes because I went on a placement.
T: how was working in industry, was it what you expected?
C: Yes and no to be honest. No in the sense that, reflecting on it, I think they could have pushed me more but yes they gave me certain things to do, which I knew were part of the role and I managed to do it. So maybe the nature of the company because some of the guys I know had good experiences, some bad.
T: what would you describe the culture of engineering to be like?
C: I think engineers they have cracked it. They know what they want, they ask for A they get A, you don't have to beat around the bush. In other sectors you have to go through a lot of chains. They ask for A, they get A and they are happy. That is something that appeals to be.
T: so what is your typical day at university?

C: for me I do come in 9 till 5 or even after that, some days I might leave a bit earlier. Just depends on classes or what's on the project. there is a lot of deadlines and things involved. If we don't have any lectures one day, we just come in and crack on, if anything needs any stimulations, anything needs any further analysis, we try and do that, any testing, practical testing for the engine, we do that. There is a lot of work with that, we have to liaise with sponsors, try and get more sponsors because we work to a budget so when the moneys gone, its gone. Apart from that, other stuff in university, I wanted to do another language but I don't know if it is our luck or just because we are in the naughty corner but they all clash with our lectures.
T: is your timetable fairly full?
C: this semester we have classes on Tuesdays, Thursdays, Fridays. Mondays and Wednesdays we don't have things scheduled but it doesn't mean we are not working.
T: how is the project working with other people?
C: I found it working with some students extremely challenging, more so than the work environment. Because you go to work and if someone is not doing their job, they get sacked. The manager addresses it, where as in the university that is not the case. Some of the guys you work with, they don't produce anything but they survive you know. I have similar things from year 1 and 2. Some guys are sort of lagging behind but they are still pulling it out but because of the nature of the project, in order for us to get a distinction we have to produce a running vehicle.
T: why do you think the university run those type of projects?
C: I mean I get it and especially for when students have never worked before or worked in a group before. They can see the planning and the challenges involved and so on, so I do see why they want to do it but it has it's drawbacks so. I mean some people, quite a few people would really struggle without that group work because they just rely on colleagues and peers.
T: so when you are working in that group are people good at group work and communicating and things or is it something that's lacking?
C: some people are and some people know. I think it just comes back to the attitude, some people just can be bothered. At this stage, in terms of communication and attitude, you shouldn't have to be dealing with this because your next step it to be in the working environment.
T: do you think engineering is harder than other disciplines?
C: it is probably up there with being like a medical doctor and some disciplines it is probably harder. Lets look at a hip joint, you have to design a hip joint to last, 30 + years. If that isn't design correctly and it fails in someone, there is a lot of repercussions. Apart from losing someone's life maybe. Lets come back to oil and gas or a car, if you don't do a good

job on the breaking system, there will be repercussions, so there is a lot of pressure and I think people take it for granted what engineers actually do. There is a lot of applications and I think you really need to take your hat off to what engineers actually do.
T: what are the lecturers like in engineering?
C: some are very erm open and caring and so on and what to see you succeed. Others are not, I guess they are too busy and like last seminar, we had a module and one guy taught one lecture and other guy come in to do some other lectures and it was over in 10 minutes and it was boldly written on his face that he didn't want to be here. Some are very good at training your mind to be an engineer.
T: do you meet with other students inside or outside university?
C: when everyone can fit in a slot to fit in a drink.
T: how does that help with your studies?
C: well especially with the group work, it helps to bond and gel and you get a bit more insight into them as a person and why they are the way they are and what they are capable of doing. It is relaxing and beneficial to deliver an overall group objective, maybe and I'm assuming all the guys think the same that they want more time for drinks but it is just a busy schedule.
T: what would you say engineering students are like?
C: straight to the point, hard working, determined, embrace challengers, good a problem solving and analytical, effective communicating from someone to senior to a labourer.
T: one thing I have seen is that when engineers communicate it is more on a work level than social, is that something you have seen?
C: from my experience from the past, no. yes they do talk about work and stuff and get into the technical jargon but when they can switch off they can talk about family stuff and vacation. I guess the technical bits, its interests you have in common and for instance if you work at Ferrari you are working there because of the passion. Your initial passion of wanting to work there and of cars so you will always find some common ground and then after that its just like anyone else you know.
T: would you describe yourself as an engineer?
C: its funny because I'm back in school so I'm not in the world of work so I would say no but then yes in a way because I am qualified and I've passed the degree and got a bit of experience but I need to be seized more in the world of work so hopefully a couple of more years.
T: do you do any other activities inside or outside the university linked with engineering?
C: I have joined the IMechE and I am an affiliate member, there are different levels. So according to be partner I also read boring articles to I do try and keep up with what is happening in the oil sector but in terms of societies and things I just don't have the time to

do other related stuff. But I do enjoy reading these articles and discover to see how things are made and I do see stuff what comes in useful and ideas of how you could adapt something. Other than that no nothing else really.
T: would you say you feel as though you belong to the engineering department or that you come and study then go?
C: yes because you have come and spent a lot of time at the uni but I think part of it. I think maybe if it was up to the university and alumni to be more proactive, it would make people feel like more of part of the team. I do feel part of it but only to a small extent.

Appendix 17 – Masters participant: Cale J (Observation)

This was in the engineering design studio. Cale has a 'Team hare' jacket on which has many company names embroider on it.
Cale brings me into the room and says that anyone can use this room, both undergraduate and postgraduate. He shows me to a few students who he knows rather well and I see a few students chatting at the computer desks. There are a section of the computers at the start of the room where there are a few students working along and some working together chatting.
In the middle section of the room is the 'Team Hare' part where all the people from the race car team project are. There section has a few computers in it and it is cordoned off and they have posters all over this section. These are of car designs and the mechanics etc.
Most people is this area are chatting, some are working alone though. Cale introduces me to them.
After this there are a few more computers at the bottom of the room and then meetings tables.
He takes me to the other side of the room where there is a section of comfy chairs and then the 'Hudrail' team. He says not many people want to be part of this team because the lecturers don't give you much time from this department. These don't have as many posters, only 1 or 2. I say can you choose which project you are a part of and he says yes you put your choices down in order. He then shows me to people part of the Drone project sat on the comfy chairs as they are waiting for a meeting. Cale says where are all your team mates and he says probable on lunch. Cale says what about the undergraduates, Joshua says I'm not sure but it would be an idea for them to be here as they do most of the work and laughs. He says would it be ok for Tianna to watch your meeting, he says yes sure and I sit down and wait for everyone else to arrive.
I ask what the meeting is about and he says a personal development module, they have a group project assignment to do for it.
The students come and it is 6 males, they all introduce themselves to me and ask me what I am doing, I explain I am looking at the way students interact etc and one boy says all we do is bully each other. 'old boys club'
They start discussing the project
One man has an iPad and he has wrote the description down of what the project is. They start discussing what the project is and negotiating it between themselves in their own words rather than the more formal way of describing what is expected of them like in the document given by lecturers. The project is to design a new product.

One man has notebook out, he starts discussing ideas of new produces they could develop. Starts making jokes about what they could do.
Another man who keeps chatting says I think we should go way and do research and look into this more. Then we should come back in 5 days with some ideas.
Other man says we need to narrow it down and think specific before we do that. We need a specific area of engineering like diabetes. Another man says yes biomedical would be good. The previous man who came up with this idea gives some ideas of products.
The man with the iPad says the idea is we need to keep it simple, we are not manufacturing it, just designing it.
One man is chatting and making jokes but not coming up with ideas, Joshua not spoken.
The man who said lets go away and meet back up in 5 days gets up and says he is going because he knows what he is doing. They negotiate their next meeting to discuss the ideas.
The man with the iPad says Friday is ok for me but when we get a plan we need to find some proper time to work together we can't keep rushing off. They agree and man goes and shakes everyone's hand.
Once the meeting has finished they asked what I had been writing down and I tell them and they invite me to their next meeting, I accept. I ask how come some of them have team tops on and some don't, one boy says because they have just been ordered and they are too big. I say how come they have to wear tops and they say it's something the IMechE make them do.
Just after the meeting has finished Cale comes up to me and says his team are just about to have a meeting if I want to observe it. I say its ok because I am just speaking with Joshua. We arrange to do an interview.
Cale comes back up to me after about 20 minutes and we walk back to the team hare area. He says hi to a lot of people walking past. In many ways this is a completely different environment to the other room. Although not all students are chatting, the environment is a lot more friendly to be in. as I leave the room all the hare team are stood around chatting after the meeting- I wonder if this is about work?

Appendix 18 – Masters participant: George W

T: when did you decide you wanted to study engineer?
G: only probably in my final year of college. Erm after taking my options is of landed itself straight into engineering. I always had an interest in it but the college structure at AS and A2 does not lend itself to go straight into engineering. I mean Greenhead in a big college round here which specialises in getting people into university and they don't do anything related to engineering, the closest is product design and art. It is not the same.
T: is maths, physics, taking things apart, wondering how things worked something you have always been interested in?
G: yes I think if any engineer say no to that would be lying. I think engineers are naturally quite inquisitive and want to understand fundamentally how something works and that's what you see in every engineer, that I know anyway. You do get some that are just here for the degree and that was more evident in first, second and third year and then they leave and don't go into engineering and some of them do it because they are very academic in terms of maths and physics and its something they can do without doing maths or physics, it is a good subject which incorporates concepts of both but most people, especially at masters level at people that want to be engineers. You wouldn't go and study postgraduate at something where you didn't want to progress in that area.
T: once you knew what an engineer was, could you say you saw yourself doing that?
G: to be honest there is such a broad meaning of what an engineer is and especially if you take into account lecturers or what you would see as engineers and then you get someone who writes washing machine engineer on their van. They define engineers as someone who fixes things. They could argue they are but I would say that are not.
T: that is one of my questions actually, how would you describe an engineer?
G: I think modern times, an engineer is someone has the specific qualifications such as a degree in engineering. There is so much we incorporate in our degree that you wont ever learn just by fixing the same appliance like a washing machine or a boiler. I am not trying to devalue what they do but that is what I could class as an engineer.
T: what persuaded you to study engineer as oppose to apprenticeships or getting a job in the field?
G: in terms of university or apprenticeship. While applying for university I was also applying for apprenticeships alongside but it soon become clear the level I was capable of was higher than an apprentice engineer. Apprentice engineer works very well if you want to become a machinists jobs but if you are capable of getting a degree you should. It will allow you to go further in your career.
T: for what reason do you need the degree?

G: you need the degree not to say you have it but you need it to understand some of the concepts and basic knowledge to apply that in numerous situations where as you wouldn't get that if you did an apprenticeship. You might get home to operate machinery and CNC programs but you don't get the fundamental understanding which is what the degree tries to teach you.
T: how do you think having that degree will influence you when you go into industry?
G: well primarily a lot of jobs now will specify you need to have a degree. So you wont even get a look in if you don't have one. So ultimately before you even start looking at the benefits, having a degree allows you to look at more jobs and I am not saying a little bit more but a lot more. Companies now wont even interview you if you don't have a degree, it doesn't matter if the degree is related to the job you are going for. If you don't have a degree now you are going to struggle and that's just my opinion because everybody. There is a lot of people and there is a lot of competition for jobs. A lot of people have degrees now so that sets the standard higher than what it did 10 years ago. A key aim of mine is to become chartered, the masters enables you from the academic side, the bachelors doesn't you need to back it up with further education. You cant become chartered with the IMechE if you don't have the degree, you need the degree and masters or you are technically incorporated or have a different type of chartership.
T: what do you think there will perceptions of you from having that degree, will there be expectations that should be able to do this this and this?
G: yes there is obviously the expectation that we can apply ourselves and do things off the back off a conversation, can you do that. But I don't think that is the case because engineering is so vast that even if you take our course here and one at another university and they are both accredited but they will both focus on different things. So it isn't because you have a masters you will be able to do anything in engineering. The way I have come through the degree I am better at finite element analysis and not fluid dynamics and two people may have done the same course but better at different things. I couldn't be able to answer questions of CFD and my colleagues wouldn't be able to answer on CFA.
T: how come you chose to do the masters?
G: well as I said the chartership elements, so the masters does fulfil all the academic requirements without further study so that does make it a lot easier progressing forward. It was only an extra year as it was part of an integrated course and it was the natural progression at the time.
T: so in terms of the masters, in what ways has the studying been different?
G: I think you are left to your own devices a little more at masters level. The content is harder and the main project, our team HARE project is run very differently to anything before. You are given responsibility and the budget to do with as ever you would wish within

the bounds of reason expenditure. Where as previous years you are a lot more reliant on lecturers and staff. There is a certain element of that on your regular modules as masters student but the biggest part of the masters is the project and you can do as you wish. You are working effectively in a commercial team environment.
T: do you think the lecturers treat you differently because you are doing a masters?
G: no I haven't experienced any differences in how they teach. There isn't a difference between undergrad and masters to be honest.
T: what do you think completing the masters will provide you with, aside from the knowledge?
G: erm the biggest one would be team hare. The skills you gain from the regular modules and probably not a considerable extension to what you did at bachelors level. The team hare project obviously teachers you, not so much teachers you but gets you use to a team environment, a commercial environment. I am not just saying doing a little bit of coursework together like a regular module because it isn't that. You know we spend in excess of 30 thousand pound budget and then double that in sponsors and various bits. It is a team structure and a team presentation but you are dealing with real money, real people, real companies which is what you will be dealing with in industry. So it is the application of what you have learn prior and applying it in the real world while you are still at uni.
T: I am guessing you want a career in engineering, what type of career are you thinking?
G: I couldn't tell you. Its so vast and as I have done mechanical engineering it is the broadest discipline erm there is lots of engineering courses such as automotive which lends itself to cars retrospectively but automotive is broad and it can enable me to go down a number of paths. My job application has been varied, I mean my dissertation subject, I applied for one in quality engineering, all different routes.
T: I guess it is so broad and then it is difficult to cover all the different fields in engineering. In psychology we cover all the different fields we could potentially go into.
G: yes that wouldn't be possible in engineering in a three year course wouldn't be long enough to do that. There are research at this university that specialise in areas of engineering that haven't even been mentioned. There you go.
T: is anyone in your family into engineering or higher education?
G: nope
T: what were their perceptions when you said you wanted to do that?
G: erm they were proud as it is something they had never done themselves and I guess they feel its limited them in a way and they would probably go back and do it again if they could. Going to university is something you should do even if you don't like it. You cant knock anything until you try it, but I know so many people who are anti university and they say I don't need to go to that, its pointless. Well you don't know because you've not been

and you've not tried it. You might not want a career in it but you have been there and you will always gain something from it, you will not waste three years of your life
T: completing undergraduate, do you think it prepared you for your masters?
G: yes because it is an integrated course. There are certain modules that were covered heavy in the third year, progressing from first year so you were almost introduced to basic concepts and mathematics in the first year and in second year you build on that then the fourth year or masters year you do the stuff in industry that is still unknown. Like doing analysis before Christmas on systems you were taught at bachelors year that this is the system and then that is not actually how it works. You know and even at masters level there is certain bits you hold back on because it is masters level and it is only PhD level you will learn that. It does prepare you some what to go, particularly on the integrated course but like I said not everyone does it but the bachelors is a good qualification to leave here with.
T: what has your workload been like throughout your undergraduate degree and how does it compare to your masters?
G: masters is a lot lot higher. The dissertation is obviously the largest project but like I said your left to your own devices and you can progress that at a rate you are comfortable with within the reason of personal deadlines and university deadlines. But the workload at masters has been a lot higher, just the amount of time you can spend on it. The modules are laid out differently whereby previously you would have a whole year to do a module where as masters is different, you have two or three modules to do before Christmas and they finish at Christmas. I don't know if that's me not being use to it or the workload being higher but we have had to do a lot of work this year. I feel like I have done a lot more work this year, even though I haven't done a dissertation this year and I don't have to do one.
T: what about the amount you are timetables in comparison to the amount you are actually in university?
G: you have a lot more lecture time and a lot more contact time in bachelors year. In masters year I think I have something like 6-8 contact hours a week but I will be in 30-40 hours a week at uni. Whereas even though you had a lot of contact time in bachelors, you didn't spend 40 hours a week at uni. It was sufficient to go home and work on it there or do bits and bobs at uni. But at masters level we have used a lot of software you cant get at home and that automatically increases the amount of time you have to work here.
T: how much work would you in terms of putting work in in comparison to your undergraduate course outside the project. Do you have to do a lot of independent work?
G: there should be yes but honestly time. You could easily spend every working moment doing it but you know what happens then is you get stressed and you try to cover all bases of everything you doing but if you go into detail on everything you will not be able to cover

it all so yes there are lots of books I should have read but you don't have time. Some lecturers puts reading lists up what are 20-30 books long and I can vouch for everyone, nobody will read them all.
T: why do you think engineering has a fuller timetable than other disciplines?
G: there is lots to cover. Lots to cover and lots of complex understanding that you only really get from the lectures. You can very easily go on google a certain equation and concept you need but it wont be in the format you need. You get a lot of contact time because the lecturers are the guys and girls you want to see about what you are studying and I think they realise that, you need the time with the proper people rather than learning it on your own. Its not like a degree in journalism where you can go and read about journalism, a cut and dried affair. It is yes a right and wrong subject, like English for example, there is no right or wrong answer, if you can back your point up with evidence or whatever then it is ok. In engineering it is not the case, you need to get it right, I think it is just a reflection of that, that ideology that the reason why you are in so much compared to other subjects.
T: would you say it is harder than other disciplines?
G: erm well firstly every subject has its only challenges and one person may not be able to swap and do the other but in terms of perception and in terms on my opinion in comparison to English or art or drama subjects.
T: I guess the perception of maths and physics being hard puts people off
G: everyone has watched the big bang theory and one of their characters on there is a mechanical engineer and documentaries on things engineers has done will influence the perception that it is hard and I will not sit here and say it isn't hard because it is. You will read the news and people are crying out for engineers and nurses and all these jobs people perceive as difficult. I don't think I have read a new article what says we need more journalists or we need more artists and I think a fundamental part of this is, I know a lot of people with drama degrees who have not pursued drama in anyway, they work in a pub, where I work part time just while I am studying. I think what it boils down to and for me to do what I am doing I need to degree or I wouldn't get an interview at half the companies I want to work for but learndo de caprio who has won numerous awards doesn't have a drama degree and I think you can be naturally good at something like art and the performing arts and you don't need to back it up with any academic study and you just take it for the skill level you have. I think that rarely happens in engineering, there are barely any self-taught engineers, not in the modern era. You look at any famous engineers that have built or designed or changed someone's life in anyway shape or form, they self-taught but it doesn't happen anymore.
T: what is the structure of modules you have?

G: it is varied, usually does follow the process of lecture and then tutorial. You have a lecture with someone stood at the front talking to you then you have a practical or tutorial where you get involved. You are either sat listening or up involved and doing. The application is very strong at Huddersfield and that is why we have so many tutorials.
T: are the assessments based around applying the knowledge then?
G: we haven't had a single piece of coursework which isn't based around something we have learnt. I have done two or three exams for modules with the structure being different and it is very much applying the system rather than working through something and it is very much in the real world what would you do. How would you solve this issue. Last year it was very much calculating through and you were basic a calculator and you would just follow through the set procedure you have learnt and you can do that without necessarily understanding something fully. In terms of coursework or assignments. The application is key. I learn more from assignments that I do from lectures. Its applying something you have seen or heard in the lecture but the coursework forces you to read into the subject more. So yes it is applied
T: in what ways would you demonstrate you learn engineering?
G: by doing. You can sit in tons and tons of lectures and not take anything in because ultimately that is coming back to other fundamental way that engineers are. we along with many people don't learn by sitting in a classroom environment, we learn by taking things apart and putting them back together. That's probably another reason why they focus heavily on tutorials, I think the classic lecture scenario suits academic people and although people will probably perceive engineers to be academic, we have a good balance between academic performance and real world common sense and application. I know tons of academics and they are really stupid people at times and I know a lot of non academics who have tons and tons of common sense and I think, well I do and a lot of my friends do and a lot of people in the design studio have that good balance between the two.
T: do you think that's something you learn or something you have?
G: you cant teach common sense. You either have it or you don't
T: that balance, is it something engineers have, can you learn to have that?
G: you can always learn to weigh one scenario up against the other and that's obviously a very big part of engineering in numerous applications but just having the common sense to carry out day to day activities, that is something which may come natural to an engineer but other people don't care. That's just the difference in how people are made up
T: do you meet with other engineering students outside university?
G: yes you obviously have your friendship groups, there are some people I don't socialise with outside university. I mean there are some people like Cale for example who is marries with kids so I have not seen him once outside university. But people a similar age to me

who I see a lot. There is some social side but not much compared to course where you do have less contact time and less work to do in general and you can go out and socialise on a week night. Student nights in Huddersfield for example, I don't think I have been out once because I just don't have time. Because you have a big lecture in the morning which if you are half asleep for you will struggle.
T: would you say the friendships you do have are on a work level or personal level?
G: it depends on who it is. There is obviously people I would discuss things outside of work
T: what would you describe engineer students to be like? Obviously there is a view in society
G: I would say we are quite accurate as you what they are viewed as. Quite introvert and socially unaware. I mean there are people I can think of which fit the mould better than I do and I think we all fit that stereotype in some way because we are not extroverts like you would classically categorise a drama student as. We are just too different. I think more or less every engineering student I know demonstrates some way of being that way inclined.
T: would you describe yourself as an engineer?
G: yes
T: what would you say makes you be able to describe yourself as an engineer?
G: the way I think, the way I act and the qualifications I have got from doing that.
T: do you think the way you think and the way you act is something you have always had or something you have developed?
G: I think it can be a bit of both. If you think of a child as a blank piece of paper and obviously they will grow up to have certain natural attributes like wanting to fundamentally understand something or wanting to fundamentally colour something in. but I think the application and the study you do at university or college or you go through GCSE and obviously that tailors you into what you want and brings it out of you more than anything. Your surroundings do play a massive part but naturally you are more inclined to a particular path. There are a lot of people who don't know what they want to do and perhaps that is because in their education they have not been enticed by something enough or they have not found their natural interest.
T: do you do anything else linked in with engineering like societies, linked in profiles?
G: erm not really. Most of the time spent at uni and having a part time job pretty much fills my week so getting out on my bike on a Sunday is the most closely linked thing. If you break something and then you fix it again so it is engineering related. Even engineering activities there is not so much for them to say you are running it full time and doing a project full time, it is the last thing you want to think about in your spare time, I just want to relax and unwind because everyone is human at the end of the day. I don't live to work.
T: how important would you say engineering is?

G: I would say it is one of the most important practices you can state. If it is not natural, its made and if its made it is designed and engineered. So everything we rely on that isn't a tree or something natural has got something to do with engineers, everywhere. Its like your phone, how much engineering has gone into that. The paper, how is it manufactured, how have we got it to be paper. The room we are sitting in, the chairs we are sat on, its all designed somewhere and manufactured by engineers because without engineers, nature hasn't come up with that itself. Even doctors, they operate with the tools engineers design and make for them. In instances such as hip replacements, engineers and doctors are equally important. There are a lot of engineering that goes into joint replacements in terms of precision manufacture, the material choice, testing of material, they can analyse joints to see how they have faired within the body. It is that research what is not done by doctors because they wouldn't have a clue what it is made out of. They know how to fit them which engineers would have no clue what to do. But ultimately they get that hip replacement on the day and then have no clue to the background and millions of pounds spent in an area like that and they are unaware. The education system is just not geared up for engineering in anyway and it is such a big failing on the governments part. I mean if you look at any recent studies, the two main areas where we are lacking is nursing and engineering so I cant understand why on earth the education system isn't altered to suit the nation. I cant understand why there isn't a degree, it is so broad and so technical and so important and the engineering degree at university is the first focused course unless you go down the BTEC route which I have seen from the people at uni doesn't prepare you enough because it is an academic subject and so requires you to have more of an understanding of maths and physics. One of my best friends, he has come from the BTEC route and he struggles with the concepts and he is reliant on me and james for example to teach him some of the higher level maths things. James is a lot more academic and he knows a lot more about maths, he doesn't know much about the practical side of engineering but josh does. Josh has done practical side and that what he has come from but I think I sit in the middle of them both. But that is just the spectrum of people on our course, different background.
T: I have read a lot of papers which describe engineering to be objective, competitive, impersonal, masculine. Are they all things you would describe it to be?
G: it is very masculine, there are hardly any girls what do it. there are the odd one or two. I think it is dominated by men and I think that's what puts women off. It is very competitive although I say that the UK need a lot of engineers, the jobs are highly subscribed for and you need to fight for the job you want. I am not so sure mean about impersonal, I guess the answer is right or wrong. Ultimately if you are designing a component to me made it will either be made or it wont. If you don't design it properly or it wont be made. It is a black

and white subject if you like. But there are areas still not understood so you can get away with not being 100% right.
T: aside from the knowledge base what other skills would you say you need to be an engineer? Team work, communication, analytical things like that.
G: all of them what you have mentioned. I think your ability to learn quick and apply yourself, especially if you are dealing with new software and you have to have a rough knowledge of how things work and an inquisitive nature of how does it work and how can I make it better. They are obviously key skills that engineers must have. Either taught or natural because you can be taught those things. It is only a drop in the ocean, I would say there are lot of others but it is hard to just sit near and reel them off, in a scenario I would be able to go through them
T: in terms of being competitive but also having to work in a team, how does it work?
G: for example at uni, obviously you are sitting exams on your own so it is an individual thing and you do get a bit of competitiveness in the grades you get but at the end of the day you all help each other out. You do help each other. There are so many areas where I might be slightly more knowledge than someone else and effectively you just go to them and ask if they can help you out with it and they will and next week you might be able to help them. It is more competitive so much that you would actively not help someone out or go against trying to reduce their potential or their grade, that is not who we are.
T: have you seen people saying like I have the best idea, we are going with this blah blah?
G: yes but ultimately what someone says is the best idea may not be the best. For an idea to run you can just say it is the best idea, you have to convince them and show them proof and justify it.
T: what happens if someone's idea turns out to be wrong? Is it embarrassing?
G: it is only embarrassing if you made a big blunder that you shouldn't have. Arguably a mistake a first year would have made but if someone beats your idea no. you can have a laugh and a joke about what people have done, you have heard me do it but ultimately the jokes we make don't matter, we can change it, we can fix it. you have to have a sense of humour to do it, if you were too uptight and stressed out you would just die early I think.
T: in terms of the IMechE and the things they implement. How has that influenced your journey to becoming an engineer?
G: I haven't really focused on the IMechE chatership documents or progress documents but they obviously set out a set of targets and skills they want you to show. There are a set of things you have to follow and even if you don't agree with them you have to do it to become affiliated. There are other institutions out there so you can choose other ones. Everyone module is almost vetted by the IMechE and it meets that requirements to say yes

we will accredit this degree so we will recognise it if you want to become chartered. All the educational criteria of the IMechE is already passed.

Appendix 19 – Masters participant: Jake S

T: when did you decide you wanted to study engineering?
J: erm when I did, erm you know in year 10 in high school I did a placement for 2 weeks and I did it at a joiners firm and I enjoyed it but I realised I didn't want to do it long terms so I went about finding something else I wanted to do and I was good at maths and good at physics and I loved motor sport so this channel I went down was the obvious route for me so.
T: what kind of decisions did you make in your education to enable you to study engineering?
J: erm well by that point I had already picked my GCSE and then I picked my a-levels based on what I wanted to do at university. So the maths and the physics that are a requirement and I did another science just as a filler subject and I did business studies which has helped with the business related modules we do. Erm that's the changed I made at a-level. I didn't do particularly well at my a-levels but whilst I was doing my a-levels I got some practical experience because I worked for a couple of races teams so despite not getting the results I wanted, my practical experience helped get me on the course.
T: did you do that practical experience because you thought it was something what would help you get on the course or because it was something you enjoyed doing?
J: something I enjoyed doing. I mean I raced motorbikes myself for a few years and when I stopped doing that I decided to help a friend stock car racing team and he helped me mechanic on his team and that's what I enjoyed spending my weekends and evenings doing. For enjoyment and it's a happy coincidence that it helped me get on the course.
T: are maths and physics something you have always been good at?
J: yes I've always been good at maths and physics, they have always been my best grades at school and like I said I messed my a-levels up but that was my doing but I got into uni anyways and I've worked hard since been here and got other grades ever since. So yes maths and physics are my strong points, I think I excel at something I can run through some equations or whatever and have a definitive answer at the end and I can see if I am right or wrong rather than someone's opinion like in English or like writing essays and that.
T: did you always kind of know you wanted to be an engineer after you kind of found out what an engineer was?
J: yes I've always followed motorsport, its something I share with my dad and it's like mine and my dads thing. Erm but then I always sort of you know you dream about being a formula one driver or a motorbike driver and then when you realise that's not going to happen so the next best thing is to be one of the engineers you know, part of the team. Erm and so working on the bikes and on the cars is what I wanted to go for so yes I didn't

really know what the engineers did but like I said when I went on my placement year as a joiner and I didn't want to do that as a career and I looked at other opportunities that's when I narrowed my choices. I narrowed it down on how do I get to this job and I focused my studies to get to a particular type of job rather than erm just generically looking at something I might be good at. I took my hobbies and what I'm good at and put them together.

T: did anyone kind of persuade you to that?

J: no my family were persisted that I went for a degree that had strong career prospects at the end of it. I mean there are plenty of jobs in engineering or there was a few years ago anyway. Erm so they were happy for me to that as a career because there would be the prospect of a job at the end of it. Yes it limits in terms of the top end in the sort of racing I want to do but other than that teachers never pushed me towards it, they left us with free choices and I never felt compelled to follow what my friends were doing so yes I suppose it was free choice.

T: how would you describe engineering?

J: erm I would say it's the study of understanding how things work and how things fit together and how that can be designed and manufactured. I would say you take ideas that people have like scientists and you make them reality. You make them become something there in front of you. You take an idea and you make it manufactural and as good as it can be. Optimising things. That's what a lot of engineering is. Applying the maths and the physics to make an idea real. That's what I would say.

T: what persuaded you to study engineering rather than an apprenticeship or just getting a job and working your way up?

J: I had an interview about this a while ago with the IMechE because they are coming up with schemes to push people to study. When I was deciding what I wanted to do and going through a-levels I always knew I wanted to go onto do a-levels and that's when I decided to go onto uni and I think uni was the natural progression because it was easy. You had to do an easy application, you get the results you go onto uni. Whereas apprenticeships, you have to go out and find the apprenticeship, you had to apply and do interviews and that kind of and you had to have a lot of extra input and as I say at the time I wasn't invested in doing a lot of work but my friend who is very like me and very good at maths and physics and he likes his engineering, he went the oppose way and he put the effort in and he got an apprenticeship and I mean now after 4 years he has finished his apprenticeship and got a full time job in engineering.

T: do you think there are advantages of studying?

J: erm I think there are advnatges to moving away. I think university makes you grow up very quickly erm in that aspect but he also had to move away as well. They offer you very

different things. I would say a degree offers you the ability to do higher engineering, I will be able to do things he wont be able to do because we have been taught how to do it. He has the more physical aspect of it, he has worked hands on, he has had that interaction with people in industry and from my placement year I found that was key thing, when you speak to people and how you interact with people who have been at a company for 50 years that don't like someone that is 20 years old coming in and saying they are doing something wrong. I struggled with that a lot. Which you cant really teach at uni but you can from a placement year but he never really struggled with that. With an apprenticeship you come in from the bottom and the people who are training you are the people who have been there for 50 years but there is some sort of expectancy from the managers that you will go in and tell them if they are doing their job wrong.

T: do you think having a degree or masters would influence expectations or perceptions of you?

J: erm if I go off my own experience from going on my placement year at Vauxhall I think so yes. They expect you to come in, especially my manager. He expected me to come in with a pair of fresh eyes and he didn't want to tell me much information about that I was doing so I could look at something and give me own perspective on it but then in the same way it puts pressure on you to come up with something nobody has done before, I would say there is pressure if you have a degree, you are expected to do more than what an apprentice does. I know the apprentices at Vauxhall spent a lot of time not sitting around but then were only there to do something when something went wrong, they were only like maintenance. Where as an engineer I would expect to be doing projects and making things and making things better before they go wrong. That's the big different you are expected to improve what is already there where as an apprentice is expected to fix and maintain what is already there.

T: what type of career are you wanting?

J: motorsport is where I would love to end up. I'm more of a bike fan than a car fan so that is where I would like to lead it but it depends on the nationality of the industry because a lot of motorbike racing is European, a lot are based in foreign counties, where as formula one, a lot is based in the UK. Teams like Mercedes employ a lot of graduates, yes I would love to. It is very high end you are competing with people from Oxbridge and other high end universities like that but failing that I would like to go into the luxury car industry. So I worked and Vauxhall and that is very much like a budget car company. I mean I had a project I was working on what would have fixed a load of problems for them but because it cost 30 thousand pound they pulled the funding for it, they wouldn't do it. With them being a budget company so yes I would like to go into high end manufacturing because it's a lot

more prestigious and there is a lot more money there. Not for myself but more money on the projects, there is a lot more interesting work to do.
T: did you feel after you finished your undergraduate degree that you were prepared for your masters?
J: well initially I looked at my masters and I looked at the modules and I didn't think I would be able to do it. For a long time, even up to the end of second year and throughout placement, you don't really get graded for placement but I was bordering a 2:1 and 1:1. I came back in final year and put a lot more effort in than I did before and even though I knew my grades were on the up, you don't know what you will end up with until results day. I ended up getting a really good grades and because I was originally on the bachelors degree and I changed to the MEng, I was looking at the modules and they were advanced versions of what I was doing now and I was thinking I am struggling a little now, I don't really want to push my luck and go for it but then me and my friend are going travelling when we finish and he is doing a masters so I had a year to fill and I would have had to find something to do, to get a job or maybe another industrial placement and my mum just said do it, it's hard to go back if you want to do it later on so she pushed me into it and then this year it has gone great so.
T: are you glad you did your masters then?
J: yes definitely because if I had left last year I would have left considerably worse off than I am not, even half way through. Because even the practical experience in the garage from doing the car, and the project management and speaking to people and managing a project is invaluable and I love that I have got that experience before going into industry because I didn't have it last year so I definitely think its worth doing. I definitely made the right choice, so yes I have no complains.
T: so what had your workload been like?
J: module wise, I have 5 modules and a group project. Modules wise it has been manageable, I would say no more stressful than a bachelors. No problems there, coursework has been getting in on time. But with us having a large team this year for the group project, the expectation is that we are going to do great things and a lot of people on the team aren't putting the effort in that they should. I think the difficulty with this year and how intense it has been in because we have been having to pull people up. Erm as one of the 5 managers of the team, I am expected to be there, doing the work and collecting everything and giving people tasks to do but I don't dislike doing it, I enjoy doing it so. I don't dislike having that. Its been tough and I don't think it will get any easier either but I have found it hard to get someone to do a bit of work they are not invested in getting a grade at the end of it very difficult. As a masters year student it is difficult to get people to do little bits of work they are not invested in but will only get an overall grade at the end is

difficult and for 4th years, they are graded in their little part and if you try to get them to do a little bit outside this, they are not interested.
T: what about how many hours you spend at university? Do you treat it as a job or only come in when you need to?
J: I didn't last year, erm I came in when I needed to come in and when I had assignments to do and things like that. I did spend a lot of time last year at uni but this year I do treat it like a job. Im in at 9 and don't leave rarely any earlier than 5. I mean you have lectures that take time out of that schedules but I am normally in the design studio. I treat the group project at as 9 to 5 job and I do assignments in the evening. So what I will do it go home have some tea and work later on my assignments in the evening.
T: so I know at undergraduate level the timetable is quite full, a lot fuller than other disciplines. Why do you think that is?
J: erm we do a lot of practical work, labs take up a lot of work. Its all well and good being taught how to do something but you want to see it being done in practice. We probably had a lab every week and they are about 3 hours long. And then I guess because there is a practical side to every element we do we also have tutorials. We are taught something and then going into a tutorial and doing it ourselves is helpful. I mean we get to do the maths, the physics with the tutor there watching you do it. There are many levels to learning engineering, you need to be taught it, have a go yourself and also see it in practice so I think that's why we are in a lot and we have a busy timetable.
T: do you think engineering is harder than other disciplines?
J: I would consider it hard for anyone who isn't good at maths and physics. I know its not everyone's forte. It is tricky if you don't have those skills. I know some people who have those skills but not at the top end and they struggle a lot with our course. We have a few business modules, maybe one every year, like project management and things like that but most of the modules are maths and physics and if you are not good at those things you are going to struggle. So yes I think it is very difficult compared to a lot of degrees, you couldn't just flunk yourself through it, you couldn't just sign up willy nilly and hope for the best. Erm I am not saying you can do that with any degree but.
T: what would you say lecturers are like in engineering?
J: erm I think there is a big different between. There are two sorts of lecturers, those that have been in industry and those that have just been research all their life because the lecturers that have been in industry and done things, they can give you practical examples of when they have done it. And they've lived and that sort of time of engineering they have done and researchers just tend to give you the data, just the information. They don't really relate it to a practical use or something they have done. I don't think in terms of teaching style there is that much difference. I have not complains with any of my lecturers this year

erm and its not easy to teach because it's such a broad range and there is so much to encapsulate inside each module. It is difficult to teach and it has to be taught at a fast and not everyone you know. You have people putting your hands up because they don't understand and if you have to wide back 5 minutes its hard to make that time up. Generally speaking the standard of lecturing Is very high.
T: what about assessments – how have they been? Because I know you have quite a few of those?
J: yes erm as I mentioned early we have a lot of practical sessions so you will go and do something and through doing that activity you might get some data like from stress and strain or something like that and you will get some data from bending that pipe, you will take the data, analyse it and write a report on what you have done. And that was what it was a lot of in first and second year. Analysing the results and writing a report about it. The final years of bachelors and masters year tends to be, we will teach you how to use a piece of software and then use this software to optimize something or make something better, do a particular piece of analysis and then write a report. In masters year they don't want the waffle that's comes with the first and second year, they want something what you would give to your manager in industry and that was a step up. Even though you are coming back to industry it was a step up and it was like right these have got harder and the level of detail and the specification that they need as the degree goes on, they get harder. They don't just want to know what the result is, they want to know why it occurred and what your theory is behind in and what you could have done differently next time. It just got progressively harder and I am fortunate, at least I think I am because I can write very well. I can communicate my ideas down on paper very well and I think that is something a lot of engineers struggle with. Because we are good at maths and physics people struggle with the wording and the context of it but luckily I have a decent grasp of both.
T: when you are writing your reports and stuff do you include personal thoughts, feelings opinions or is it fairly factual and objective?
J: yes I think it is fairly factual and objective. I think we are kind of discouraged from putting our personal thoughts into the reports erm you tend to avoid generic opinions and go with the industry consensus on a subject. You can put your own conclusions and endings into reports but most of the time its these are the facts, this is what they show, this is why. If I was going to do it again, my personal opinion would be to do it this way but it is more facts and figures. Yes the analysis and results speak for itself, you have to explain it to someone who hasn't done it before.
T: do you meet with other students inside or outside university?
J: yes well we do because the reports we do aren't individual, we all get the same report. If you have a group of friends like in the team, we all bounce off each other. If you don't know

something, rather than spending hours and hours looking up or research how to do something, if they can show you within minutes and then you know that, you don't have to go away and research it. And likewise I know stuff that they don't know. We often meet up in the design studio, that design studio is a great facility. So we do often meet up there, not so much now. It was better in first, second and third year and we had times between lecturers and we didn't have that time to fill with the formula student stuff. Because now if I have a three hour break it's like three hours of formula student stuff to do but then we would sit down and have a chat with my mates or grab some dinner. And outside of uni we meet up all the time, me and Jake go racing together and we go to the pub on a weekend and stuff like that. Yes I do meet up and I have got some good friends from being on the course.

T: what would you describe engineering students to be like?

J: I think there is a broad range of what engineering students to be like to be honest. Erm I'm not sure, I think we are very opinionated as a bunch. We all have an opinion of this is right and we like that opinion to be heard. I wouldn't say difficult to work with but it can be just clashing opinions of a subject and it can look like we are being arguing with each other but you often come out with a better result like a combination of them both. I think my only experience of being in an engineering based society and a racing based society is that they don't tend to be that socially active. They don't go out on many nights out, I did but it was hard to get a group of them together.

T: why do you think that is?

J: I don't know. I think there was always a combination of reasons, some are just socially awkward and they didn't go out and so people didn't have the money. Some of us were up for it, 5 and 6 were often up for it. I wouldn't say they were socially awkward, they just weren't keen on going out.

T: do you think there is a problem with defining engineering?

J: yes and it is one thing that does irritate me so when anyone that does a job they haven't done a degree in engineering. Like a plumber who just sticks engineering on his van, where as I have studied 5 years to be an engineer and they have just put the title on for them. It would be hard to change and I think the effects it has on the public, when people say I am an engineer they just think oh they are a mechanic and that's the difference. If I said oh I'm an engineer they wouldn't say oh you have studied and you have got a degree, they would just think I had worked in a garage for 5 years and I think that's why it's frustrating. Your effort isn't recognised but it is difficult to change, you can't stop people renaming the company or the work they do but I can't think of any other discipline where they have that problem.

T: would you describe yourself to be an engineer?

J: yes erm yes I would now yes.
T: what is it what enables you to call yourself an engineer?
J: I would say firstly having experience in industry, an engineering job. So when I came back I was like yes I've done some engineering, I can start considering myself but I was still consider myself to be training and when I finished by bachelors I was like right I have finished a normal degree, I've worked in industry. I'm an engineer now. At the end of last year I would defiantly say I have come full circle and that I'm an engineer. Erm I don think this year will add anything to that to be honest, I would have still considered myself to be an engineer even if I hadn't have done my masters but I would consider myself to be a better engineer now but not more of an engineer than if I had left last year. But yes having experience of an engineering job and an engineering degree but someone who has also done an apprenticeship I would also consider to be an engineer, just something where you have had a degree of training in engineering works, engineering discipline you know.
T: do you do any other activities that are linked to engineering, inside or outside of the university?
J: yes well I'm a member of a racing society at the university. I actually stopped the other things I was doing like the stock car and the bike racing because I came to uni and they were both in Leeds so I stopped them and when I came to uni I picked up the karting but it's not necessarily you go and you do engineering but you know you get in a kart and you need to know how the engineer works and stuff like that but other than that the team takes up most of my time. I would consider the team and part hobby, part uni as well. I enjoy going in the garage and figuring out how things work and fixing it if it needs fixing. So yes, I've not been part of the engineering society but it only started out last year and I didn't really have time.
T: erm so what type of things would you say you need to learn to become an engineer?
J: you need to be able to know how to apply maths and physics to things. So take a scenario and know how something is going to work out and also practical experience. How to make something, how you are going to create something, how it is going to come to life. So you need a good understanding of theory but you also need to know will that theory translate into something possible and they are two different things and you are trained more for one of the apprenticeship and more for one on the degree and I think the degree needs to come closer to the apprenticeship. You need more practical experience. I know at the start of this year I didn't have much practical experience but from working hands on in the garage with the lab technicians I know a damn sight more than I did 6 months ago. I call it workshop appreciation, how things in a workshop run and what tools do the job and even down to how cutting metal correctly and putting a screw through it. If you want to do

any job you need to know how to do the aerodynamics packs so a combination between the two.
T: how important do you think engineering is?
J: I would say without engineers things would be a lot different. Everything you see has been engineers pretty much. Cars, the phones, the technology you know everything gets puts together. It is a very important career, motorsport is there for entertainment and it is not a necessity. It provides people with entertainment, it depends which aspect of engineering. You know medical engineering can save thousands of people's lives but motorsport is for entertainment. I do think it is very important and the world needs engineers so you know.
T: I've read a lot of papers on engineering being objective, impersonal, competitive, masculine, are they things you would describe engineering to be?
J: I would say competitive. I think masculine is an old terminology because my favourite lecturer is leigh Fleming. The course is mainly male orientated and I am not sure why that is. I don't know I wouldn't be able to put my finger on but yes I think it is leading more to not entirely masculine. I would say it is competitive. Competing for jobs or rival designs or depending on the aspect you are looking at motorsport, that is very competitive. What were the others ones sorry?
T: objective and impersonal
J: from my experience I don't think it is either one of those things. I don't think it is impersonal.
T: I guess for a lot of you it is more like a hobby and not just a job.
J: yes I always wanted to find something I wouldn't mind getting up on a morning to do and this year doing 9-5 it hasn't bothered me to do it, I enjoy it. If my career can go the same way I would be more than happy. Again I think some people can see it as a job. I don't think everyone does engineering because they see it as a hobby. I think people who have it as a hobby find it attractive as a possibility. People who go into medical engineering or military engineering but yes if I persist with the route I am on, getting to automotive or motorsport engineering, hopefully I will have a career I enjoy doing.
T: would you describe yourself as being an engineer in terms of being analytical?
J: yes I consider myself to be very analytical and black or white, very straight forward in my approach to most things.
T: even in your personal life outside uni?
J: yes I don't know how to context it but yes
T: would you say most people in engineering are like that? Is that a skill you need to be an engineer?

J: erm I don't think its something you need to be a good engineer. I think people who have that skill will be good at engineering but I don't think you need to be good at engineering. Like I am very structured, very tidy and not bordering on OCB but generally speaking I am a tidy person. I need clarity to think straight and when I can think straight the work I do is good. My bedroom at home, I cant sit in my bedroom at home and work if it is a mess so I will have to tidy it first before I do my work. Some other people on the course, they are happy to be messy. Like even my desk it has to be tidy and clear before I can start working but some people have stuff scattered all over it. It's a different mind-set. I think it helps me in my approach but it's not something essential to be a good engineer.
T: do you think engineering is a mind-set?
J: I think yes how you get to answers is important but anything what deviates from an answer doesn't really need to be there. I am also in the same sense, I like to see every set in detail. If I am doing an equation I will write each step out in full for the answer and in order and neatly on the page. I would say that's a trait of engineering but then again there are people on the course who will write things out messily. What I often find myself doing, I have two notepads. So I take my notes in one and then I go home and write them up neat in the other. I don't have time to write stuff up in neat as the lecturer goes through what he is saying but I probably spend one hour a night going through stuff and writing my notes out. That helps recuperating knowledge and retaining more of it. That's just something I do as I have seen some notebooks people revise from and they look like my worst nightmare.
T: what would you say makes a successful engineer?
J: you need to be dedicated and willing to invest a lot of time into something because it is very easy and it has happened a couple of times myself where you work through something, work through an assignment and then realise and then realise its wrong and you missed a variable at the start or something and all the hours and hours on stimulation and things like that that you have done are useless and its very hard to pick yourself back up after spending three days in the design studio to then have to re-do that. So you have to be dedicated and a bit persistent at times. I would say you do have to have an analytical approach at times, you want to learn this and want to learn that. You need to have direction. I would say persistence is the main thing, it can be sole destroying losing a load of data and having to re-do it. I think you have to be confidence in your ideas, in what you have come up with. If you take your idea to someone in industry and you are a stuttering mess while your trying to present it and you don't know the ins and outs of your design they are not going to invest in it so you have to be confident. And in a team of 20 people you have to get your idea across and show why it might be better than someone else's. at the same time you also have to be absorbent of other ideas as a combination of two ideas may be better than one. It takes confidence to argue your idea but also you have to be

right because if you get outted as being wrong you do get shot down by even your colleagues so you have to be right. Often I would only do that if I had put a good amount of research into that topic. I put a good amount of research into why the thing he suggested in possible or not.
T: what other skills would you say you need to be a good engineer?
J: team work and project management are the two big ones and I know that is the same for a lot of careers. That whole team project wouldn't work if a few of us didn't work well as a team. Communication is massive, basic communication, like how to talk to people. In industry when you are talking to people who have been there for 50 years and you are giving them new ideas and the project management will be valuable in industry if you want to do management are all skills a good engineer would have. I don't think everyone has all three nailed down but you need a couple of them if you are going to go into a top end company.
T: what would you say engineering use to be and how has it changed?
J: I would say engineering use to be very much male orientated, you were in a workshop with some tools making things. Getting your hands dirty and I would say its changed because its become a lot more, its expanded a lot more away from maths and physics because we have sophisticated computer packages, I mean we have designed a car on a computer basically. We are able to test its aerodynamic features and 20 years ago it didn't have it. You don't have textbooks anymore, any information you need in online you don't need piles on textbooks anymore. We still work in a workshop but we have the class room learning side and computer side, I think we spend more time on computers now than we did in previous years. Running stimulations and things like that. It has changed with technology and I think the approach to psychology has changed. Like the social stand point. Wider demographic are interested in engineering.
T: how have the policies and practices of the IMechE influenced you are the study of engineering?
J: they govern what is, they accredit the course. That gives you confidence that what you are being taught will be useful in industry. They provide the link between industry and study. To be accredited we have to follow principles and guidelines the team is an IMechE accredited module. They are engineers, they have input, they show us when we are going right or going wrong. It helps you to be confident and be sure of yourself and what you are doing so your not going to walk into a company as a graduate and not understand things what someone is asking you to do. It's good that that is there.

Appendix 20 – Masters participant: James C

T: when did you first decide you wanted to study engineering?
J: erm it would probably be in the second year of a-levels. So a bit of background first, I did 4 AS, maths physics, geography and then product design as well and then coming into my second year I hadn't don't well at all and I was on the point of dropping my maths which is the one I didn't do best at the I decided to drop geography and then I started looking at things to do with product design at a degree and then I thought I could actually merge the things I had done in maths and physics with product design and then obviously mechanical engineering stood out from the crowd then so I looked into what they degree was all about but I have quite a few family members which are engineers so my father is a service engineer, his father was in engineering and his brother was a chemical engineer so there is a bit of a heritage in it anyway. But yes it is something I have always been interested in, the mind set you need to do engineering anyway.
T: were maths and physics something you have always been good at?
J: erm through school I had always been in the top sets so I had never really struggled with anything. Did my GCSE's and came out with fantastic grades in those but then when it came to sixth form but I stayed at the same school instead of going to the better alternative which was the college in leeds to do my a-levels. I know my a-levels were really poor in the first year so I knew I had to step it up in the second year. Erm but I guess it was half and half, I knew I wanted to do it because maths and physics were the type of things people find difficult and you can get far in life with them because they are difficult and sought after degrees and then half my parents and knowing that.
T: when you said you felt that you had that engineering mind set, what would you say that is?
J: the best way to describe it was, I think it was one of the deans in the school who said it in first year. As a child if you have ever been given a set of lego or mecano and if you felt you could just go for it and you had fun playing with that and do whatever you wanted with it. or if you had a natural ability to visualize things quite easily, to be able to just picture something or drop it down or just talk about something easy. That's the mind set they look for it. there are two types of people, those who get the lego, look at the instructions and build it then play with it, your not that type of person. You take it, build it, think its boring and take it apart and do what you want with it. and always wanting to know why things work as well. anything day to day you just have to ask questions and be inquisitive.
T: is that something you have seen in engineers as you have been studying?
J: I have yes, those that I know pretty closely because obviously the ones you find who are really interested and focused on doing it, they have that type of mind set. Always wanting

to ask why, always questioning why. And they always want to know how it works. Then you do always get the second type of person who has gone into it thinking it would be something different or perhaps can see an end goal instead of the subject. things like when you learn the answers just to pass the module sort of thing. Its that type of learning the basics of engineering to do whatever they want to do in a job, rather than having a genuine interest in the subject, you get a mix of people.

T: so is engineering as you say, something you have always been interested in since you were little?

J: erm yes in terms of like knowing how things work and things but in terms of like knowing the think between the two, no not really until my a-levels.

T: when you kind of knew what an engineer was, is it something you could see yourself doing?

J: erm yes it was basically just a natural ability to get on with those things already, to know there was a subject field dedicated to that.

T: so how did you kind of come to understand that engineering existed?

J: erm I guess what my dad does, I have always know what he has done and I have always taken notice of things like when we are on a road trip, a lot of the lads on our course are interested in formula one and things and yes it is a typical boys thing to be interested in but on top of that it's not just it's a fancy car but what is underneath it and its not just a certain thing in it but it is the fact that you know how and why that makes it impressive. I knew all of that and I want into all of that but mechanical engineering was suggested to me and I was just like is that not just oil and things. when you are given the title mechanical engineer, in fact when I was in my part time job when I first started here and they would ask what I was studying and I would say mechanical engineering and they would say, you get a small minority say oh wow that is really interesting and the vast majority would say isn't that learning how to fix cars and then you have to explain to them. And that is the hard bit actually explaining what something is. There is not one specific thing you do. Knowing about engineering had always been that but knowing it was engineering, the link has not always been there.

T: how would you describe engineering?

J: (laughs) that's the difficult thing. The way I have said before to some people. Doesn't matter whatever you are using or doing, if you are say to a computer and say you take a bog standard object, there has been an engineer at some point building or designing that. I will point at a chair and they will think it is a joiner and you say well where do the legs come from, where does the steal come from, how does that all come about. And oh they say someone has to design all that, well that is the mechanical engineer. Then I will take a table, a brick out of the wall. Well the company that makes bricks. Well who made the

machinery to make the bricks. Well yes that is the mechanical engineer. Then you start to sort of play on them a bit and eventually they start to twig that everything has been designed and some point and the chances are everything what has been designed involves a mechanical engineer. When you say there is a lot of maths and a lot of physics, everyone says oh it must be really hard then because there is the stigmatism that maths is really hard, which is can be for some people.
T: what kind of persuaded you to study engineering as oppose to apprenticeships or getting a job in that field?
J: I think it was more progression because my experience, my dad. He didn't do a degree, he did an apprenticeship and after that started working in basically what was a garage as a full time job and I think basically where he has got to and what his brother does as a civil engineer and he is probably on double the wage having just as much work. You want to get a degree and do something you want to do. And I think a lot of people know it accounts to a lot more than apprenticeships and you see a lot of people doing the apprenticeship and then they find themselves in our shoes a few years down the line because they can see they want to progress further than where they are at. They find themselves as a technician but want to be the person who is designing the bits that they are actually making, they want to be on the other side of the wall in the office.
T: why do you think the degree enables that?
J: a lot of the time, the degree is a tool box of sorts. Every module is the same for everybody, there is not a lot of choice like many other subjects and that is mainly because you need to know the basic principles. You can specialise, like you have civil engineers or aeronautical engineers and they will specifically do something dedicated to their field. Everyone does the same and you cant deviate from that and then you have to finish the course to realise how much you have covered basically. From me starting university and if I was presented to make the metal part of a phone case, I wouldn't have a clue. There are a lot of science and engineering what goes behind it and you don't know that until you start your degree and then you have a lot of appreciation for it. you realise it is well about what I am capable of doing yet and you realise you have to progress through your degree to get to that point and then with me doing the masters, it is a top up of that. But at the same time, a lot of the stuff we do. There are a lot of health and safety about it as well. we don't just design things. we know how materials works and can say what they can and cant do but is it also what if it fails, will it kill somebody? And we are accountable for that as we are designing the stuff what could kill people. Again you need to know the basics first before you can design it so you know what could go wrong and how to control things as well.
T: how do you think having that degree will influence you when going into the workplace?

J: obviously we did a second year placement and I would put in with the role of project engineer. So I was given a task from a company and basically it could be anything, putting up a building or building machinery and not everyone could do that if they don't understand how it would work and I would also validate it as well. so the degree for what my experience has been means I have got that extra level of knowledge to understand how things work with a lot more detail. For example if you asked anyone randomly on the street how a bit of machinery worked such as a kettle or toaster everyone would looked blanked and if you come to us we could say of yes that's really easy that or if we didn't the degree has allowed us to know what would work and what wouldn't work, it is an educated guess really. It doesn't tell us the answers for everything, it just says this is what you will use, and this is how you will apply it. you learn how to apply it then.
T: do you think there will be expectations and perceptions of you in the workplace from having your degree?
J: yes. This is an example what happened this week. I still work part time as a project engineer from my placement. I had somebody from an outside company who I had ordered to come in to do CO2 levels in the office and the office I walked into was an export office to do with logistics and they had seen me around, they knew I was to do with project management but they didn't know why I was still there. Then I had to explain I was still doing my degree, my masters degree and their reaction was that you must be quite a smart person really but then that is the stigmatism you get really because if you say I'm engineer again everyone just links maths and physics. There is a massive stigmatism because everyone hated maths, even at school I hated maths and then I still took it at a-level and then until you apply it, you just sort of get along with it really. But then again because you do maths and physics everyone just thinks its hard. Going back to the question, if people think it is hard, even we will do it, you refer to people as academics. Obviously you have your red brick universities and you get two people who go to a company like rolls Royce and they only recruit the best of the best. You people from oxford and Cambridge, they will have everything down on paper as perfect but then the person from Huddersfield does know it, but they may not be the best at it but it is the common sense behind it as well. the oxford person may need to be told what to do every minute of the day but we might have the common sense behind us to think right ok I will take a step back and take a different angle.
T: how come you decided to continue to do a masters?
J: erm more of my own personal expectations of myself really. Like I said my a-levels were not the best really and I failed to get into my first choice which was leeds uni and then off the back off it, if I am going to a university which is not as good I want to do the best I can so I did that and surprised myself so on top of that I did the masters and then the placement year and I didn't expect to be doing that for more than 12 months and then it

changed to 18 months and then they kept taking me on part time so now by the end of this year it is going to be full MEng, full BEng plus experience in engineering as well and as of that it is not just one placement, I have worked in numerous fields because I have done summer placements as well. so realising how far I can take it, I have done as many things as I can to take it as far as I can. So the placement was part of that. The amount if can push me forward in comparison to everyone else, the masters sets you much further ahead because you have spent that time.

T: how do you think the masters will be beneficial to working in industry?

J: the big part is the project and if people haven't done the placement year people may not have worked as part of a team properly. I mean people get to the end of their degree and just into a job and not have the confidence to do what you have learnt because you have never applied it or seen if it works. Obviously you never see it through your degree, you see it all on paper but never see it made but obviously this project you do. The beauty of it is, you can see something from start to finish, full completion and not only that but all off the subjects on top of it. to now it works really well at the end of it all, fills you with a bit more confidence in yourself, your esteem in yourself and your own skills so when you move on from masters you know what you are doing is right.

T: in what ways has the masters differed to undergraduate study?

J: there is a lot more responsibility because funnily enough you are only doing another step on modules but there is a lot more responsibility.

T: in terms of what?

J: not we technically have a degree, we just haven't graduated with it. the subject teachers that have taught us the modules are the heads of their departments and you get thee people to teach you. Your work in more independent but because what you learnt already is top class so you are actually pushing yourself further and it is not your responsibility to demonstrate what you did in your degree as they is taken as a given, you have to do above and beyond. We always ask who is this piece of work aimed at and it is aimed to the professors, who is an academic who knows what you are talking about so it is a totally different style.

T: would you say it was a different way of studying?

J: yes erm, the way we are guided hasn't changed, we are still doing reports the same way we did before. The amount of workload has increased, you seem to be in close proximity with other students more and then we also have that area in the studio. You will see a lot of us, like me treat it as a 9-5 job. So even if you are doing an assignment, you know everyone in there is also doing assignments. So it is independent in a way but everyone is still working at the same time so we still have the same problems. At undergraduate it would still be the same but people managed it differently, some would do assignments the

day before, the night before and you might have some people who do it two weeks before and you were never at the same point because everyone did it different whereas now we all agree, it is just our own little opinion at the end.
T: would you say lectures treat you differently now you are doing your masters?
J: outside of lectures maybe but I guess that is the, how I see it lectures have their degree and when they teach, for example when they teach first years all we did was recap a-level maths in one of our modules for first year so they probably have no interest in it as they have probably been doing it for 30 years, they have no enthusiasm so it is really boring. Whereas you get to our level and we are learning, in fact one of my modules is purely based on research what they have done from the technology building so it is stuff they are really invested in, so the teaching is different. They still teach us in exactly the same way they teach a normal lecture like we were an undergraduate student but after they talking to us, we have proven we are capable of getting a degree so they get on a little bit more with us, they don't have to rely on explaining everything to us. And on top of that we have been here 5 years so a lot of people we are working with now, like john baron who helps us with the project, he knows a lot of us personally and I think he even has a lot of us on facebook. Heads of the course, we know them personally as well and when we go out on placement we have a mentor so you get to know them personally because any problems you have go through them. Just after Christmas there was a handful of us what went out for a curry in Huddersfield with the dean of the school and a few other lectures and we all know each other on first name terms.
T: I am taking it you want a career in engineering. What type of career are you thinking?
J: mine is different to everybody else. When I speak to a lot of other people and they have done a lot of design stuff, that is sort of where they see themselves going. In my second year I didn't really know which field of engineering I wanted to go into to I applied everywhere and I ended up landing a role of a project engineering and I didn't know that kind of role existed and when I went to do it I realised I wasn't doing the same think every day. You hardly spend anytime at your desk, you end up talking to so many people and doing so many different varied projects it is never boring. So the next place I did was very similar and now I am looking for roles in management in engineering, they are very few are far between. You need to demonstrate leadership and have experience but they fast track you through to management positions in the year and a half.
T: how come that is something you wanted to do?
J: I think it is just enjoyed. It is just the amount of varied work I am doing erm when I heard back from people who did placements who were just sat in one room re designing one thing about 3-4 weeks and testing it and then re designing another part. In that time I had bought in equipment, solved problems between people in production, you name it I had

done loads in 3-4 weeks, plus I had free roam of a company. I could do whatever I wanted. I just preferred the job role

T: when I went to a company yesterday they were talking about the different skill sets needed for the different roles in engineering. Do you think you have the skill set for management?

J: I have seen it. erm obviously the way the course is set up, you do a lot of individual work and a lot of group work. When you are doing the group work. You always find there are certain people in the year who take on the leading roles, that is just a natural thing that happens, nobody says I will do this. everyone just sits round a table talking and naturally somebody just takes over. They never say they are ok with it, it just happens. We do some projects where there is a focus on leadership but not many. It tends to just be here is a group project, here is an end goal, do it and provide a report.

T: do you feel your undergraduate degree prepared you for your masters?

J: yes erm bit like if you think back to your maths, when you were doing GCSE maths and every year you felt like you were doing exactly the same, which you were but it just got progressively more difficult. It is the same thing we do here with engineering, it's the same principle. You start off with the basics and you learn the next thing and there is a link and you put two and two together and advance it on a little bit further and in the final year it's the same, it is just the same with the masters. What you find is when we do exams in the first, second and third year, your formula sheet is pages thick and you just flick through and find what you need and understand why and what happens. In the masters year it is more on us to create that formula, to actually derive it. you hear people complaining we haven't got a formula sheet but the reason is, out in industry there is a lot of rules and regulations and people have to come up with those and they are not always researchers. So we take what we have done and turn it back on itself and reverse engineer it so we understand it better. Modules start off basic in the first year and then steps get added every year. Its that step by step progress. Everything is interlinked with each other, there is not one subject you can do without having the influence of another. We do enterpriser modules as well where we have to design a company and logos and then finances and do all the marketing for it and that is just something we have to research. some of the skills we have to learn quickly, use our intuitive to go research, speak with other schools.

T: I guess that is something you would have to do in the workplace, work with other departments etc. how would you say your workload has been?

J: the level of technical difficulty has gotten harder every year. In the level of workload, that has been the same every year. You have a lot to do in first year as you are trying to prove you know what you are doing and every other module has its own objectives. In the first year, it is really just a re cap of a-levels and to bring everyone to the same level so

when you progress to second year they up the technical difficulty and you learn a bit more to have the basic level of knowledge you should go out to the workplace with. And then you come back for final year and the workload is still the same but the technical level goes up and it is like this is it, this is all you will really need, then you will specialise and learn it on the job and then the masters you take it up again and this is a bit more than degree level and it is specialist but widespread. The workload is still the same but in the masters is has got harder but it is because we have to project and we are self-managing it and there is a lot of work to do.

T: what about timetables hours, compared to how much you are in?

J: it depends on the type of person you are really. Some people prefer to work at home, some here when you are around everybody. The first few years you have a lot of lectures, maybe 15-20 hours of timetabled. Final year was around 10-12 hours because of dissertation and now maybe 6-7 but then this year we are in 9-5, you cant afford to not be here. Final year it was the same.

T: why do you think it is so intense?

J: just the shear amount of things we need to learn to be able to understand it. you can learn one thing without another and you cant move into the second year if you don't understand the first and if you were to miss anything we do, if you miss a bit of a module and you don't understand it, you will struggle later on in the degree because if it is a fundamental part and we have added onto to it you will never get it. so then you have to spend more time outside university catching up.

T: would you say engineering is harder than other disciplines?

J: based on my personal opinion and my friends I would say yes just because in my undergraduate degree and a lot of the time they would say oh I have a few days free does anyone fancy doing anything and I would just be working, I would simply just not have time. Like we have 4000 work reports set and we have a week to complete them, that is not difficult. They might have a lot of research studies or reading, I felt a lot of work on my part. If we are set a 5000 work assignment and we have three months to do it, alarm bells start ringing because you know that because 3 months is a lot time to do some work so they expect a lot and 5000 words is not a lot, we get that this year.

T: what are the structure of lectures?

J: sit down and listen to a lecture and understand it. there is a lot to learn. Some lectures ask a few questions to us but the majority of the time it is like being back in class at school. The teacher has to teach a certain subject so they would teach the subject and do it for say an hour lecture, you need to write it all down or they might give notes and 5 minutes for questions at the end. You don't really work in groups

T: do you have to do reading before hand?

J: not really. If I haven't understood anything from a lecture I would yes and I would do it straight away so it is fresh in my mind. But having to read up before a lecture, not really. The way they present materials and without the content from the lecture it means 0 to you. So the best thing to do is just be prepared and focused for that lecture having known you have everything you need.
T: in what ways would you say you learn engineering, or demonstrate?
J: I remember one of my friends he came from a BTEC so I remember sitting down with him a lot and teaching him a-level maths and I still do it today because he didn't come from an academic background. Teaching it for me is the best way, you retain it much easier. A lot is group work, so doing the reports or the exams is the only real way of demonstrating it. presentations, reports, group work.
T: do you meet or socialise with other engineering students?
J: yes, with being is close proximity. Both inside and outside of uni, like the people I am with now. I have known them for like 5 years. We go the pub for a few drinks or we meet up on a weekend. Because we are close nit and we have the same interests we find it easy to get along with everybody.
T: what would you say engineering students are like?
J: (laughs) it's a mix. Because of the subject type, there is a stereotype which is true. A lot of people are introverted. the stereotype of everyone being a little bit nerdy and into the subject they do is definitely true. You just cant help it
T: would you describe yourself as an engineer?
J: I would say now because there are some people I will talk to and start talking about something and they are like I don't have a club what you are on about and I just think that is common knowledge. To other people I like to still see I don't know anything and that is just if people have done it for years and I will treat it as if I don't know anything because they are the people who have done it for years. I wouldn't want to walk into a workplace and start telling people to do things differently when they have been doing it for 30 years. You still get a lot of people who still view you as a student and they don't put trust in you and it bites them because you did know what you were talking about and they didn't. I respect the experience people have. A lot of people think they are too good for roles now they have a degree
T: do you do anything else inside or outside university what kind of links in with engineering?
J: no we don't have a lot of time at all, when I do have free time I like to just relax
T: so a lot of the journal papers I have read describe engineering as objective, competitive, impersonal, masculine. Would you describe engineering like that?

J: yes erm yes it is definitely objective based, you can never change that. Competitive I have not seen it here as a student. as an engineering company there are probably another 10 which produce the same, they have to have their own niche or something better than someone else. When I went to leeds uni to look round a lot of people didn't like it because it was so competitive. I got a better grade than this and a lot of lectures were proud of their work and how much money they were brining into the university. They were not bothered about teaching.
T: how would you describe engineering in terms of analytical, team work, communication?
J: erm a lot of that stuff we pick up natural. To actually do the subjects we are doing and do it well like before you have even started the degree a lot of people have those skills. Like being analytical to us is natural. Break it down, logically. That is one of the good things we are good at, we all have those traits. To do the things we do well, we all have to be good at those. Again the subject means we do a lot of things outside of comfort zone, like we do finance but because we work with numbers a lot we are seen as adaptable. When you look at graduate roles like HSBC want engineers because we are analytical, logical and good with numbers.
T: what about communication on a social level?
J: because of what we are doing now, if someone is slacking a bit nobody wants to say you are not doing enough. Nobody wants to, there is trouble when trying to converse with people. Some people shy away from presenting. Some people when it comes to group projects some wont talk or do anything till they are pushed.
T: I was surprised in the meeting when you turn round and would disagree with ideas from lectures as you always believe they know best?
J: the thing is with a degree you learn the skill set and you have many ideas you can apply to one problem and they will both work. It depends on the influences you have as to what sort of ideas you produce
T: do you think you can learn that level of creativity for ideas?
J: it is meant to be something you can learn, it is something you have.
T: can you see that in students?
J: yes some find it difficult to think outside the box, they have tunnel vision. They see an idea and think that is what I am doing. I did GCSE art and I found it difficult to move away from one particular idea, I mean I could draw but I couldn't think of other ideas but I could think about it in my head and not others could. You can sort of pick it up but you cant be taught it, although they do try but it is hard.

Appendix 21 – Masters participant: Josh B

T: when did you decide that you wanted to study engineering?
J: erm it's been more of lifestyle choice than anything else. I started riding motorbikes when I was 5 and started racing at 6 and from there is just carried on. You know, I did my own work on the bikes, went to college to do manufacturing engineering and did a BTEC rather than a-levels because I was more practically suited. And then finished that and then this course, automotive and motorsport engineering lead straight on from that really. I got a good enough grade to go straight in so I applied and got straight in basically.
T: did you find the fact that you did BTEC as oppose to a-levels different when you got to university?
J: erm the first year was horrible. The theoretical, mathematical basis what I had wasn't strong enough. Purely because the college course wasn't as in depth as it should be for maths. So it was a struggle if that was your question but you know you just work hard so. I've had to compensate a lot more than others on the theoretical side.
T: do you feel like that still influences you now?
J: yes a bit.
T: are you still trying to catch up?
J: a little bit sometimes yes. Even though I had a good degree, sometimes you can feel where you don't know where to start. But once you get going it's not too bad.
T: do you think people are different at different things in engineering – so there is the practical part but also the theoretical.
J: yes definitely. What you tend to find is that people who have done a-levels don't really have much practical ability. And that's not really their fault, it's just how the courses are structured. They don't have the equipment at the college what I was using. It's just different ways of doing the same thing really.
T: do you think people choose a-levels because they are more that way?
J: yes it follows on from more a school environment I would say. Yes I believe so.
T: so what persuaded you to study engineering at university as oppose to an apprenticeship say?
J: it was a big thing at the time actually. Erm quite a few of my friends got apprenticeships and a lot of them were moving away and at the time I was still heavily involved with the racing and I didn't really want to move away from this area. My tutor at college had close links with the uni and he kept showing me courses and the prospectus and saying you should maybe go for that. Then because I got such a good grade I thought go on then.
T: do you think you made the right choice coming to university?
J: yes

T: in what respect do you think it will benefit you?
J: well I am going to get paid more at the end of it hopefully. Essentially yes.
T: I know when you are doing an apprenticeship you can still study at the same time and then you can work your way up. How do you think having that degree will influence the level of job you may go in to?
J: I don't agree with this if you have a masters degree you should go straight in as a manager because I don't believe anybody should. I think they should have to work up. One of the tutors at college had his own engineering workshop and he said that if he hired anybody for any position they had to go do two weeks on the shop floor first. I kind of agree with that, I believe you should go in at a level you are comfortable to work and then you can progress. There is probably a few views on that. A lot of the lads on the masters course think well I've done that and I've got my certificate I am going to go straight in as a manager and I can do that. And I mean one of my mates he is very academically strong if you like and he is a good project engineering and I believe he could but I don't think I could. So personally I would like to go in a little bit lower and work my way up. Rather than trying to jump in and know what I am doing.
T: so how do you think having that background of coming to university will influence perceptions of you in the workplace?
J: well I imagine it sort of depends where you are. people on the shop floor would just think you are another manager, erm other managers would assume that because you have your certificate so you know what you are doing. I imagine generally we are deemed to be intelligent people (laughs). So hopefully that rings true.
T: how has the masters been in comparison to your undergraduate degree?
J: I think this year is structured better. So in the first year of the undergraduate we do 6 modules and one of those is a project which accounts for 2 but in this year we have an ongoing project, three modules before Christmas and then two modules after so it is a lot more intense but you are only really learning three subjects at once rather than six so I think its worked out ok for me so far. Couple of big assignments and you tend to find because there is not a lot of time they tend to come together. But I like it so far, I think its better.
T: has the intensity of the work been harder?
J: I wouldn't say harder, its more advanced. It's built upon what you have already done and what we are finding out now and in final year we were offered optional modules and you tend to find the core modules in the final maters year are building on the option modules. So if you didn't choose option modules which I am finding out now. I didn't choose dynamics but not I am doing a advanced dynamics module in my masters. I had to do

aerodynamics last year and some of my friends didn't so they are struggling with that. So it's just swings and roundabouts really.
T: how have you found the modules that you didn't choose in undergraduate but are now doing then? What have you had to do to catch yourself up. Like do you have to do extra reading?
J: oh yes yes yes. Just work harder basically. You either want it or you don't. I am blunt like that, if you want it you just have to figure it out I suppose.
T: I take it you want a career in engineering – what type of career do you think you want?
J: so when I did my placement year, I was learning how to be a calibration engineer for engine control and I am fairly sure that it was I would like to do.
T: how did you find your placement year? Was working in that environment what you expected it to be like?
J: erm it was fantastic. It wasn't exactly what I expected it to be like but it was amazing. I really enjoyed that experience.
T: what did you like about it?
J: everything. Basically everything. You could do your own work. I was on flexitime so I could turn up when I wanted and leave when I wanted. We were treated well. I had to move away but I got invited to take part in test trip to Austria. It was just brilliant and I got paid for it.
T: what was the application process like to get into your placement?
J: mine wasn't too bad some of them are a nightmare sometimes. What you tend to get is either an online application form or log in details to a portal where you have to log in and upload things and if you are lucky there you might get a telephone interview and then you might be asked to take part in tests and then it goes on and on. But luckily mine was an application form with a CV and covering letter. I was a bit cheeky with mine because I already had an offer from somewhere else and I said that to them, I would prefer to come to your company can you do anything and they rang me and said can you come for an interview on Wednesday and I think that was the Monday and I had the job by the Friday.
T: how come you would have preferred that company?
J: erm well they were offering more money and I believed it would give me a better opportunity and I think it did, definitely.
T: why do you think the application process for things in engineering is so intense?
J: because they want the best. It's a lot of money at the end of the day. It might not be for big big companies but it almost puts a talent block on the market then as well. so if you have 5 really go people going for a job but they are only going to take 3 but all 5 prove to be really good then you are going to take all 5 then nobody can have those other two

people. That's find of how it works so. There a few different reason but that's one of the main ones.
T: so did you always know you want to be an engineer from when you were little?
J: oh yes yes
T: did you kind of always know what an engineer was?
J: erm no
T: so was it just the interest in it then you kind of found out that it was engineering?
J: basically yes. I had no idea you could kind of do project engineering. Which it might be an engineering company but you are just taking charge of projects. I had no idea about that, even when I started uni I had no idea but I've always liked tinkering with stuff.
T: were you always good at maths and science at school?
J: not amazingly no. I have always been average, sort of B C level. Erm it was college, because it was marked in a different way but I understood what I did so it sort of boosted my grades up.
T: when you were little and you were interested in motorbikes and things, did anyone in your family have that interest with you?
J: oh yes me and my father and his two brothers. We are all the same yes.
T: so is anyone in your family an engineer or studies at higher education?
J: no none of them. Erm well I tell a lie my cousin did a degree at uni but my mum and dad haven't no.
T: what were their perceptions of it when you said you were going to continue studying?
J: well my dads been pushing me for years. Hes a HGV driver and he hates it and he said whatever you do, don't turn out like me. at times he has been doing my head in but he has been really trying to push me through and it's worked out for the best really.
T: so what has your workload been like so far throughout your degrees?
J: intense
T: is it harder than you thought?
J: yes oh yes without a doubt. College was, I wouldn't say a breeze in comparison but they say it prepared you. Maybe a-levels would have but I don't think that college course did. But I wouldn't change it.
T: so what are your working hours like, what are your timetables hours like?
J: timetable, well this year we are only really timetabled Wednesday afternoon, Thursday afternoon and Friday morning but because of the formula student project, you treat it like 9-5 anyway. It's not too bad, we are in pretty much in everyday anyway.
T: have you always treated in like 9-5 in your undergraduate as well?
J: no I was probably one of the worse ones. I only use to turn up when I needed to turn up. I use to come on the bike and part it under the stairs and if I had a spare hour I would just

go home but now I come in the car and I actually have to walk in, it's been a lot better. Now its change round and I'm doing a lot more.
T: at undergraduate level, the engineering courses timetables are a lot fuller than other disciplines, why do you think that is?
J: erm the first couple of years they are just trying to get everyone to the same level really. They need to find out what you know and what you don't know. As well as building a knowledge base for them to improve on over the years. That's why we do a lot of lab sessions which try to give you a practical take on things and I think it is purely that full because of how much we have to get in. it's a bit unfortunate but that's how it is really.
T: do you think that engineering is harder than other disciplines?
J: oh yes definitely
T: in what respect?
J: every respect. I would say so. You are having to think about things properly. A lot of what we do is validation. You know anybody can run a computer package and get an answer out of it but how do you know it's right. A lot of what we do is validation and that's where your time comes in really yes
T: so what are the lecturers like in engineering?
J: erm good good. I think this year has been the best year we have had so far.
T: do you think they treat you differently now you are doing a masters?
J: erm a little bit. Especially because we have had teachers we have not had before for this year. So they expect you to know and be of a certain level which isn't necessarily fair if you haven't done the subject before, which we are finding now but it is been addressed and now everyone is aware its been better. There has only been a couple we have had problems with.
T: what are the structures of lectures and things. Is it group work, someone just stood at the front?
J: it's more been lectured at with questions throughout the lecture. A lot of what we do are worked examples because the only real way to learn how to do it is to do it. they will talk you through it and maybe give you another example to try later in a slightly different thing. They try to teach you the theoretical side and then they give you an example of it.
T: is there a lot of set work to do at home or is it just what you see as relevant?
J: yes basically. Set work, it doesn't exist. I have never had read this book. That's not what it is about for us. Its more you might know you are going to be learning about this set topic so it is good to have an understanding about that. Only time I have had you must read this is this year when we had a module in the business school. And that was run totally differently, saying you should be doing this much reading. No, that's not for us that. You

know that's why we chose engineering, for us it is either right or wrong and that's how I like it especially.
T: do you think your mind-set has always been like that – it's either right or wrong?
J: pretty much yes
T: even when you were growing up?
J: yes
T: do you see that in other aspects of your life as well, outside university?
J: yes. It's fun with our lass sometimes, if it's not my way its not right. Another example, when I'm building my race bike, it's not exactly how you like it then it's not right. It makes it much easier because if it not how I want it then I know.
T: do you meet or socialise with other students inside or outside university?
J: yes a lot of my core group of friends is from engineering when we started at uni. Without them it would have been a difficult set of fish I believe. They have helped me and I've helped them and its been really good.
T: when you meet them is it just work level friendship or would you discuss other things?
J: oh yes everything. Absolutely. I had a xbox night at mine Saturday and everyone was round.
T: what would you describe engineering students to be like?
J: erm probably a pain for people looking outside in. can probably be quite abrupt. Again like me we sort of know what we want, its either right or wrong. It can be fun. I think I don't know, I think we are easy to get along with but that it what I would say. It's either right or wrong and we know what we want.
T: so would you describe yourself as an engineer?
J: yes I would
T: what do you think enables you to be able to call yourself an engineer?
J: I believe personally. You need to have enough theoretical knowledge to be able to explain. In other words a layman. So if I was trying to describe something I do, and enough practical knowledge to be able to describe how it can be made and I think the two go together. I don't think you can have one without the other and because I can do both I am happy to call myself an engineer.
T: when did you think that you could call yourself an engineer?
J: well truly in my own mind its when you get your degree but it depends what you judge it on because I could really say I've been an engineer from six years old. So I have had a slightly different upbringing to others. My theoretical knowledge at degree level is now good enough I believe but I have always had practical knowledge. It's swings and roundabouts but I think its when you get your degree.
T: do you think there is a problem with defining what engineering is?

J: yes it's a bit of an ongoing joke really. I mean highway engineering, erm no. it can be a topic for debate sometimes.
T: do you do any activities inside or outside engineering linked in with engineering?
J: personally I don't and that's because I never have really. When I first came to uni I didn't really like it and I didn't get involved with things. I would rather be off on the bike. I did join a society once, it was a bike club and we went for a ride out and it lasted all of 3 months.
T: why do you think you've not been that involved in stuff?
J: I was just never bothered, I lived a home and I like my own company to be honest, I don't need people round me all the time. Erm I had a job, working in a pub. When I wasn't at uni I was either working or working in the pub then bikes at the weekend. I have always been really busy, I've never made time for it, I've never bothered really. It wasn't for me.
T: do you think a lot of engineering students are like that?
J: probably not no. I think the party life of university is all engineering students. They work so hard to meet all these deadlines that you need to let off sometimes, I think we do that quite well. I think as a group of people, we are all really focused. You know if there is a deadline coming up, you work really hard and get it done. I think as a group of people we look on that more than other courses might if you like.
T: when you come into university do you feel like you belong to a particular community or you just come here, do your work and just go?
J: now I feel like I belong because I've got this project. before I've not really been bothered and it doesn't bother me. I could take it or leave it but now it is nice to feel part of something. I use to come in did what I had to do then go.
T: so what type of things would you say you need to learn to become an engineer?
J: erm you need not just a mathematical background but an applied maths, so like a physics. You need to be able to visual problems or draw it out whichever. A lot of it is just sequencing, if you work out how to do the method, you can do most of the questions. So theoretical, logical and a good practical base. I would say is essential, others may not deem it as important. You need to be able to know what you are doing.
T: do you think anyone could be an engineer?
J: erm I am going to stick my neck out and say no. I think a lot of people especially at the younger end cant make a decision to save your life and I think you need to make a decision and stick to it and if you cant do that then I don't believe you could be. I call them people pleasers who just say yes to go along with the group, you cant be like that.
T: I did notice that, like in the meeting the other day in the meeting when you were arguing your point with the lecture.
J: but even if it is a rubbish idea, if someone explains it to you in a way you understand then it doesn't matter. Nobody guesses right first time every time but its all about trying to

explain why you think it should be done that way and yes as long as you believe in it and you say I think it should be done this way because and provide evidence then why not.
T: so why do you want to be an engineer?
J: I like the way of life that comes with it
T: would you see it as a job or a hobby?
J: more of a lifestyle if I'm honest. Yes I'm a nightmare at home, I get stuff and take it apart and half build it back up and do other stuff. She goes mad with me. I don't think you would meet an engineer what just calls it a job.
T: how important do you think engineering is or being an engineer?
J: vastly I mean we are really, we do everything really. Anybody can build something but again it all comes down to validations, especially for safety. Everything needs to be validated and accountable. You tend to find more work going on for engineers in the validation and consultant.
T: how would you describe engineering, I've read a lot of peoples what describe it as objective, competitive, masculine, impersonal. Is that how it is?
J: yes I would say. It doesn't have to be masculine you know. But it is a more, you know if you sat in one of our lectures you would only see blokes. I would like to see more women in it personally.
T: why do you think they don't?
J: well I don't really know to be honest. Why don't you.
T: I guess like maths and science you always see it as boys subjects and you don't really seem interested in it at school. Would you describe yourself as being an engineering in terms of being objective and analytical?
J: oh yes yes
T: would you say they are qualities you need to have or can you build those?
J: I would say everything you build. A lot of it is being able to make a decision. If you can make a decision and stick to it and explain why then you will be ok. The objective and competitive all comes from experience really. So for example, trying to get a job. In this industry is it competitive.
T: what about in terms of competitive with the projects that you do?
J: you want to be the best don't you. A lot of arguments stem from that and that's a lot of where the good ideas come in because you are trying to justify why your idea is the best. Its all a competition really.
T: are you encouraged to have personal thoughts feels etc about your idea.
J: I think that's a trait of people. If its your idea it's the best. I don't think you would meet an engineer who would through an idea out there what is not feasible. In the end it might be proved to not be and you tend to find that in team hare. You throw an idea out and

someone will say no and you say well why, why cant we do that. Especially in team hare, the rules wont allow it. they are very strict with rules, I mean you have seen the rule book. You will hear that a lot though, well why not.
T: so what would you say makes a successful engineer?
J: been able to explain why you believe this is the right way to go about something. Everyone can criticise and say no. if you can look at a range of ideas and pick one and explain why with computer or hand calculations. If you can justify why that is better, you need that.
T: so how have you assessments?
J: they vary really. They have changed a bit from first and second year. We use to have labs and you would attend a session and do a report on it and you would have to do some background stuff on why you have done what you have done and what the results mean. Where as sometimes our dynamics last term, we were introduced to a software package and given a problem and we had to learn how to use the package, complete the problem and write a report on it afterwards.
T: so they are all report based?
J: yes more technical reports. Even our dissertation is. They are all really technical reports.
T: what about exams and they more right or wrong answer?
J: yes but if you can justify why you've said that it might not necessarily be a wrong answer. A lot of our stuff is calculation based. The stuff we do is not necessarily so complex but if we are a few decimal places off or round something up wrong, it will alter the final result massively so a lot of our work is method. You are given a formula sheet and if you can plug the numbers in and follow the method correctly. You might be asked to explain an answer why you have got an answer like you have. But mostly mathematical.
T: do you think there are any other skills outside being objective and analytical, like teamwork communication?
J: yes you need to be a good team player really. You wont work on many projects where you are by yourself. Communication is key. You need to have a good IT base. For example you need to know how to use EXCEL.
T: how would you say being competitive links in with being a team player?
J: well that is where the conflict lies
T: have you found that?
J: yes every week, everyday. it's all a bit of give and take really and that's why you need to fully explain why this is the best way to do it really.
T: do you find it hard to persuade people onto your idea if they already had one of their own?

J: not really if you can prove why your idea is better than theirs, they will be a bit miffed but if you can explain why it shouldn't be a problem.
T: what did engineering use to be and how has it changed?
J: everything is a lot more computer based, for example CNC machines. 20 years ago they wouldn't do the stuff they do now. As the technology increases, the knowledge base increases. Erm I would say the technology progresses engineering now you can do more and more. There are ways to make things do more and more.

Appendix 22 – Masters participant: Joshua H

T: When did you decide you were interested in engineering?
J: erm probably going back to secondary school doing physics. After doing GCSE's I chose to go into further study and did a-level physics which didn't go very well and I dropped out of sixth form but after that I still wanted to go into engineering so I went and did a two year BTEC diploma. Did that for two years before I applied for the degree here in Huddersfield.
T: have you always been interested in maths and physics from when you were little and looking at how things worked?
J: yes yes I've always had a bit of an interest in building things, designing things. Between parents and family members been in various engineering positions from an electrician and various other things like a mechanic so I have always had that sort of background so it has just continued.
T: was it your interest that motivated you to study engineering or the fact that it was like that's all I have known sort of thing?
J: erm no not really. It was more my decision to go into engineering rather than anyone else's. no one pushed or convinced me to go into it but if I had listened to by mum I would have ended up a doctor on a children's ward.
T: what persuaded you to study engineering as opposite to apprenticeships?
J: I am not entirely sure. A lot of friends were going on to do sixth form and stuff. I wanted to get into university, one of the things I really wanted to do was get into aerospace engineering and for that you do need degrees. You need to have a lot of knowledge to get into that subject area.
T: what do think the advantages of studying engineering are?
J: I think it's partially a different path. One of my friends who I went to college with, he is doing an apprenticeship so he is working and he is being sponsored to go to university to do a BEng where as I chose to go straight into university so I don't know.
T: why do you think companies like you to have that degree?
J: erm I guess one of the things is so they can spend less time training you because you have a grounding in a specific area. I mean a lot of the stuff you do learn in university is theoretic so it doesn't apply to the job you will come to but you do pick up software which is a big thing when going into industry. But doing an apprenticeship you don't get that overall knowledge I think. You are very specific to one job, one company.
T: how do you think having that level of knowledge will influence perceptions of you in industry?
J: I think partially but it depends on the company and the size of the company. I went on placement to a small company and a lot of the staff there, like the directors of design didn't

have degrees and they started as an apprenticeship and just worked their way through it. I wouldn't necessarily say they had a slight bitter tone and it sort of felt like well I got here without a degree so why do you think you are better than me. it kind of came off like that. But I have heard experiences of other people who went to bigger companies and they have a much wider range of staff from university and masters so they are treated much more fairly so I think it just depends on the company.
T: you are on your masters course now, what persuaded you to do this?
J: I think part of it was because I didn't know what I wanted to do next. I could have started to look for a job and I did have the opportunity to go back to the place where I did my placement but I don't know I just felt like I wanted to push myself more, especially when I have been speaking to other people about chartership and things like that. Something to aim for, to become recognised and it does distinguish you among other people and while I have been looking at jobs at the moment, they offer jobs to people who have a bachelors degree of varying different results so having that masters puts me ahead of them when applying for that initial job.
T: what type of career in engineering are you wanting?
J: erm one area that I did enjoy when I was on placement was the design side. So working with various different modelling software. So creating products in 2D or 3D and one of the modules I have enjoyed more is where you stimulate things for testing, so measuring air flow around an object or analysis to see where a component will break understand certain situations so I think it would more be in that area. The stimulation, the design, product development, that area.
T: did you always know you wanted to be an engineer?
J: erm I don't know. I don't suppose I thought about it that much when I was younger, it was more towards the end of secondary school when I was like I want to know more about engineering, I want to know more about physics, I want to know more about how things work. I do like science fiction and part of that is understand the different aspects of science so I did know I wanted to go in that direction.
T: did you use to do things outside school and college what did relate to engineering?
J: I remember once summer me and a friend of mind built a little cart using old skate boards and creates and things out of his garage. Erm with my dad being an electrician, he has always done lots of DIY around the house so I have always helped him with things like that so I have always had things going on. So building things with mates, with lego or actual practical things with my dad.
T: has anyone in your family studies higher education?
J: not really erm my mum spent some time in university as part of her work, working towards a promotion but other than that I don't think so.

T: what to you does it mean to be an engineer? What do you think the role of an engineer is?
J: erm I guess it's pushing the limits of what we currently have. So all technological advances have all come from people pushing the boundaries. Go faster, quicker, cheaper. So being part of a job where boundaries are being pushed and things are being made better does interest me. its difficult to explain.
T: what did you think engineering was before you started studying it?
J: erm I'm not too sure to be honest. I mean it wasn't a big focus back in school. The closest thing we did was woodwork and things like that, they were simplified versions of it. I remember one thing we did was get a few pieces of wood and see what we could do with it, you know something creative. Some people put together a snooker cue. That was the closest thing, even the sciences, it was just the generalised stuff. The electronics, lots of physics principles that aren't related to engineering.
T: when you finished your undergraduate degree, did you feel prepared for your masters?
J: erm yes I would say so. The majority of the work isn't much different and going through the years, the assignments do get more complex but there are more of them so you get use to them so they don't seem as difficult and that has continued all the way through. There has been one of two modules in the masters which there hasn't been much preparation for. There was one just before Christmas which was called finance for managers, which as an engineering student, you don't do any sort of marketing or engineering study so it was something a bit different and a little difficult to get into. Not like other subjects which was similar to or built on the knowledge foundations we already have.
T: why do you think the university make you do that module? Could you see the benefit of it once you had done it?
J: erm kind of I mean not everyone will be looking at going for lead design and some will go down a managerial route so it is beneficial to have that knowledge of financing and marketing even if you are not directly involved with it. im just not sure it was taught very well for engineers. A lot of the teaching material was based around different companies so it was either oil companies and their finances or supermarkets, which isn't very engineering. Then we had an exam, part one of the main questions in the exam was to do with budgeting within the NHS. None of it is really relevant to someone who has been studying engineering for 4 years so some of it could have been taught better.
T: what has your workload been like throughout the 4 years?
J: the workload has never been overwhelming. There has been a lot of assignments and a lot of times when there has not been a lot of time to prepare for exams but there has usually been sufficient material to always keep up. To stay on top of it. I personally have

not always been on top of assignments and they have sometimes been deadline day finishes but more or less they haven't been too bad.
T: what about your timetable hours?
J: for the masters the timetable is very sparse, I think I'm timetabled for 10 hours but with the group project and various other projects we do it would be nearer to 20 hours in university. Compared to previous years, I think from first year to final year you spend less timetables hours but more independent, you just have to and come into uni in your own time.
T: I have heard from a lot of undergraduate students that the timetable is full in comparison to other disciplines, why do you think that is?
J: erm I'm not sure, two of my house mates did the computer science degrees and they generally tend to be in university as much as me. I guess one reason it might be different is because it is a broad subject area so there is a lot of different subjects to have to teach. Erm on top of theoretical stuff, practical stuff, stimulation stuff so I guess that might be the reason why because it is so much broader.
T: do you think it harder than other subjects?
J: with no background in engineering, definitely. I would argue that there are some subjects, with no experience in any of them that general people will find them easier. I think some subjects do come across as more observation based, so you observation and then your interpretation and engineering is more facts based and you have lots and lots of formulas and you are working with tight tolerances. You are looking for, there is no half measured and a lot of the time are looking for the right answer and there will be a right path to get there but it may a lot of the time be very complicated. Some equations even at masters level I am struggling to get me head around because they are so long and complex.
T: what would you say the lecturers were like in engineer?
J: overall I would say the lecturers I have had are quite good. You can tell which ones come from an engineering background and than those who are just academic, you can definitely tell in the teaching methods.
T: which would you say was better?
J: I would say those who have an engineering background. They tend to have a better way of relating the theoretical stuff to a practical background so it might have been something they have seen or worked on. Where as the more academic tutors base examples on theoretical stuff.
T: what are the structure of the modules you have? Lectures etc
J: it depends on the type of module you have. Like theromosynamics and fluid dynamics are all about the formula and equations so it is a lecture and someone stood at the front but when it comes to learning how to do it in a practical sense or using stimulation is it a much

smaller group and it becomes a little more one to one and the one I am doing the minute is more marketing focused so it's a lot of discussing about the best marketing approach and a lot of group work involved. We have open discussions about products where designs have gone wrong, tutorial sessions where we have been split into groups and come up with out of design and justify it and we do have a group assignment where we have to create a product and essentially try and sell it.

T: how have you found working with other students?

J: for the most part it has been ok. A lot of the students does come down to the fact that you are working with your friends, you know being in uni for 5 years with close groups of mates. So you end up working with those. You do with all group stuff, there are one or two who don't put the same amount of effort in as someone else. There is not much you can do at this stage.

T: do you meet and socialise with other students?

J: erm yes erm well I have mixed and met with other students because of my housemates. At university there isn't that much of a mix.

T: the friendships you have on your course – do you mix with them outside university?

J: yes I have done

T: would you say the friendships are work based?

J: with some it is just work based and I will speak to them about lectures or assignments but there are some people that I've become friends with and talk about hobbies, what they are doing at the weekend, family. It's a mix of both.

T: so what would you say engineering students are like?

J: I don't really know. You get a mix of people, you really do. You have a bunch of people who are outgoing and are easy to get along with. There are a bunch of people who are quite and mainly stick their groups and you have some people who are extremely intelligent and can someone be a prier and they are so forthcoming. Wherever there is a question to the room they are always the first to put their hand up and they go on with length explanations so everyone is different.

T: do you think there is a problem defining what engineering is?

J: I would definitely say yes and they give names to people to make them feel better about their job. Being called an engineer is better than an alternative but then there are people like myself who have gone through university and working on new designs, new products. It lowers the value of it I suppose because going through a lot of training and learning to get to that point of saying I am a qualified engineer who hasn't done the same amount of work also says I am an engineer.

T: would you describe yourself as an engineer?

J: yes

T: what do you think makes you an engineer?
J: I would possibly say based on my very limited experience of working in a company and creating designs and creating products. While I was on placement I did design some products and during my time there I helped build and test them before they were sent to the customer so I have been part of a products entire build cycle. Design to testing. Plus the knowledge I have for various different computer software programs kind of put me ahead of someone just starting out I guess.
T: what would you describe the engineering culture to be like?
J: I don't know if it would be classed as an engineering culture, it just a bunch of people studying the same thing and because you are with them for so long you just become friends. I mean when it comes to cars there are a few people really interested in that so they create their own sort of groups but in general I don't think there is anything else really like that.
T: do you do any other activities inside or outside university what link in with engineering?
J: yes there a couple of pages on facebook what report on new technologies what are being brought out and new things being developed. Being a member of IMechE, they bring out news letters on different projects around the world. There is an engineering magazine I get on new developments and jobs and different political events may effect engineering.
T: what type of things do you need to learn to become an engineer?
J: having the skills to quickly pick up software is definitely one. The more advanced engineering is definitely software based, all the research and development. The theoretical stuff doesn't really come into play. Companies have software set up and you plug in the numbers and it will give you an answer. you don't do pen and paper, writing out the equations. I'm not quite sure what else.
T: how important is engineering and being an engineer?
J: erm well I mean with all the difficult problems in the world at the moment, engineering and the sciences is where problems start getting fixed or the foundations of the solutions come from. Look a human revolutions have come from someone building something in a shed. The first aeroplane, first machinery, first mass produced cars, all that kind of stuff.
T: can you kind of see yourself as being an engineer and fitting in with what an engineer is?
J: yes erm yes like I said being interested in science fiction, you see different devices and technology and think it would be amazing if that sort of thing existed. Well why doesn't it exist, well there is this reason, this reason so you say ok well how can we overcome these reasons. It was one of the reasons why I got into engineering and one of the reasons I want to go far in it.
T: how would you describe engineering? I have read papers on it being objective, impersonal, masculine.

J: erm I can see where some of those come from. Being objective definitely, you need to have a very clear idea of what you are trying to do and what your aim and goal is, especially when you are being analytical, you need to have a very precise set of steps for a very precise goal. I guess it is competitive because everyone is trying to design the next best thing, you see it with phone companies. Impersonal, I am not so sure. I guess a lot of it comes down to sitting on your own on a computer working away. In big companies there is more of a push to have it more open and groups working together. Lots of group discussion and ideas flowing around. In terms of masculine erm I don't know I mean over the past 5 years there has been an overwhelming majority of male students but as times have changed and engineering have become more computer based than practical based, there is nothing stopping women becoming engineers. A lot of it is less like in the 1900's is was very dirty, heavy work but in this stage there is no reason why they cant get into it. maybe there is still a negative stigmatised to it. I don't see a reason why anyone cant become an engineer really.

Appendix 23 – Masters participant: O M

T: when did you decide you wanted to study engineering?
M: I decided a long time ago, I was in high school. I thought about a number of things during that time, I think was in my second year and we were told or asked to choose our career paths and I was sort of brainstorming what I really wanted to do. But the situation was, as a kid, I always wanted to be an architect and when I was a kid and I use to go to bed I would draw a number of houses and even today I still look at buildings and wonder why I chose mechanical engineering. But anyway at that time I thought what I am I going to do and I thought of law and the banking industry and I looked at it and I thought everyone seems to be going down that route. So then I thought about the fantastic things I could do as an engineer and my friend was there who mentioned dismantling an engine and putting it back together and watching it run, it is fascinating. You enjoy the feel of doing that and so I signed up to become an automotive engineer and the rest is history.
T: so did you work in industry before you came to study?
M: yes
T: how come you decided to come back to study?
M: erm after college I started working as a mechanic for well erm one of those major automotive manufacturer and when I was there I was basically repairing the vehicles and I got to a point where there wasn't anything that could challenge me enough. I got to a point where I was really young and I had an apprentice working for me and I thought when a problem came in I would determine if I was going to talk the problem on or give it to my apprentice. And most of the things I thought was easy and I would give it to them and I would teach them along. But then when a real problem came in that nobody seemed to be able to solve or want to solve, I would say I want that one and I would push the boundaries, push the boundaries. Instead of my staying here and solving the problem, I want to be a part of those that create the problem in a sense that those designers that design those vehicles, those at the inception of the problem if you like. And I am here at the back end, resolving the problem when the customer has it so I want to go from the other end because I felt a bit restricted because I can only work in accordance with what they gave me. I wanted more leverage so I decided to go to university.
T: is engineering something you have always been interested in?
M: yes ever since I was little. It is a natural part of an engineering, an engineering mind if you like. As I kid I didn't understand it but if I, I think I go to a professor some time ago and I think he was doing similar research and he brought up a couple of questions and then years later I still remembered the questions and I was trying to remember what I did as a kid and he was trying to assess people from an early age, I think from for years old to see

their behaviour pattern and then as they develop into adults to see if they develop a trend. He mentioned it but I didn't go into detail but years later I was thinking what I did and I now look at kids and see what they do and it may be a bad thing and you could say to a kid you will go down that way, you will go down that way. I genuinely think people act a certain way go down a certain route because it is almost intuitive. There may be two kids and you can give them both lego, one will put it together, the other will want someone to help. You can look at both of them and think that one will be an engineer or a scientist and that one wont. I also know if you put a lot of effort in you can reconfigure your mind but as I said a lot of this comes natural.

T: what kind of mind-set would you say you need to be an engineer?

M: very analytical, very inquisitive and I am going to use this word loosely, very technical. You know, be able to look at that wall and sort of imagine what will be on the other side as a lot of it will come through imagination. You get pictures in your mind what you want to solve. Or if there is a problem, you want to solve it, you want to get to the route of it. There was a philosophy I had when I was working with vehicles, with my colleagues, when we had a problem, they will generally say that is too hard I don't want to do it but I would look at it from the perspective that is this was good at one point in time and for in to not work at this moment in time it is something within this configuration that has gone bad. It was good at one point, it was working perfectly and not it has gone bad so it is my job to find out what component within this vast configuration that is not perforating as required and replace it. My other philosophy was a man made it, I can do the same. If a man made it then I can fix it. If god made it I can accept my limitation but if another man made it, whatever capacity you are in, I can do it as well. So having that sort of foundation working from, I was not afraid of anything.

T: what attracted you to study engineering?

M: I always believe if I am going to do something, I want to do it to the best of my ability and there are times when even when you had a degree, even to a professor level and when you do anything there will be a number of possibilities and a number of assumptions made because most of the time you wont have all the data to work with so erm but working at the lower level as a technician, I was never comfortable being told something and not understanding where it came from. Somebody came around in my last job with a clipboard and white overalls and I solved the problem better than them and I thought why should I listen to that person, why don't I know it myself so I figured based on the society we are living and working in. my only way to get where they are coming from and to understand it is to go to university and see what else there is to know

T: what would you say an engineer is?

M: in a nutshell, the people who solve the problems of the world. That is probably it, I cant give you a. if I was going to use a dictionary meaning but in context, the people who go about solving the problems you can ever think of. Lets go back to the primitive days when people would go back to living in caves, now we live in buildings. Now we drive cars with air-conditioning and all this happened because of engineering so that perspective. Engineers solve the problems that human beings have.
T: how do you think having that level of knowledge when you go into the workplace will influence perceptions of you?
M: erm it is almost as, I wont use any technical terms we use in a subject but people generally have perspectives based on what society expects them to believe. So up to this point, I had this conversation with an engineer many many years ago and he said engineers are not given the credit they deserve. Generally speaking a person who is a lawyer or a doctor are respected. If you look at society as a whole, it will teach you if things are good or bad, and that is where engineering comes in. I don't think the credit is given. So me going into a workplace is really down to the perception of people and we may go there and do our job and people will appreciate what you do but the dominate force is society perception.
T: what type of career in engineering are you thinking?
M: erm at moment if I had not worked before I would have thought of with no experience I would just taken what is given to me and tried to morph a career but being a mechanical engineer the spectrum is to wide, we cover a lot of groups and nobody can be everything and because engineering covers so many principles and topics, you will generally end up in one area and become a specialise in that area. Try to do everything and you wont have enough time in your life to do it. I generally think about going into design engineering as at least it gives me the opportunity to create something from scratch. But at the same time if I ended up managing a firm, I would still do it. I don't want to restrict myself in my thinking.
T: how come you chose to do a masters?
M: after completing the undergrad and working before and I noticed a lot of people who have completed the unergrad then come back and do the masters so I thought I might as well just complete it and then go out. But I also in some point in time I want to do a PhD and why I am not going straight into it is because I want to do something I want to do and I enjoy doing so when I start working again and whatever discipline in engineering and there is a problem to be solved, I will take on a PhD in that. At least I will want to do it so it is sort of creating the foundation for what I am aspiring to do in the future on top of which I do believe having a masters will create the foundation for managing at a certain level and as I have worked before I don't mind going in at the higher level.
T: do you think people perceptions and expectations of you will differ from having the masters?

M: sometimes yes but not all the time. Sometimes that has been tarnished by individuals behaviour as I know people can go through study with a lot of help and then go in the real world and cant function and that sheds a bad light on others. People will expect you to operate at a certain level and having done the masters now, I see where we have been exposed to things we have not in the undergrad course and of course we have a good foundation and sometimes things are coming at you so fast, you study for the period, flush it and try to get on with the rest of the course. You may notice higher level, the tutor may say I expect you to know that. And it is true you should know it but as so much information is coming at you, you cant maintain it unless you do it over and over again. Some people come in at this level from industry and that is why. Yes some people will expect you to know certain things and that's not wrong, and naturally there could be many reasons for that. It could be jealously, of you have a masters so you should know this, that sort of thing. There are a number of reasons why that could be the case, we cannot do a sweeping statement as to why.
T: what was the transition like from your undergraduate study to your masters?
M: the lectures are a faster pace, a lot of principles are assumed to be known. Nobody would take the time out to explain certain things, even at the undergraduate level. They assume you know it or that you should know it. The responsibility is more as well, it makes me laugh some people in our group still have student mentality or undergrad mentality where you get an assignment, do it and reference it of course but you don't have a true understanding or appreciation of what you are doing. Then you get to masters and you are given more responsibility, we are building a car. Up to this point we are just following theories, someone else's research and reference it but now we are doing it for real and this component has to be perform and all of a sudden you get to a point where you have to validate your argument, your product. Why you are doing what you have done and as I would say you can say to many people you can go out there and design whatever you like but can it be manufactured and erm is there anything, can it perform as this is not theory anymore and although it is not entirely in the real world I think it is creating that transition to the real world. There are a lot of things going on there what we had to think about from the ground upwards and as students we still have a lot to think about. Its not just a car, we have to think about safety, will it function, will it do this, will it do that. There is a lot involved, it is a science. I do believe at masters level it does create the transition.
T: at undergraduate level it is a lot more about right and wrong answer and things are black or white but as masters it is a lot more about justification and personal thoughts. Do you think that is a difficult transition?
M: yes sometimes because you see the modules are hard, one has to appreciate that, it is hard. There are a lot of assignments coming at you at a fast pace and understandably so.

With maturity you understand, multi million Pound Company's have a lot at stake and the consumers, they have a lot of stake from ethical, safety etc. but as undergraduates because it is knew to you, you want some reassurance. You have the question but you are not sure, although you want to think for yourself, you also want to pass the course at a good level and so you don't want to take any chances but at the pasts level it is sort of a wake up call because the responsibility is on you now. The teachers are not there to give you hints or something along the lines now. You have to think for yourself. So right or wrong yes but of course they do mention there is no right or wrong as long as you can justify. But it takes a while for people to get to that point

T: the group project you have been given, how did it feel been given that task?

M: erm of course I felt I could cope but perhaps that has to do with the fact I have worked under strained circumstances before, I spent years in the military. I also know from experience you will be given a challenge and you be able to solve it some way somehow. It can be solved as long as you think about it long enough and apply yourself. It always can be done but the only problem generally speaking, when you have a group there is a group dynamic going on along with everything else and people will operate from different levels and you have to understand that and give and take and that in a challenge in itself, its about give and take. It is not just the project, it has to be harmony and for everyone to get along and understand the principles of why you need to pull together. This applies to industry as well, for an aircraft, parts may be manufactures in the far east, a part may be manufactured in france etc and all these groups of people working in different countries to be able to assemble an aircraft in the end and for it all to work it takes a lot of collaboration, a lot of meeting and leasing to bring people together. There a lot of layers and levels to go through to get to the end product so it is good we are doing the group project to help people understand that when you work with different people or in collaborative environment and you have to almost naturalise yourself. I think working in a group is one of the biggest challengers but I think if you are an engineer mentally because don't forget, not everyone who does engineer is an engineer mentally. I have seen people change course along the way. But you have to get through the meetings, the struggles, thinking he is not doing his work, he is not doing his. Then to get to the problem of manufacturing a car. I tend to speak less in meetings but I am ok with it.

T: what about the ways of learning, timetables hours and assessments, do they all differ from undergraduate level?

M: of course days are shifted around. We have three hour exams now, we use to have two hours. We have some two hour exams still. The way they are assessed it not much difference. The timetabling is shifted a little bit but I view it as the same almost

T: would you say doing the masters has provided you will more expertise and independence?
M: yes you become, it develops you more professionally. If you are going to work in an engineering environment, the fact that we cover so many subject areas, especially business management, finance for managers. If you were in an engineering environment you would crack on with your job so to speak but now you understand it from a management prospective, the funding, what should be given priority, how budgeting relates to what you are doing. It will enable you to understand the environment from a more holistic point of view rather than just an engineer doing an engineering job in a corner.
T: while completing your masters do you think it has changed you in anyway?
M: I do, I think it prepares you mentally to take on a career as a professional. As an undergrad you go out there, perhaps on a grad scheme which does the same thing to some extent. Doing a masters you are mentally prepared, even for the grad scheme if you will take that route, it helps you understand the world of work a bit more and the culture in which you are working. Without given you the responsibility to drop you in the deep end, masters prepares you for that world.
T: do you think lecturers treat you differently?
M: I think they would like to and that's just by virtue of suggestions made like you should know this you should know that. I think they would like to but also there is a lot going on in a university environment. Perhaps the care is not there, sometimes it just feels like they are getting the numbers through. At the same time the lecturers have a responsibility to deliver on the material, the numbers of the classes are greater and the pupils are of various backgrounds so accommodation has to be made for all these differences and you have to apply a level playing field. As a student we sometimes have to struggle to understand what is happening and you spend a lot of time working through the presentation and I think it is a good thing as everyone has something to contribute but I think they do look at us from a more mature perspective but there is a lot to be considered.
T: engineering has a fuller timetable than other disciplines, why do you think that is?
M: I think there is a lot of material to cover. In engineering because it covers so many areas and we have to get it in because the modules we cover are dictated by industry. Most students don't know but industry big players gather quartile to discuss what industry requires and the university try and tailor the material around what they require so I think in order to get all the material out and to get students exposed to all these they back up the timetable.
T: do you think engineering is harder than other disciplines?
M: if I am going to be erm I think I would have to sit down with people from other disciplines or follow another course to justify a statement but I do believe engineering is

hard when I look at material from other courses but in order to say that with confidence I would have to follow other courses.
T: how have you found teaching and learning in engineering?
M: like most things in life, when someone is exposed to something for the first time, it will take a while for you to become comfortable to apply it. Some people learn by experience and even if you told me you gather something by theory when you go in the real world the theory and reality are different in some regard. Of course the theory is there to appreciate this topic but some theory will be distorted in reality to make it work from an engineering perspective. You can always teach someone in a classroom but that career context will depend on the pupil sat in front of them and they will have to apply themselves and if they are delivering something which is not getting through then you have to apply another strategy whether it be demonstration or whatever it is. Same with engineering, I can learn about aerodynamics for example, I learnt it around stimulation but I only understand aerodynamics when I rode my bike off the hill and feel the wind resistant and I think actually it makes a lot of sense. Those come from experience so the teaching it always to be understood as introducing you to something because for instance we were doing a module earlier and some terminology got mentioned, PIV and I had never heard of it before and certainly now if I went into an environment where that was used I would be able to say I have heard of that before. And now I can start understanding it.
T: do you meet or socialise with other engineering students?
M: we do yes.
T: how do that influence your learning?
M: it doesn't
T: how would you describe engineering students?
M: well it depends how your brain is wired. An engineering student will see an image and put it in a CAD model where as an artist can put it on paper and physically draw it. They can do something different to what we do. They of course see things differently and talk about things different but it what you are taught over the years. If you are told to do maths you will. Engineering lectures will also be different, you are conditioned depending on the career path you follow
T: how do you think engineering students have been conditioned?
M: generally conditioned to solve technical problems, so you will think about things from a technical, analytical, scientific point of view where as someone else might think of it from a social view as well but engineers do think about social view from the stakeholders you will need to consider. We look at it from a functionality point of view. For example a formula one car is designed for speed and to win a race, whereas the car for the domestic market must be comfortable. You don't think about things from a social view, you think about what

material do you want it to be made from and how long you want it to last. What the cost of it, sustainability, you go down that route.
T: would you describe yourself as an engineer?
M: I would yes
T: what makes you an engineer?
M: an engineer is primarily the way I think. It is very much to do with that and that is coupled with your training. Getting to a professional engineering status, there are accredited bodies in our society to evaluate where you are at. And after a number of years you may get accredited to that level so that is partly to do with society but I think it is rightly so as you could leave university thinking I am an engineering and you get into the working world and start facing challengers and then you start feeling more comfortable as you face them. As an engineer you have a lot of responsibility, hence the reason you have to consider experience as you could design something on the computer and it look nice but will it work and that's the part I am concerned with, will it work in reality and protect people and save lives.
T: I have read a lot of papers on engineering being objective, competitive, impersonal, masculine. Is that something you have seen?
M: no. competitive, that is the nature of the world, if you are not competitive you simply wont survive. Humans are always competitive, go as far back as you want. People pay money to see a fight, like a boxing match. Its exciting. Its always about competition. If you are not competitive, it is almost as if you are boring.
T: is there competition between students?
M: I don't see it, I have not seen that. I am not saying people aren't like that but as an engineer you cannot be exclusive. As an engineer you have to be open especially if you are working in a group, you have to listen to everyone's contribution and make sense of them all and use the best idea. If my idea was not the best at the outset I should be prepared to accept your idea and run with it. As long as it makes the team succeed. You cant be an individual, you wouldn't go far. You kind of accept you are part of a team.
T: do you think there is difficulty feeling you belong in engineering?
M: engineering by nature is like that, you always moving and talking to other people. You get use to the changes in environments. One day I could be working on a pressure vessel then next week some thing else, different client but the engineering fundamentals share all of them. Or if I am just a crane engineer or aircraft engineer and then you could become a specialise in one area but you have to collaborate with other departments of this object. New technology comes out and you need to learn it and follow it and you always need to work with others to get the end product.

You feel like you belong in engineering but not in a particular pocket. Maybe mechanical engineering because it covers such a wide spectrum you get use to being all over the place so maybe that's why you get the feeling, I'm just here

T: what other skills would you say you need to be good at engineering?

M: you need communication, you need team work. In engineering you will never be able to work alone. I would have to think very hard for a scenario where engineers work alone because a lot of things are so interconnected. You have to be brilliant to communicate your ideas to make sure they are compatible to one another mentally you need the engineering thought process.

T: how did completing a placement influence your studies?

M: it helps you to appreciate, especially if you are following engineering along a certain route. For those who have never worked in engineering capacity before, it is an eye opener of what happens in the real world and it gives you some perspective and theory rather than trying to imagine what is being said.

T: if you were to say you were studying engineering what is the reaction?

M: the reaction can be wide. They think oh that must be hard because it is a lot of maths and physics. The reaction is generally like that.

T: what else would you say you need to succeed in engineering?

M: you need confidence and you need to express an opinion but be flexible.

Appendix 24 – Masters participant: Richard H

T: when did you first kind of get into engineering?
R: erm well I have always been tinkering bits from a younger age but I never really knew I wanted to come into engineering, equally so going through school and sixth form, I never really knew what I wanted to do. It was only when I took a year out and I started looking. After my a-levels I was pretty much burnt out and fed up with education and I didn't really know what I wanted to go into. I carried on doing my part time job for a bit then stumbled across this course here and I am from Huddersfield away and I thought I do quite like electronics so I will give it a go. It wasn't the grades were an issue, I thought I was fed up of education but as it turns out it was a good move and I have enjoyed it.
T: what is it what attracts you to it?
R: I just like building things and making things work and bringing things to life if you like. The course equips you with the knowledge to do that at a more detailed level as well. like considering when I was younger like putting a motor on a remote control car to make it move or something like that to building things from scratch like I do now. I do do it from time to time but nowhere near as much as I should. To do my own little projects, maybe once the masters it out of the way I might get some time back.
T: have you always been good at the subjects liked with engineering like maths and physics?
R: physics yes and it does involve the maths but maths as a concept I have never like. Although I can do the maths I was never good at. My GCSE maths was fine, I did really good at that then I took maths for a-level and erm no I didn't do very well but the physics I did. I know why its because you can apply the physics to a real world concept, I can visualise what's going on but numbers mean nothing to me when there is nothing going on and although I did make up scenarios but then maths for the sake of maths is not enjoyable but when it is applied to something it is far more fun and interesting.
T: when you kind of knew what an engineer was it is something you can see yourself doing?
R: erm well I didn't know there were so many disciplines in engineering. Electronics was where I wanted to go, the engineering part wasn't really clarified, it is only when I have finished the course and gone out into industry and further study and I can see were the different disciplines in engineering come together to go into real world things. I think in this country at least, I think the profession engineering encompasses too many disciplines perhaps whereas like Canada it is far more of a respected status.
T: what would you say an engineer is?
R: I can answer that as oppose to a technician. I would say one up from a technician. So an engineer for me would be design a solution to a problem that hasn't had a solution as yet.

Using your knowledge, pulling knowledge from multiple disciplines in engineering. Whereas if something breaks down and coming up with a fix for it would be more of a technician role. That is my understanding of it.
T: so why did you decide to study engineering?
R: erm as engineering a profession, as I say I didn't really understand it, it was just my electronics what got me interested. I wasn't sure on the careers afterwards or anything like that.
T: how come you decided to study it rather than apprenticeships or getting a job and working your way up?
R: erm the apprenticeships that I found were more for an electrician and it has wound me and a couple of mates up because they have just got a house and they can't rewire it because they are not certified to do so, even though they know how. It is just because you don't get that certification with the electronics course because it is another disciplines. They are probably 90% of the way there with the material they need to know to get their licence.
T: have you got anything out of studying engineering that you didn't think you would?
R: of yes there is a large amount of professional develop you get, it is taught on the course and you get it from your placement. That includes team work, business related issues, managing projects. As well as sort of driving your own work forward and what you have to do when you encounter problems or technical issues. On placement as well you have to be able to describe your problems technically and non-technically to various people who have a stake in what you are doing and I think you do need to know how to do that and who you are talking to and what that person needs to know and at what level.
T: how do you think studying engineering will influence you when you go into the workplace?
R: Industry is far more fast paced and it is product driven. In academia is it nice that you get to complete your project, you get to see it through and write it up where as in industry it is get it to a point where it is working and get it out the door. There is no I did see these little quirks I would like to go back and see what they were. You don't get time for that. If the quirks come back to bite you you get to look at them. It is fast paced like that and it does bug me a little bit, it is something I have had to get use to and it is a difference coming from academia studies and coming into industry. That is the challenge doing the masters part time on something that is related to my work, what I do in my job. I have had to keep on with my masters work even though the product went out of the door years ago and there were problems with it what I am investigating but the company were not bothered about. I have had to change my studies so many times to make it less stress from the company and more of something what I want to work on so I have been pulling bits from the company.

T: how have you found that, negotiating between what a company wants and what you want?
R: erm difficult because it is not like this everything I think it is just because the company I am working for at the moment is because it is new to building products so it has been fast paced and they had to establish a route forward. Rushed would be a summary word there.
T: what about doing research which is not solely directed by you?
R: erm well I have been working with dave, he has developed something for his PhD which looked very applicable what I was trying to do with my masters in the sense that I could use it. my application so long as I develop as a bolt on to it which made sense because I had the skills to do this back end stuff where as he has the developed circuit and needed something to control it so we managed to collaborate that and we worked closely and got it into two papers.
T: how do you think having you undergraduate degree and masters will influence you in the workplace in terms of expectations and perceptions?
R: erm yes I think the skillset, so 60% of the in depth maths stuff I have learnt in have not used in my work as it is more hands on rather than sitting down and studying a theory. But the university equips you for knowing where to go to find the knowledge you need in order to build it and sometimes you have to do the theory in order to know what you need to build. And you have to know oh yes its that part, because you don't always used it day to day so you don't always remember it. at least you know what it is you need to build it and where to find it. so you might have done something and be able to apply it. I think on the course it is difficult to teach the practical skills industry needs just because of the setting really. You are not building a product, you are going through the course which requires a different mindset, you are studying at university so there is a leap you have to go through to industry and I think employers know that. That's why I think placement years do help, we have a placement student with us at the moment and she has come on really well in terms of putting skills into practice.
T: do you think because the course lacks that practical element it is why a lot of people do mess around with things at home?
R: I think it is a really good thing if you mess around with stuff at home. If you want to come into this field of work, it shows interest and I think you are right yes. I think if you study the course but are not interested in building things then it sets you up for the more management route because you have an overview of the technical stuff but you take a management route going forward but you are not building things, you just need to know the technical aspects required. That is just what I have observed.
T: at undergraduate degree you were timetabled in a lot in comparison to other courses, why do you think that is?

R: oh right (laughs) erm are we? I mean there is a lot of theory, maybe 60% you don't use but the course has to equip you with disciplines inside electronics. You go into communications or digital design. 60% I don't use by field I have gone into in electronics. There is that much going on, the course does well to equip you with what you need.
T: what about assessments, what type of assessments did you have?
R: there are exams to test theory, there is sort of design a small circuit to perform a function. Normally to a mathematical theory and logic, I know that was one of the exam questions. There may be a coding questions in an exam. Communications is mainly maths based and there will be a lot of derivations to go through, algebra erm so there is that side as well. there is course work as well and that is when the practical side comes in although a lot of it is reading based and stimulation based. I know first and second year there are a few where you have to build the circuit, prototype it out and make sure it sort of runs through with the maths. There is the final year project where you have to have a physical output at the end of it where you do have to produce something.
T: in the assessments does it just tend to be factual based or are personal opinions accounted for?
R: personal opinion of where you want to go with it.
T: what like I chose to do this because..
R: erm I mean you got to choose what you wanted to do. I created my own project based on what they wanted and I had to run it by the supervisor I had in mind to check it was technically challenging enough and say what I thought I could get out of it with the intended outcomes I thought. You have to be able to back up your decisions with evidence. You have to back up why rather than weight up an opinion based.
T: did you find the way of thinking at undergraduate level and now the way of thinking when doing research, did you find that difficult to adjust to?
R: erm I think I have managed to maintain, you have to find your own route forward. You have to go off and find knowledge in undergrad as with postgrad. The difficulty for me was industry and postgrad study at the same time. Erm like I say it is a different way of thinking.
T: what about at undergrad when you would have been given a project which needs to do this and this, whereas research is like flexible and you are looking for where you are going to do?
R: it is always a challenge, I didn't find it difficult. It wouldn't be research if it wasn't challenging or it would have probably already been done but erm the interest is there so I opted into it.
T: do you think undergraduate study prepared you for your masters?

R: erm yes both from a knowledge point of view and where you need to go and get the knowledge. You do encounter that at undergrad and the masters
T: how come you decided to do a masters?
R: I knew I wanted to do some sort of postgrad study and originally the masters was incorporated with the undergrad course but as it happens a knowledge partner transfer ship came up which included doing the masters part time while working full time and you got all the training benefits with it. it was a good scheme really run by innovate UK. I got lucky really.
T: how come you felt like you needed to or wanted to do postgraduate study?
R: erm from a career point of view I knew it would make me stand out and from a chartership point of view you only part meet that from undergrad course for the educational requirement. I knew in some form I had to do it and then in industry when you are chartered you get to progress quicker and get the higher salaries. I did look at doing PhD's as well but I think I am more suited to industry.
T: how did you find the transition to doing your masters?
R: erm it is a step up as it is a masters by research and you are taking on a problem that doesn't set have a solution and you are scratching your head for a little bit and you are trying out solutions and I think you do tend to have an initial idea where you wouldn't mind going. I know mine changed direction a few times but erm you have to know when you get stuck you need to keep trying to do a few things, go off and do a paper study, see if you can get some ideas from other things that might have had a similar problem and try them out and you might get close enough results that you progress down that route yes.
T: that is one thing I have seen, engineers do help each other out a lot but at the same time there is a lot of banter with people
R: a lot of the time if you are really stuck with a circuit, I mean me toby and dave do it and we will have a rant and they say oh what about if you do this and of you are like I haven't thought of that. It might lead you down a path you didn't think of. You can bounce ideas off each other and it is a good working environment. It is good for collaborative research when you can do that.
T: how often do you see your supervisor?
R: 2-3 times a week
T: do you think that relationship is important?
R: yes yes erm I mean I know that compared to some researchers I am free range. I know what I am doing and where I am going. I know some supervisors are strict and methodically.
T: how do you think the relationship with your colleagues kind of helps? Is it mainly work based or would you go to the pub and chat about other things?

R: it is a work based thing. Out of work, well certainly yes and no. if the conversation comes up out of work it will go on for ages, much to the frustration of other people who we are with who aren't interested in what we are on about. Erm but I think yes, if it comes up it will go on for ages. We're not trying to avoid it, it is just what we are interested in.
T: I guess it is a mixture of a hobby and a job
R: yes and you kind of want to talk about what you have done through the day, like oh I had this problem or I was doing this and finally got it working sort of thing. I think you do talk about what you have done through the day it just so happens we can go off very technically very quickly and start splitting out a load of words what don't make sense to anyone else listening in.
T: because you have done your masters, do you feel people expect you or that you should be an expert?
R: erm I feel like for what I have researched I should know what I have researched but it terms of engineering as a discipline, you are expected to know more as you progress through a career and being able to coordinate information flow better as you progress. But yes if you are going to research something, I don't see why you shouldn't bring that to the table when you move on and I think it looks really good.
T: do you feel like you have changed while you have been doing your masters?
R: stressed (laughs) very stressed but that is just not because of the masters, I don't get anytime to do it in the day. I am doing it evenings and weekends and it is a tall order. Erm technically obviously I have advanced but work relationships and just generally knowing how or getting better in sharing ideas or thinking about other issues than aren't exactly mine to help someone else out and sometimes that does lead you on to thinking about something for yourself. And also I think it is good sometimes to think about something else every now and again and put aside your work and allow fresh thinking.
T: the engineering drop out rate is quite high, why do you think that is?
R: erm maths, if you cant get along with the maths that would be difficult. I don't know of any other, I cant see any other issues. A lot of the time you do have to write a report, maybe if you struggle with report writing then you may not be able to convey the information across. Erm but erm which is a shame really as that might not reflect technical skills but I cant see any other reason than that really.
T: I know a lot of people struggle with aspects of engineering but they still stick it out, why do you think that is?
R: I think there is a different between being interested in it and the challenging technical aspect to it. you do have to have a level of technical knowledge there, maybe if you were interested in it and you found there was a big leap, that could be an issue.
T: would you describe yourself as an engineer?

R: erm I think once I have my masters and I am well on my way to working towards my chartership I would yes. Yes I have the engineering job title at the moment but erm yes I think by the goals and the targets I have set myself and where I see myself going, that is when I would call myself an engineer
T: why not at the moment?
R: erm just from a technical level erm because some of the decisions I do make, not so much my research as I am driving that but maybe in industry, it might be the correct technical solution but it may not be the most beneficial to a company from an industry point of review and I think that is a balance to getting cost, quality, time of design and things like that. I would like to be elaborate with what I design and make sure it works really well but it just has to, all the company is bothered about is if it works as a product and if it is as cheap as possible. And there is an art to doing that erm because you have to remove your curiosity to a point so you can just get it working so you know my company supervisor would say oh you just need to do this and it might not be a decision I have done myself. It might not mean I am doing it wrong, just not the best way. Until I can make that sort of decision or not need as much input like that.
T: what kind of skills you need to be good at engineering?
R: erm you have to have interested erm you have to be interested in one you are doing. You have to be as objective as possible, I think objective and interested conflict sometimes. Erm but technically you have to be analytical, you have to analyse where the problem is. You have to be methodological in the way you do it. I once sat in an interview as my supervisor was off and I once got fired this question when I was in an interview so I fired it back. I said describe a situation when you encountered a fault and what are the first steps you take when you try and rectify it. and it is generic procedure in electronics, you work from your basics up and just tests levels of functionality.
T: what about soft skills?
R: you do really well if you feel comfortable enough to just pick up a phone and ask someone, it comes back to the sharing ideas thing and bouncing ideas off each other. You do well if you just pick up the phone and ask someone. Communication side of it and a team working aspect there. I think that is more in industry, from a research point of view, erm I think you still have to have communication to bounce ideas off but in research is it more you are close to people working on similar things to you. I think there is a risk of going off too far on asking people who are working on things completely different and getting ideas mixed up or going off too much on a tangent. Erm to what you were originally asking for but erm you still need to be able to ask and talk about it
T: would you talk to people from the same department who weren't necessarily doing the same thing as you?

R: that's just wasting time. I think you already have a lot on your plate erm, for collaborations. Some of it is interesting, I wouldn't be working with dave if I hadn't been bouncing ideas off each other and it was only when I spoke to him I knew what he was doing and thought hang on a minute maybe I could use it and equally I helped him out but maybe you don't want to overload your plate and there is a risk of doing that if you talk to too many people.
T: would you say that engineering is quite competitive?
R: there is an element to it. I think some more than others, some really like proving their knowledge and really showing what they are capable of. Erm i do like taking credit for what I have done, I am happy to give credit to others for their work erm but I don't like it when credit is stolen from someone. Happens a lot in industry when your manage might take credit for your work. Not so much in research because that is your project, unless someone beats you to a research paper somewhere. I think there is and you have to understand you have your own schools and there is that many niche disciplines that you do have your own strengths and others erm you cant be the best at end of them and you have to understand your own skill set and there is a danger in overspecialising in those.
T: in lectures and things when I have been observing they will say oh you should know this or you should know that. Is that someone you do already know or do you have to go away and learn it?
R: I remember the jump from first year to second year and they were like you should have covered it and they don't re cover it for you and there are one or two things you have to go away and look up, especially the more challenging things. you are then expected to know it in second year but I think erm there is a lot to take in and it is where you have put your eggs in what basket. In some lectures, especially the more challenging ones, you are reluctant to give that subject your attention compared to the easy ones perhaps and that's where the gaps show in second year. But there are some easy stuff and you do forget the basics and you are like I cant believe I forgot that. In lectures that will simplify stuff for you and it might be a basic formula and they will be like you did it at GCSE and you just cant identify it.
T: what would you describe the engineering community to be like?
R: there are all sorts of forums what are on the internet for just tinkering with things. technical, non technical, sharing ideas. On those forums there are a few people who go on there and shoot the idea down straight away. There is a sort of eticate to forums where you are like I new on the forum and I don't know if this is the right forum and all you want is a simple answer and someone will just give a big technical response of why they shouldn't be doing it. it might not be the professional way of doing it but as a group of people you do like

bouncing ideas off each other and you do have a rant with each other as some of the things we come across are frustrating.

Appendix 25 – Masters KTP participant: Toby

T: when did you kind of get into engineering?
To: Ive always tinkered with it because my dad, he had his own electronics company, it when bust when I was quite young but there was always bits round the house so if you wanted to build something go look in the cellar or in the spare room and you could find bits to. normally things that didn't work and you could glue up. Then I did my first undergrad in engineering and I soon worked out by the end of that that I didn't like working in the studio for musicians but I liked building new bits of equipment for people. Building new interesting things and that's when I went back to university and did the second undergrad in electronics. So yes its been a progressive thing
T: what is it what kind of attracts you to engineering?
To: I like the problem solving aspect, I like there is certain things where there is rigid sets of rules and then certain things what are very open and you have to swap and change between the two. You also have to have a very strong sense of intuition at times but you really have to back that up with research and data and you really have to balance the two so it means there is always something different and always a different approach to every problem.
T: when you kind of knew what engineering was, is it something you could have seen yourself doing?

To: yes it took me a long time to get up to speed with a lot of it. a lot I was doing was in evenings and weekends after work just getting up to speed but it is one of those things where there are multiple levels to it. you can sort of see yourself just about achieving the next level and there are all these other levels which are achievable so it is sort of one step at a time. You are half way to do it but not all the way there if that makes sense
T: so have you always been good at the subjects linked with engineering?
To: physics and maths no. I got thrown off my a-levels but that was more through being a bit dis-effective at 17/18 but no I have not always have the patience with the maths, especially at undergrad I had to do a lot of work to get up to speed with my maths. There are often engineers who work from a practical view and come back from there and then there are people from a mathematical view and work forward from there and you have to really be able to do both and it took me a long time to get up to speed with my maths. Nearly there now I think. There is still big gaps, I still have to have my maths books in the top draw to look things up, things I should know but its difficult. The practical bits I've never really seen as an obstacle. I've always just got on with things.
T: do you think people tend to be one or the other?
To: I think they tend to have a comfort zone as one of them but the danger with that is people don't like straying from that but with some things you have to start from a theoretical point of view. Some you have to start from a practical. You sometimes have to say this may not be what I'm best at but it is the best way to start this project and go that way but that can be quite difficult sometimes.
T: what kind of persuaded you to study engineering rather than apprenticeships or a job?
To: well I worked full time all the way through my electronics degree. I did it part time while working full time. Erm and the jobs I was doing were paying well and they were utterly mindless. The job that paid me through my degree because I couldn't get a student loan. I worked in a chocolate factory fixing machines. It was awful. Luckily there was a few other students from this university so you would meet two or three people off the shift who you knew were in the same situation. Trying to doing assignments in your lunch breaks and things but yes it was just the two things I really wanted to get one. One day I would like to work for myself and that autonomy and the other thing was just something to think about on a day to day basis rather than go to work, turn your brain off for 8 hours and then go home and then repeat again the next day and the next and the next. A lot of engineering jobs are quite dull, they are not all interesting but there is the chance that going to work there might be something interesting and that's what keeps you going day to day.
T: so why did you decide to do a masters?
To: Erm my tutor approached me about it. it suited me because it's a full time wage, supposable integrating the masters on a day to day basis. I would still be able to take on

this wage with the KTP and I will carry on as I have been doing like part time and they will sort of free up a bit of my time and I will be able to sort of get a bit of a social life back a bit rather than working 60 70 hours a week trying to sort of get everything going. I would have liked to have done a PhD afterwards but it is just finances. If it had been 10 years ago I would have but now I have to pay the inconveniences of counsel tax and mortgages.
T: what do you think you have got out of doing your masters?
To: the nice thing about the masters been funded by the KTP is that I could do almost anything in that field and I didn't have to apply for funding, I didn't have to do a tutors project so I could do something that was completely my own and whether is succeeds or fails is completely on my shoulders and I couldn't blame anyone else for it. having that level of autonomy and control I enjoy, I couldn't have done the taught masters. I would have learnt a lot from it but sometimes things like that. I struggle with structure, I prefer more of an organic way of doing things. I suppose that is different for anyone.
T: do you think you have got any other skills out of it?
To: I do work very closely with two other people, the sort of 5 o clock bell goes and its not KTP time, its sort of masters time and three of us who do work closely together. Not on the same project but if you are stuck on a problem I will go to one of my colleagues and one guy who did the KTP was a year ahead of my and he finished his KTP but he is still finishing his masters and someone can just look at a problem from a different thing and all you need is one piece of information to and one question to say have you looked at it this way and it just gets it moving again for a few days. It has taught me a lot about, I think everyone views team work different and it has taught me a lot about the ideal team working situation what works for me which is always useful in the future when you go to companies and look round and you see all the teams interacting and you know straight away if you will fit in or not.
T: so what kind of attracts you to doing a PhD?
To: I would have liked to have done it to go into a bit more detail. From the sort of mathematical and modelling perspective. As it stands the practical work I have would stand up as a PhD, it is certainly a lot more than what a lot of people have. The masters I can get done a lot quicker because the practical bits I am quite good at getting it working quickly rather than endless derivations. It would be nice to do the PhD erm to test myself as I know it is a weakness doing the sort of level of documentation required and doing sort of proving things from first principles but I think I might be a bit burnt down from them and it might be time to get a job
T: did you feel kind of prepared to do your masters from your undergraduate degree?
To: I felt prepared from the undergrad academic perspective and all the work I had been doing before that and the sort of hobbies on weekends, all the practical skills there. Its just

we sold some tiny components on and historically these components would have been nice and chunky and we could solder them on to boards but they are tiny now and I spent a year or two working just doing these boards in my early 20's and things like that I would have struggled with if I hadn't had that experience before and it would have been a big learning curve just with practicalities. We have a placement student at the minute and I am trying to teach her these practicalities as I know how difficult they can be and how daunting they can be if you have been doing just paper based exercises previously.

T: a lot of students go out and do engineering hobby things in their spare time, do you think its just because they enjoy it or because it is not focused on in university and students feel it's a skill they need?

To: I think to be in electronics you have to really enjoy it and you have to do it as a hobby. I don't think it is something you can do half heartedly. If it interesting this, it is often flagged up that we don't do enough practical work at undergrad but not as much as people would like. With it being a former polytechnic there would be a big push behind it. I think the university has it right. The theoretical things you are taught but the practical things you have to want to do. And people either learn it themselves or they wont. The practical stuff the clue is in the name, its practice. The academic stuff you can bang your head against a wall for years and still not get your head around it, you do need a helping hand with it.

T: so the way you have to think at undergraduate level and the structure of that and then going to a research degree, did you find it difficult to adapt to with the flexibility and things?

To: I felt it suited me a lot more doing a research degree because I struggled with the structure a lot of the undergrad. If I was working full time and there would be an assignment in that week and I would be finishing night shifts and thinking oh I need to write up that assignment and I was exhausted. Now I can hand things in when are convenient to me and the only thing set in stone is the end date.

T: you don't necessarily have the structure in terms of going through assignments and things

To: no you don't get walked through it the same way. I prefer that, I am not someone who is particularly good at being managed. I prefer making my own mistakes rather than someone saying do this. I have wasted weeks before on things that wouldn't work, if someone could have accurately told me it wouldn't work is a difficult question but erm I think you do need to make your own mistakes as there are so many processes to go through to answer the same problem you need to. that's one of the things you really develop from the undergrad to the postgrad, making your own mistakes in the process, you learn more about yourself and you develop your own process for approaching problems when you learn the university.

T: what has the transition to postgraduate study been like?

To: erm it is important at this stage to separate the masters and the KTP, erm I have a lot more positive feelings about the masters than the KTP but sometimes it is difficult to separate them. I still enjoy what I am doing for the masters and I think it will be something I am proud of at the end so yes positive experiences at this point.
T: what do you think having that masters when you go into the workplace will bring?
To: the big one for me is that it will allow me to apply for my chartered status. Once you can apply for that. We have an odd status in this country were people call themselves engineers, there is not much threshold. You can do an apprenticeship from school and call yourself an engineer or you can work for years and years and years and still not be there. It seems to be when you put the line in the sand. Erm most countries abroad say you cant call yourself an engineer until you are part of a professional body and get your chartered status. I think as well if you have gone through your postgrad work, I hope employers see that this is someone who doesn't need direction, this is someone that I can leave a problem with and come back in a month. I don't need to micro manage them, I can trust them. They will come back with a solution for me or analysis in some data. I hope it takes me that one further stage in being trusted.
T: do you think there are expectations placed?
To: there is yes. There are expectations, there is talk with a big shortage of engineers in the company but a lot of people don't think it is worth the hassle. It can be very very stressful, it can be quite thankful for weeks and months at a time. Especially if you have non technical people managing technical projects, they cant understand why you are not getting certain results so I think. I think a lot of people move on from engineering very quickly.
T: why do you think it is? Why do people stick it out?
To: I think that you have to find something rewarding about it and I think if you don't find anything rewarding about it the money is not good enough to keep you there, it is reasonable but you have to have that mindset. People tend to go into parallel disciplines like project management and just move away from the technical side of things. People either do that because they have hit the top of the peg in that field or they have hit their own limits in what they can do technically and they need to move on.
T: how have you found doing research?
To: I find I have to set myself very clear goals. It is very easy to fall into the trap of oh I have read this very interesting article and then you look at the references and then you find another article and you realise its 3 days later and done nothing but you have read a book what has no relevance. I have to be very disciplined on myself for not getting distracted but I know a lot of people what struggle with that sort of thing. It is sometimes difficult to maintain momentum at university. That is one of the positives about doing the KTP and being based in a company, ideally you pick up university level of detail in terms of going

into things but you keep the deadline of industrial projects. You meet in the middle but it is a lot of work.
T: how about how much work you put in in comparison to undergraduate?
To: I said I wanted my hours to go down. I have done 10-12 hours a day, Monday to Friday for the last 5-6 weeks and 7-8 hours a weekend. 26 days since a day off, it is hard work. It's the nature of the thing. The undergraduate, you knew when you were doing a piece of work, you hand it in and you know if you will do well or not. If you set your own boundaries on things, you can think I would like a paper out of this or you might want chartered status or a bit of design work for when I want my own business, I will slot it in. my hours have gone up drastically, I didn't think they would go up this much.
T: what was the application process like?
To: because I applied through the KTP, I did a job interview for that. Then I had to apply for my masters once I was there. It was straight forward. Yes it was fine.
T: what about supervision?
To: I have two supervisors. One has long term healthy problems so I don't see him that much but I think he is probably the most intelligent person I have met in that field. He can answer a question with sort of two or three lines and solve a problem you have been having for months. He can do it without not belittling you at all. I don't know how he does it, he will say oh yes it didn't work when I did that either and it works this way. My second supervisor I see two-three times a week because primarily he does the administrative side of the KTP. The one thing I have noticed in attitudes changing is people tend to give you the benefit of the doubt more when you get to postgrad once you have done the right of passage of undergrad. They assume you know what you are taking about rather than going off on one. That's not true of all lectures in that department, some of the really belittle their PhD students and treat them likes slaves but I have come out lucky, they are both really good guys my supervisors.
T: do you think the role of supervisor is important to your studies?
To: yes yes erm for me. the two supervisors, what I rely on my second supervisor is that he drives things along, he says don't get bogged down with that its fine, don't go in to any more detail, keep going. First supervisor I go to him when I had odd ball difficult problems. Sometimes he will give me an answer there and then, sometimes he will give me an answer in a month so he has been mulling away at it but I think, I don't think many supervisors could offer both. You sort of need a project management supervisor and a technical supervisor. I am also lucky both my supervisors haven't got excessive numbers of PhD students, some in the department have sort of 40 PhD students. I cant say it really work, it just seems a game people play to get their name on a lot of papers.

T: do you always feel you can ask questions or for help or do you feel like you should maybe know the answer to that?
To: I think within the sort of research arm I am with, it is such a wide field that I don't think anyone feels embarrassed to say I haven't done this for 6 months I have forgotten. I went into my supervisors office and he was doing some coding and that's what I was doing in industry and he said look at that I cant, I've not been doing it for weeks, I've just forgotten it all. I don't think there is any egos down there at the moment. It is very easy to just say I cant get this going or I was stuck of this problem for two or threes weeks, I was an idiot and I just missed something out and they were fine with that. They have probably done the same thing.
T: do you meet up with other masters or PhD students?
To: just really there is a few guys who I did the undergrad with and they are doing PhD's and we meet up once a month at the pub for lunch and a catch up with people. The research you met the other week, I see him every other day and we tend to work closely together, if we are stuck on a problem and I said the guy who sits next to me, the other KTP associate. I see him every day, he sits this far away from me (demonstrates with hands).
T: do you think having those relationships help?
To: I think having the right ones really do erm I couldn't do research, you go into the offices in the research hub and there is a room full of 20 people sitting at computers and probably look like they work in a big team but don't speak to each other. I think the right handful of people work really well.
T: do you feel like you will or should be an expert in your field?
To: depressingly I don't think my opinions of myself have gone up but my opinion of others has gone down. You look people who have been doing things for years and years and they still make the same mistakes so my expectations are going down not up. It takes people a lifetime to get really good at any subject in any discipline of engineering. I think as soon as something thinks they have mastered a subject, they stop learning, they stop challenging themselves and that's when people hit a ceiling. You have to always know you are not that good and that's how you keep learning and developing.
T: do you feel like you have changed while doing your masters?
To: its difficult to tell because with doing nights on the undergrad I was like a zombie for four years, I think I have become more confident within the field. In some ways yes and some ways no, I think I have tried to maintain certain ways of working which I have always used but just developed and defined them rather than some new reinvention of myself. Yes I think that is it.
T: have you published any work or been to any conferences yet?

To: not yet no, I am getting brow beaten about that one. I have two or three drafts but I am trying to push for the developments. I have been told my way of working is like a painter and I just demonstrate a finished product rather than the academic way of documenting each stage and publishing a paper. Erm I do fine the, because I essentially work as a design as well as doing the masters I find a lot of the publishing culturing in the university a bit. People are more interested in quantity of publications, as long as they are in good journals they are good enough rather than quality. That's the thing we have in engineering at the moment, you see so many papers with glaring errors in and so many based on stimulations and people haven't gone to the effort to build one and see if it conducts these wild accusations they make about it. stimulations we use are only simple first or second order proximations, things get so horrendously complicated when talking about practicalities. I read a lot of publications and I believe a lot of people wouldn't be able to function outside the university. So yes I have three drafts to finish at the moment but it is a question of time I think.

T: would you kind of describe yourself as an engineer?

To: probably junior engineer, I will go with junior engineer. Yes well there is two or three levels. There is junior engineer straight out of university. There is the middle type guys who don't have specific names. I am probably seen between a junior engineer and a middle man who is just left to get on with things. The chartered status is difficult to distinguish who is an engineer and who is a student but I have done design work by myself and realised an end product now so yes what the hell im an engineer.

T: when did you kind of feel like you were an engineer?

To: I don't think there is a set date or circumstance, I suppose when I started working on customer projects. It wasn't when I was in undergrad, when you are actually building things for people.

T: do you do anything inside or outside the university what is linked in with engineering?

To: erm I have my own lab set up at home, just because I like working at home and I want to be self-employed one day so I am just building up a set of junk. I like working on old cars because it is a similar sort of process what I have to do day to day bit different practicalities, so you are using your strengths you use every day but you get a break but it is a big like a therapy.

T: what would you describe the community of engineering to be like?

To: there is a kind of a division where people let their work speak for themselves and they come to work looking a bit scruffy and there is the other side to it where people are well dressed and there is the forceful tone in meeting and things like that. A lot of passive aggressive meetings. So you tend to, I am probably guilt seeing the people I work with being on side and not. There is a lot of banter between the people you work with, but I try

and distance myself from the power point brigade. Where they talk about things rather than getting their hands dirty. It can be very hostile at times, I have been in meetings and they claim to be from a technical background but they are just playing the career game and its just a setting stone to some sort of management role. You always have a lot of people with very poor social skills, I think it is 97% male. The bulk of those have questionable social skills and it is sort of an odd place to work and some people can be very rude to people. Some people have some higher function asperges. It can be tricky at times.
T: why do you think people lack social skills?
To: I think people don't understand people so they like numbers. I think it could be that. I'm not sure if it just attracts that type of person but there are some people really poor in their social skills. If someone is quite rude to you and you come away feeling quite angry and you know he didn't mean it but you are still angry. One of the difficulties there is is people cant go to work mindlessly drifting on and you cant just stop thinking about things and when people get dragged into a meeting saying things and you read into things and then you yourself think that was a stupid thing to say. I try my best to stay out of it, working by myself and in my own company seems the best. I think if you work with 2-3 people with a strong working environment, that is the best relationship.
T: so I have read a lot of papers what describe engineering as objective, impersonal, competitive, masculine. Are they things you have seen?
To: it is very masculine. It is very sad, I think I am not really up for psychology but I understand there is the male way of problem solving and female. There is one who thinks have we done this before and there is one what looks at it from scratch. And you really do need both. One needs to be driven by the other. You get very strange work flow in engineer. Objective, can be. Sometimes it can be, it goes back to the people who have the intuition on a problem which isn't usually objective and then they go through the steps to prove it and they are objective in the second half so they need to demonstrate a mixture of both but it doesn't always work that way. Competitive, it can be. It flits between, there is a healthy level of competition in our design office. It sort of people encouraging each other along and each pushing each other because we sort of push each other along. We have an office in America and it is competitive with them and we have never met them but there are emails what bounce back and forward and that is competitive. It is more that it is going through change, when I was doing the undergrad they pushed up to understand project management, we have not met the people in the middle, we have dome finance and project management but we have not met in the middle. Engineers will stick together against outsiders attempting to manage them without understanding what they actually do.
T: are there any other skills you would say you need to be an engineer?

To: technical skills is a bit dangerous at the minute, I am a little bit specialised at the moment so there is a good skill set with programming that I need to. I did it at undergrad and I did well at it but it was sort of an introduction so I need to make time to really brush up on them. You seem to need to do that, spend a month on an evening just brushing up on something. There are some parts of engineering what haven't changed in engineering in 40-50 years but some change by the month. Soft skills. I need to be more assertive and to the point, I think I have come along with that but I have noticed that the more non technical people judge people on confidence rather than what they are saying, it is more tone of voice, I need to be aware of that.

Appendix 26 - General design studio (masters) – level 4 (observation)

Sign in team hare area saying 'computer use of 5th year students only'

I come in and say hi to Cale, he says hi and one man says we don't usually get girls this pretty here, what's Cale doing what we aren't. One man laughs and says I get first dibs because I'm disabled (he has a pot on each arm). – no wonder women don't want to come into engineering.

There are around 9 students here and they are all on their own computes. They all look to be working on project work. There are a group of 3 students chatting about work.

At the opposite side of the room there are a number of students working together around a few computers, almost everyone over there is chatting.

One man asks another man if he has got some work done and he says no, the man replies 'I could go to the zoo and get a monkey and he would do a better job than you'

One boy says 'well if someone has made the nose right then it would go on easier' another boy replies in sarcastic tone 'oh you've done this wrong, you've done that wrong, take responsibility for yourself.

Taking about entry routes and doing BTEC in comparison to A-levels. There ideas were that A-levels give correct theory and maths ability, where as BTEC more practical and one boy really struggled in first year because he didn't have much theory, it was mainly hands on in BTEC.

He said in first year of undergraduate they would be in everyday, in comparison to other degrees who would only have 7 hours of teaching in the whole week, they would have that in one day.

Assessments were after every lab in undergraduate. They would have a lab on a specific topic and then have to write a 4000 word report on it afterwards and they would have about 5 of these to do for one module for one year to demonstrate they full understood that specific topic/aspect and then they would then have an exam to demonstrate they understood the topic as a whole. At the end of the lab reports there would be a section where they could discuss how that certain aspect in the lab report would be beneficial/advantageous and any personal thoughts or opinions, they clearly started this is the only place they could really have input.

Assessment for placements and jobs are the same, they have numerous selection processes to pass including interviews and tests etc.

A lot of people drop out as they have no idea of how much work is expected of them, one boy says they only had about 3 or 4 days off over Christmas.

Students always talking about work, not heard them discussing anything else. One student starts drawing on the board, discussing ideas, helping each other out with their side of the

project, asking students if they have done a certain aspect of the project, if not why, what are they struggling with, can they help them in anyway.
They said there are around 50 students on team hare, some undergraduate students who only have to design and then the masters students can use these ideas in the final project if they think they are good enough.
Discussing what the project actually is and where the race will take place and the rules and regs. of what the car has to be to pass. They show me a really thick book they get given. They said all of their ideas have to go through IMechE to make sure they are suitable and if anything has to be altered. He said they race against other universities, however all universities set the budgets and theirs is not very high. They say its an international competition and it can get very competitive.

Appendix 27 - Drone masters team project (masters) (Meeting observation)

Design studio meeting – 4th and 5th years. Nobody has logo tops on.
One masters student says 4th years comes up with the designs and we just supervise these. He says its good because they have already been through 4th year so they can coach them with work but also the project.
One man at front discussing things, everyone from audience shouting things at him. Its not very organised.
Paper sent round everyone and then write names on it to say they have attended.
The design is up on the board and someone says these are all the things people have created and we have put them together, people then point out things what are wrong. A lot of debate and confusion around certain topics, some people are getting very heated.
One supervisor here making fun of the situation, making jokes and some students laughing at this. not very supportive.
One boy goes up to front and takes over computer, he says that does not concern you, these boys are working on this not you.
One boy says this design is just peoples concepts coming together to find out what's wrong, stop being so picky, another boy says its not being picky seeing where improvements can be made. The boy comes back and says this is not the final design, these are all things we can look at later, this is just to get an idea.
A lot of swearing. Shows video of something they have done so far and it does not work.
Joshua says if you want any videos to go on social media or our website you will have to make sure you take health and safety into account, we cant videos on what look dangerous.
12:30 end of meeting
Joshua coms to sit next to me after the meeting to chat to someone and he says it wasn't the most organised meeting – I ask if it was always like that and he says yes at this point because people want to get things done and people are waiting on other people or someone is changing ideas etc.
Joshua starts discussing an idea with a student, discussing this idea and throwing things back and forth.

Appendix 28 - Sub team meeting team hawk (Observation)

We sit on a few chairs grouped together in the design studio.
One of the boys is chatting to josh about something he was trying to do in the workshop but the technician said he couldn't do it. this boy then leaves when the meeting starts as he is not part of this sub group.
Josh tells me why the undergraduate students are not here and the excuses they came up with when he was arranging the meeting yesterday.
One boy then starts by asking another by how far he has got with the suggestion he made to him last week.
They discuss this and use a lot of terminology – questions asked back and forth.
One boy says to josh if the other boys were here you would be able to discuss your bit. He says I know they were suppose to be re-designing bit I cant see anything on the U drive and they were suppose to discuss the designs today.
The undergraduate boy then discusses the design he has done and discusses how it will work. Draws a picture of it to explain.
Masters boy asks question about performance of what he has designed.
Boy gives suggestions of what he should do for now and what to work on. Undergraduate boy argues what he thinks he should be doing next – masters boy says no we need to…
Undergraduate boy says we need to speak to Shaun then and masters boy says yes we will.
Boy says yes but I still think we don't need to separate it and ignore bits on testing, masters boy says yes and further explains why things need to be done as he thinks. Masters boy says 'all we are actually interested in is…'
Masters boy says if you do this bit first, I bet you are already nearly there with it actually.
Undergraduate boy then further talks about some testing he has done
Masters boy says I will try and find some information out for you about this receiver, I think Shaun will have that.
Undergraduate boy then talks about some equipment he needs ordering. Masters boy then says if you do that what we discussed and then if you have time because I know you are writing your dissertation you could…
Boy then asks another question about separate part of object and masters boy says it is ok I will look at that. He says I know you were saying about magnetising etc but it is something we need to look at. Undergraduate boy then provides him with a few pointers on this topic and masters boy says he will take over and look into it. masters boy says I would rather focus on you getting that work done. Masters boy then makes notes on what he needs to look at.

Josh asks undergraduate boy how long it will be before having a finished product. Boy says I also had done it but it blew but it wont take long. Josh says we need to start testing some stuff because Jake is pushing me for a date when we will be done.
Masters boy asks more questions about what he has done so far and then undergraduate boy answers. Masters boy says it might be easier if we… and refers back to drawing other boy did to explains what he means. Undergraduate boy says yes if that's the case I can keep everything I have done so far and add it on, boy says yes that will be easier. Lot of terminology used.
Undergraduate boy asks questions about costings and how he is buying a blank pick so it is s blank chip so it is not expensive. Undergraduate boy says can you put an order in for them please. They talk about what picks have been used and what they could do with ordering. Terminology when discussing this.
He says by Friday I don't know if I will be able to tell you which configuration we will be using though masters boy says.
Undergraduate boy shows masters boy pictures of the types of picks he has been using and which will be best for the project. they discuss this in terms of attaching it to the model etc.
Masters boy says worry about this first (and points to paper they have been drawing on) because in terms of your project aims, they were to come up with a way to…
So you are looking at additional things here outside this and so you don't need to. boy says I know but I need to look at other parts as well as this because they all link in and then he goes on to discussing other things which he things he could do which may be worth doing.
Josh says yes in terms of diagnostic, yes that would be useful.
Masters boy discusses these ideas and says it is too complicated for this system (drone) an explains why. Masters boy says I a just thinking for you and you could mention it for future potential in your dissertation.
The undergraduate boy discusses how his picks are running and some issues he is having so masters boy explains in terminology why this is happening and how he could fix it. he says when I got did that I got those types if results
Josh then says we need some porotypes of how this will all fit into the airframe. Masters boy says Shaun has put it on the model but the wires still need doing. Josh says yes I was just thinking in terms of the top plate.
Masters boy discusses wires etc and then undergraduate boy says in the rules they mention about audio and lights. Masters boy brushes this topic off while undergraduate boy tries to pursue it.
Josh says it is just something to think about because the sub themes are on final demands.

Appendix 29- Team Hare - Design meeting (masters) (observation)

Before the meeting I am say with 3 students, they are discussing a problem they are having about the gear stick. One boy discusses a solution and then says I am forever solving problems, just come to me and I can solve them all. He says everyone is stressing out and there is just me coming up with all the answers. One boy says yes but you create a lot of problems as well (laughs). They then discussing drinking on nights out and how one boy drinks WKD. Two of the boys go now. The one boy then starts talking about learning in engineering and he says there are some people here who go and pester lecturers all the time to get additional help and these sometimes get more help but some lecturers done like to give more help out to some people as they think it's not fair. I would rather work things out of my own and ask my friends. He then says we have to help each other out as lecturers don't.

13 people – two girls sat together. 2 lecturers
'Team leader/project manager' goes through meeting from last week + things they had to do and how they have progressed on these.
Each student is focused on one particular aspect of the project, e.g. gears. Other students ask questions about how someone has got on on their aspect. Asking how long things will take them.
Lecturer gives suggestions of how to overcome a problem Cale is experiencing and another student gives critique of this idea. Lecturer then comes back with an alternative idea.
Again another project approached – Cale again. Discussing where that idea has got to so far. Cale says we will have it done by next week and hopefully it will be how you (other students) want it to be.
A lecturer asks how far they have got with NDA and Cale says not far, this is what is holding us up. Lecturer gives another bit of advice about this and says is a 4th year student not working on cooling – he says yes but again he is having a problem with data.
Continue catching up on how far each aspect on the car have got.
Lecturer asks if they can do a certain thing and he says that would be very hard to do – another student says between 3 of us working together we will get it done.
Cale talking with one lecturer on the side for half a minute.
Talk about how they have applied for budget from IMechE for aerodynamics and they have to write a report at the end of the year with how they have spent the money and what it improved.
Lecturer says 'ok I trust you' as one student justifies ideas of why they have chosen what they have chosen.

Lecturer says I think you should discuss a plan of how you will use consolidation week as I would like a meeting with 1st and 2nd and 4th years, with everyone who is on the project. People who you would presume were not very confident people to look at are extremely confident when discussing their ideas in front of the group. They bounce ideas off each other, there are a few main people discussing the ideas.
Says they can and are coming up with these ideas and although they did not submit them for the car for the competition and this cannot be changed now but they can try and get them working then it gives next years team a whole lot of new ideas to think about.
Lecturer questions another idea and student answers and he says good at least you have thought about it.
One girl leaves meeting early
When talking about steering one boy says good, that's simple, practical and functional for what we need.
Lecturer says about steering – one of the hardest things is the person being able to turn the wheel and then they laugh and say well you (person who is going to drive car) best get to gym then and build your muscle up – everyone laughs.
Someone sends some designs over to one of the other boys and he tosses a design off and says well that will break.
James, project manager sums up meeting.
Lecturer gives advice for cost report, talks about putting it in spread sheet. He says it looks hard but you just have to be methodological.
Lecturer says he knows someone who is a really good race car driver and he says he asked him to see if anyone could help him with some work. Lecturer says if you help him, he could help you in many ways.
He then asks how many are interested in marshalling at Derbyshire trial. We can man a few hills then, I will tell the organizers.
Lecturer says by the way did you get my fridge in the workshop, boy says yes but the only thing is, it doesn't work. Another boy says it's just the fuse what's gone. They laugh and say we are a team of engineers and we cant even put a fuse in a fridge.

Appendix 30 - Formula student meeting (masters) (Observation)

The students gather around the tables which have been pushed together and Jake S shows a product he has made for the car. O Mason says we need to be careful when fixing that together because when he is hot this this and this can happen…
Jake S says to one boy we have got a lot done this week and expands on what they have completed, this discuss this.
James says ok lets start on sub group meetings and discuss what we have done this week.
The first sub group asks john if the technicians will be here over Easter and he says he doesn't think so but boy says I will be in and I'm sure a lot of you will be in as we have things to do.
Says they are discussing about getting signals through but not in something we can read so we are all doing some problem solving on that but we are going the right way.
John provides a suggestion of where they can get some race kit ordered as they discuss finances.
Move on to next team and jake s talks about produce he has made and john asks how they will fit it and jake H provides suggestion and says he will look Monday at it. john says he is not keen on the idea and explains why. They agree it is something to think about.
Says they need to rope some 4th years in for help for manufacturing – they said they are on holiday for the next week but are willing to help. James says the more the merrier
John says well we are ahead of last years team
They ask O Mason about steering wheel and how he is experiencing a slight issue, John provides suggestion and O Mason says he thought of that and discusses the mathematics behind it.
They work through some future things which need completing and they discuss what can be done for this – plans made.
All experts and have a lot of information in their own field of the car.
John talks about things what have gone wrong in past and they say how they are thinking of overcoming this.
John provides suggestions/advice on how they should decide who will be driving the car.

They talk about creating a testing plan and john says we need a car first – they move on to the last thing to discuss in the meeting plan.

Appendix 31 - Team hare – masters (Observation)

I come into the team hare workspace and Cale says we are just about to have a meeting because there are a lot of parts what aren't fixing together.

O Mason says to another boy, 'well I've been telling you that for ages, you didn't listen to me' laughs

Jake H is in charge of the meeting not James even though he is the project manager.

Jake says to one of the boys directly about putting certain things in certain files, boy disagrees he's not done this and it turns into an argument. Boy says whatever and Jake says no not whatever, you've done it. he then justifies why things need putting into the correct files.

Jake says he spent 16 hours over the weekend fixing all the models because they were a mess

Jake H and Jake S start arguing because they Jake H has taken something out of the final model. Jake S says this is wasting time because there were only two components wrong so why exclude it all – other Jake says fine do you want to do it.

One thing wrong with exhaust what George is responsible for and he says he knows nothing about it, he will have to ask..

Jake continues reading out all the problems they are having with the model

Comes to next problem what is wrong and boy says well I will need your help with that because…

Talks about negotiation of things now – what needs to be done how they will do it etc – calmed down.

A boy says an idea for a part and George says you know when someone says a really simple idea and you think why have I never thought of this before.

A boy turns up to the meeting 20 minutes late, nobody acknowledges

Make jobs about where the break light will be and the hot wire they will use to cut some material – use technical language when joking.

Boy puts idea forward and Jake says no that is too painful.

George says why have you taken my idea and run with it, it was a joke – laughs.

Shows pictures of cars and Mike (boy who came in late) says a least we have a pretty picture when it doesn't technically work. Jake says stop putting it down you pessimist.

10:40 meeting finished

They go back to the team hare workspace and start grouping us talking about what had just been discussed in more detail.

Start showing each other websites where they are going to buy materials from.

3 of the boys from the meeting are working alone on the computer

Some boys still chatting about the car – group of 2, group of 3, group of 2 chatting

Cale now talking with Jake s and Jake says the thing is if you really want something doing, you need to be down there pushing it. Jake says you don't want them to be waiting for you and your part because that's when they will start to get pissed off.
Only 6 boys working in the team hare area now, everyone else gone after meeting, some to workshop.
Cale and Jake s only people chatting now – still about work.
In the general design studio there are a few boys chatting but a lot sat alone working.
Jake says a lot of them are down at the workshop doing the fun bits while we are stuck here doing this.
They start talking about how Jake H was re-modelling and they say that they don't know where to start. Seb says Jake has asked me to do so many things, I don't know where to start. Jake S asks what he has asked him to do and Seb tells him and they says I might just go home.
George then asks a question and Jake S and another boy go over to his computer chatting about it
Jake S asks who Seb's personal tutor is and he says might has asked for a meeting with me. Cale says oh mine is John Allport, he has a lot of patents on start stop engines and things. Jake S looks him up online and says he recognises him.
Seb says for god sake, He (Jake H) has just changed something else – Seb shouts go away.
John Baron comes and asks what the emergency meeting was about. Jake S explains what has happened and Seb says Jake H is being a director.
John asks what has gone wrong and George says this happened and this and this. John says well that's what can happen with solidworks
John Baron says well someone needs to be in charge of change management. He says we cant let Jake do everything because he is working his socks off. We need someone else with cad model experience. John says Jake H seems to be forgetting about his own assignments and just focusing on this. Jake S says yes we all seem to do this 9-5 and then assignments on evenings and weekends.
John Baron says we need someone else who is a cad expert, well you all should be really, someone must tell him.
Jake S then asks John where he could get some aluminium from. He explains what it is for and some quotes he has been given. Talks about the supplied the university uses and Jake says ok I will sort it.
John comes up to me and says his son is trying to make him do a PhD but he doesn't have a lot of spare time. He says he wants to look at what industry needs from engineering students and what the IMechE say they need because the IMechE have not changed. He says we can meet up.

Cale and Jake S are chatting about where to get the metal from and they ring a number of places up for quotes.
New boy enters and logs onto computer – he asks where everyone is and they say at the workshop.
Seb starts talking to this new boy about the test they are doing later on today. Another boy joins in the conversation and they start talking about grades and modules then.
They start laughing at one of the boys from team hare who is muscly but just sits around in the gym all day. They joke about this with him.
The new boy says I thought you would have finished that by now Seb, he says I had but Jake H said it was wrong.
They say has anyone done the cost report Jake H sent them out to do, they laugh and say no, did anyone even reply to him. They say no, he is like that neighbour you just ignore.
They talk about racing at the weekend and some races they are attending soon.
Cale asks Jake S how to do something, Jake helps him.
Few sets of people talking about work: Cale + Jake S, Seb + new boy and 2 people silent.
One of the boys starts writing on the board, they say are you allowed to write on Jake's board. He says I asked George and he said he wasn't going to stop me. he says its for the meeting.
One boy comes in and they start chatting about football – it then goes back to work and manufacturing produces after a short while.
They have a picture of the car what it will look like they and they say it is going on social media today, Jake S says yes but I don't know if I was to commit. Jake S starts talking about fuel tanks with a boy and what it needs to be made up of. They say they are buying a red one, one boy laughs and says that's the main thing as long as it looks nice, I bet it wont even run.
They laugh about Jake H's eating habits and laughing about him. They ask where he is (in the workshop) and then start talking about welding and parts on the car.
Boy finished drawing on board and George comes over to look at it. George takes pen off boy and starts adding things to the board and says we need to think about that, boy says yes but that's worst case scenario isn't it. they discuss things and George asks some questions – does your rear wing have to be in this space..draws on board and they discuss this. come to no conclusion but George walks off.
A girl comes in and two boys say hi to her, she sits on own with earphones in.
A boy comes back from the workshop and says they have something working but it is not very pretty. They discuss this a bit more.
One boy asks George when deadline is for something. They then talk about components which were dropped from the car and why.

Josh comes in with a part and they say finally. All that for that (little bag of something) and it too that long. They all look at the part and say it needs testing.
They tell josh about the meeting he missed this morning and then him and Jake S start chatting about fuel systems.
O M comes in and nobody acknowledges, he goes and chats to George.
Jake S says we have just got our exam timetables sent through and I have got 17 days between my last deadline for coursework and the exam, he says that's easy because I only have one exam to revise for.
Josh logs on to computer and also asks if anyone has a personal tutor meeting.
Jake S then says he is going to meet Radu and ask him some questions. He says does anyone else want me to asks him anything.
1:00 we meet in the team hare space and walk down to the workshop. They talk about top gear and getting an engine for the car. There are three cars in the work area what students are working on.
The students discuss what to test first and which students are going to test their component first
Josh starts putting the car into gear and cleans and makes sure oil is in the engine. Jake S helps him and then goes to find the fuel tank.
George asks if James is coming down and josh says no, you know what he is like, he cant deal with all the fun, he is like a wizard. Seb is looking at car and a part has come off what is black and shouldn't be. They laugh and say that should not be like that, another boy goes to wipe it.
There are 7 boys here.
They laugh about how much horse power the car will have, josh says we need to get it working first.
One boy is putting a part back together on the car on his own, they say don't do this… while standing watching him. Josh goes and helps him and he does it straight away. He says it just needed threatening.
Josh talks about the operation he has had on his arms, it lasted about 2 minutes.
Cale is talking to 3 of the technicians about the radiators and what they want to do/test
One of the technicians talks to Jake S about ceramic coating – the technician says it is getting too hot and someone needs to be done about it. they discuss it and he leaves him with the problem
They then talk about someone else he has ordered and the technician says get a gauge as well as it will allow you to..
Jake S then asks the technician where he can get some aluminium from and the technician offers some advice and names.

Two boys are connecting something to the car, they negotiate who is going to do what while attaching it.
Jake S and technician are still chatting about aluminium can be used for and different types of it.
They talk about the urgency of getting things together and getting it working so they can get it tested.
Boys from the team keep coming and going
The two boys are still fixing the parts together, Josh explains to me what they are doing – to do with fuel.
They then start talking about racing on a weekend and where they go etc.
Rob Northway and a first come into the workshop to work on one of the other cars, one of the formula student says something to him and Rob laughs.
The boys are still fixing bits on the car, only to working on it, the rest are stood around. 3 not talking, Jake S and other boy still chatting about racing.
Josh + Seb start chatting about parts and how parts fit differently.
Josh goes to ask technician what they are going to do and if it is ok. They technician comes and they demonstrate what they have done (fixing parts).
They switch the car on and all gather round the car. Someone trying to get it started while someone at laptop, they negotiate between the two.
They have the pedal set up on the desk which someone is operating
They cant get the car working so a few of them are gathered round on the computer trying to figure out why
Technician comes and says they have broken it (laughs). Technician also goes to look at computer
He provides them with some ideas of what could be going wrong and says right see if your fuel box is controlled now, it is but he still cant get the car working
Technician says right what else could it be then, they explore some more options.
Another technician comes and takes a look.
The car bangs and they both stop trying to start it, both technicians laugh.
Car still not started, they discuss what is happening. Try and fix aspects of it, only seems to be one person practically working in the car at a time. They take it in turns to mess with it.
Cale tells me about the reports they have to write for the car (it is three) and what is involved in these reports. He tells me abut how they have to have a running car to get a dissertation. He says he has to put his faith in other people to do their part of the car.
Working on the car together, everyone doing different things. Trying to figure out the problem, say they have to go through the process of elimination – trying the sparks they say. Technicians leave.

One boy gets electrocuted when trying to start the car, they all laugh. Another boy says I will do it now. Works when sparking. One boy says this is a great game, George would be having a health and safety nightmare.
They put parts back together now they know the sparks are working.
Get car working and they all jump around and hi 5. The car then cuts out and bangs
John baron comes and they say oh god we don't need his negativity when the car isn't working.
He starts talking to me and says if they get a running car before the marks go in they will get a distinction. I have promised them that, I will fiddle the other parts of the marking criteria as long as they get a running car.
He says it is only a 45 credit module so they should only put 450 hours into it but they do loads more. He says some students know what they are doing, some thing they do and some don't at all. He says it will work for them though, they will get t going because its been working all week.
John asks Seb what they have changed and he says absolutely nothing – Seb is sat at the computer trying to figure things out. John leaves. Two technicians come and they are working on the car, messing with it, taking parts off, trying to start it.
Josh talks me through what is going wrong and why. He discusses how they can fix it but says it will take them hours and hours.
Technician and josh work together to look at parts and discusses it. technician gives advice on what to do.
Technician says to leave it overnight now so everyone goes back up to the design studio.
We go back upstairs and they tell the other boys what is going on, they don't seem interested.
Jake S says to a boy who comes into collect his bags from the work space if he got the carbon fibre sorted. The boy says yes its ordered, we just need to see if it works now. Jake S says yes well that's the hard part.
One boy comes and tells jake about some parts what he has got prices for. Jake says cheers mate email them to me.
Jake S and James discuss ordering some materials. One boy says he is off home but he is coming back later.
George is watching a video on how to fix something together + how it works.
Josh was left still doing the practical in the workshop
George says to one boy have you blown the engine up, and laughs. Jake S says don't mention the engine, it's the rile of the day.
One boy leaves and George jokes saying try not to destroy any engines on your way home.

Cale comes in and says no joy. O Mason says well he's the man (Jake S). Jake S says I'm not the man, Seb is (blame). Cale explains what is wrong and O M says what are we going to do and Jake S says Seb is trying to figure it out because he is the guru. Jake S says to O Mason I thought you would be good at mapping, he says I am but Seb did it last year.
Jake starts talking about an assignment what is due in. he discusses what he has done so far and shows it to him. He says he has been coming in on weekends to get it done. O Mason shows Jake S what he has done of the steering wheel so far and what he plans to do, they discuss how he will do this.
Seb comes in and says its broken and explains to O Mason what has happened. O Mason explains what he thinks is happening because he changed one small detail since the car was last running and Seb said it would have no effect but O Mason said it would. Another boy joins in this conversation and says it wont be working because you changed is because this does.. so you need to do…
He gives him some advice on what to do.
A lot of people working individually, only Seb + one boy chatting.
Most people left now and say bye.

Appendix 32 - Masters team Hawk meeting (Observation)

When I come into the room the boys are taking about the social night they had on Wednesday. Josh tells me they went to laser quest then went on a night out in Huddersfield. He says they do this about 2-3 times within the year.

A boy walks in and they start talking about the budget and how much money they have left in the budget. They talk about what they have bought and what they still need to buy. One boy says we don't have a lot of money left and we don't even have a drone either.

They arrange dates when they could practice flying the drone – only around 4 out of 10 boys actually discussing things, others just sat there. Some sat together, some sat individually.

Meeting not very organised, they keep going off topic. One boy says right what's the next point we need to discuss in the meeting to try and get it back on focus. They says they are going to freeze the model today because everything should be ready now. They then hand some pictures out of a component they have made and the lecturer asks a question to the boy handing them out, boy says go on josh you answer it, it is your baby.

They negotiate how they will make this component, 3D printing. Lecturer asks questions and provides points on improvements they can make and where they could potentially get it 3D printed etc – advice.

They continue to talk about the component and having a plan A and B in case something doesn't work. Student says you need to be able to add springs quickly on the day if needed to Josh.

They then talk about saving weight on the drone and how this can be achieved and they start blaming other students for their components being heavy. 'well if we are starting to point fingers'.

One boy says a student had a good idea of not carrying as much weight in the competition but they will lose two points for it. They discuss this and say maybe not carrying as much weight will be worse because it will cause it to be uneven etc.

They then discuss other issues they are experiencing. Fuel system – lecturer says the boy in charge of this came to him with some equations and they were wrong and he says he doesn't know why because they are first year maths so I don't know how he messed up with them. Lecturer says they discussed this and he has gone away to fix it.

One boy says to other when on about the insurance they have had to get 'it's only when you start asking questions that problems come up'.

They then discuss how the IMechE published the list of FAQ which they asked at the start of the project. Lecturer says well you are either the only university engaging with the IMechE or students say or we could be getting people in shit for drawing attention to things.

Students then start discussing model and how they can overcome some problems – around 6 of them provide suggestions.
Then start saying they want to do laser quest again and they will start football up. One boy says I promise to not be so competitive next time. Start laughing about what happened at laser quest then meeting ends.

Appendix 33 - Team Hawk meeting with BEng (Observation)

Before the meeting Josh H starts chatting to me and the Slav lecture they have just had and how hard it is in terms of all the theory they have to learn. He says one of the option modules he has chosen is marketing and new product development and he says that it is just justification of marketing methods of choice. He then says they have changed the structure of these meetings so it is not just a free for all but now only the sub team leaders discuss each component.

Start by discussing the model and how it is nearly done. They start discussing the landing gear component because that is still not on the model and the student in charge of this provides the update.

They then move onto the safety landing and hand out pictures of this component and one boy says this is Josh's handy work. A BEng student then discusses the processes behind the component.

The only lecturer here questions a decision the students have made. Student says I get it, it's not an efficient way of going about it but it was the easiest way. Lecturer says well if you are going to do it that way you need to employ…

Moves on to next sub team and lecturer asks question when discussing and the team as a whole say they have not considered this until they do the testing, that is when they will be able to know.

Moves onto last sub team and the student explains what they have done and the lecturer asks a question and the student answers. The lecturer then adds insight into what could happen when weights are added in testing and they say no that is wrong, in testing it was fine and didn't swing much so this shouldn't be an issue.

A student then also questions this component and the decisions made about the pins and the student in charge of this sub team says we just need to tests so we can be sure.

Another student also questions this component and the person in charge of it says yes we will look at it.

They provide pictures of how the battery will be mounted and the lecturer says do we have spares of things, one of the boys says no because the company are really slow.. and the lecturer says yes I have had experiences with them, I can sympathise.

The meeting has finished and a few students leave, a group of them go up to the computer and start adding the landing gear to model and they all huddle round discussing it, a group of students are chatting about another component still at the desk and Josh and one of his friends are chatting to me.

They are chatting to me about a team project report for the marketing and new product development module Josh does. They then talk about the differences between electrical and mechanical engineers. They say mechanical start from the bottom and design a project and

then think of materials, weight etc after. Whereas electrical engineers start from the top and fully think everything through and then employ in into a design. They talk about how this meeting is not timetabled, only the masters meeting is. They say lecturers come to them and help out if they have free time from both the mechanical and electrical side. They say they have a meeting on a Wednesday which is about the critical report what has to be submitted to the IMechE, along with a video displaying the Drone actually flying. They say then than have sub team meetings as well where people will go to the workshop etc to work on their components with each other.

Appendix 34 – Lecturer interview: Leigh

T: so why do you believe students are motivated to study engineering?
L: erm for a range of reasons. A lot of them study maths and physics at A-level and don't really know what they want to do and engineering is a combination of them both. Erm a lot of them say they like doing practical things and like knowing how things work and I think for some there are really good career prospects and security with jobs at this moment in time.
T: do you think it stems back from high school?
L: yes I think some stems back further than that like they like playing with lego and mechano, remote control cars and things like that and other are from later in school.
T: does there tend to be typical students coming into engineering?
L: no not really we see a range of students, although they do tend to be male but within the male cohort there is a massive range of characters and personalities.
T: what do you think the advantages of studying engineering at postgraduate level?
L: at postgraduate level it develops a specialism so if people want to go into a specific sector like automotive or medical they can develop a specialism because a lot of the degrees are quite broad. Engineering is so diverse you can go from developing a car to a new lipstick it really has a large spectrum. Some of them don't feel they are ready to go into work, they don't want the 9-5 job, they are just putting it off and others it's about increasing earning potential. For others if you have a masters or a PhD it decreases the amount of time to have to wait to apply for chartership after you have had a few years in industry and you can't do that if you just have a BEng and a chartered engineer typically earns more than a non-chartered.
T: do you think there is an issue with attracting students to study engineering?
L: yes definitely. Kids don't know what engineers do. You go and see a doctor so you know what they do, you know what a car mechanic does because you interface with them and you know what the pure subjects are because you study those at school but you don't study engineering and unless you are related to an engineer then you don't know what its all about. So we do study to attract people, especially women. I think about 10% of our cohort is women.
T: why do you think research in this area is important?
L: because it's the future of the world, engineers are going to save the world (laughs). Because its so diverse we wouldn't have any medical equipment if we didn't have engineers, we would have any renewable energy sources if we didn't have engineers. Its just fundamental to technology, saving people, saving the world, improving quality of life.
T: so how do you believe engineering is viewed in society?

L: probably mixed, so in this country particular the term engineer is used frequently for trade people. So a heating engineer is someone who comes to fix your boiler, a refuge engineer is someone who picks up your rubbish. Erm like continental Europe, they see it more as a profession like law and medicine. So it depends in where the world you are as to what its seen. If I say to someone in the UK I'm an engineering, they say oh you fix cars, so its not widely understood.
T: do you think if that was changed it would attract more people?
L: yes yes and people like the institute of mechanical engineering and the institute of technology are always brining out new ideas to try and change public perception of engineering but its difficult when the term engineer is protected like lawyer or vet or doctor. So its not a protected term so people can use it for whatever they want and it is just a word, it comes from ingenuity, kind of creative background. So restricting would be difficult but yes we need to change it but I don't think anyone knows how.
T: so what do you like about teaching and research is engineering?
L: the teaching, I just enjoy motivating students, I like to see them develop as professional engineers. The teachers is not sharing knowledge because I don't think I have deep academic knowledge in the subjects that I teach but facilitating learning so I like to see students grow and learn and become researchers and who progress themselves as oppose to being there to help share knowledge. In terms of research I like that my research has a direct impact on peoples quality of life. So my research is in the medical side of engineering. So I can see that my work on hip replacements has helped people and I guess that's what makes me tick.
T: so what do you believe the application process is like for postgraduate study?
L: I think it's not understood. Like the deadlines and the process for our undergraduate students apply for Postgraduate study, it's not widely publicised to them. Erm so it's not widely publicised how you go about it and what you do and a lot of talking. If you have a final year project student and you think they want to do a PhD, that conversation is the application process and then you will be told what to do properly. So I don't think it's necessarily open and transparent.
T: do you often approach undergraduate students to complete postgraduate study or do they come to you?
L: it's a mixture of both necessary. I've never approached anyone but people come to me and say have you got any funding for PhD's and I say yes if you go to this bit on the website you can learn more about it and things like that but I've not actively sought out sides who I want to work with. I will sometimes say in a lecture of I've got a PhD, if anyone's interested come and speak to me.
T: what do you think funding is like in postgraduate study?

L: I think in engineering we are lucky because there is funding, I know in a lot of disciplines there is no funding if you want to do a PhD you don't get paid for it. I would like to see more funding targeted at females, I think the prospect of having that route at the end might attract people so I think we do ok.
T: so what do you think about the proposal system?
L: yes so all of ours are showing on the web and I would imagine that a lot of them on there are outdated.
T: how do you think it is for students to apply for an already set proposal rather than creating their own?
L: I think its easier. I don't know, I will say I don't know.
T: why do you think it's important for students to get into research?
L: from my personal point of view I think its an amazing career but I think it's a really struggle at the start to stay motivated to do your PhD but what I have found it is breaks down to glass ceilings. You know when I was trudging along doing postdoc work on fixed term contracts with no money and I could see all my friends being a design engineering on 30 thousand a year and now I've seen my career pick up but they are stopped by a glass ceiling because they don't have the qualifications. It's taken a while but now I am coming up to 40 it's a really rewarding career and I see the benefits. You know I've travelled the world, I get to work with amazing students who are just really inspirational and I get to do research what really impacts people's lives. But also without research and without our students continuing to do research we get good students in but we cant retain them. It's technology and advanced technology, it can change the world.
T: so do you think there are expectations of students entering postgraduate study?
L: I think there are expectations of students entering any study or any form of job. I think there are expectations of being successful.
T: what do you think those expectations are?
L: it depends on the supervision team, for me I wouldn't expect them to know anything more than what their degree program taught them. So I would expect a certain level of knowledge in engineering but that's the entry qualification. So having a 1:1 or a 2:1 would have given them that grounding. I wouldn't necessarily expect them to be able to do research. or the process or anything like that but other supervisors do take a different view.
T: do you think undergraduate study prepares students for postgraduate study?
L: it depends on who's supervised their final project and what the nature of that project was. So all my final year projects are quite research based and I do sort of take the students through a process of research design. they are to do a literature survey for my kind of final year projects but there are others what aren't like this. some don't have that research process so some will be more research ready than others.

T: what is expected of postgraduate students as they first come into the degree and how does that change throughout?
L: again I think its subjective of the supervisor but what I would expect is the first year to be about training in research, training in experimental procedures they need to use, getting to grips with any software packages they need to use, background research and in second year I would expect them to be quite autonomous and put those skills into practice and actually get the results they need and I would expect them to drive the research. in the first year you are kind of holding their hand and helping them find the way but in the second I would expect them to come up with their own research direction. If you are doing something for three years you having to enjoy it and its better if you put your own stamp on it so I don't tend to be too prescriptive and then in the final year I would expect them to be more of an expert than I am and our progress meetings are more about them updating me rather than asking me stuff.
T: how often do you expect student to be working on their PhD's?
L: well I only have one full time PhD student and he treats it as a 9-5 job and I think its easier if they are in when I am in. saying that I did have a student, she is suspended now, but she was entirely flexible around childcare and she would tend to work out school hours and it might be why she has now had to suspend. My supervisor expected me to be in 9-5 so that was successful so it's kind of what I expect.
T: why do you think some students work from home?
L: people just work differently in different ways. I don't think the researcher hub encourages people to come in. my student had a desk in a lab and he works from there and he tends to be there all the time because it's a nice quiet place and a bespoke computer. So I suppose its just personal preference, sometimes when I work from home I get a lot more done than I do here.
T: why do you think the student hub isn't that great a space?
L: well I think it's a great space, but I don't know if students use it as much as if they had their own dedicated space. I feel the student feels it has been successful so it obviously hasn't hampered progression but because they don't have ownership of an area it might be hard.
T: engineering has a high dropout rate, why do you think that is?
L: I think at undergraduate level its because its hard and its challenging. I can remember when I did my degree and I was living with people doing arts and humanities and it's a different kettle of fish. Its more in line with medicine and things like that, people don't realise how hard it is. I think a lot of people don't know what it is either, after doing maths and physics and chemistry but then have never done engineering so they don't know you have to be practical and analytical and theoretical. So I think that's part of it and erm yes I

think it is just because its hard and people don't realise and we try to see at open days this is hard, this is going to be really challenging but obviously people done listen until they are doing it and they say oh yes its really hard.
T: do you think its harder than some disciplines?
L: yes I do, well I would find it hard to do something creative and design because I cant draw but I think it's intensive in terms of contact hours and how much work they have to do. I went out with a bunch of the MEng last night and they were saying going home. They work a lot more than their housemates, they do a lot more work than geography or English literature, there's just a lot more to do.
T: do you think enough support is provided to postgraduate students?
L: I think enough support is provided but they may not know about it. So I was taking to a PhD student the other week because they were struggling and I said have you been to the student support offices because we have a really strong team of guidance officers in the school and they assumed they were just for undergraduates, they didn't realise they could access that service. Research office in terms of administrative support is second to none in the university. They know all the rules and regs and are so helpful to the student. Also there is a personal tutor system, so when I was having problems with my student who is suspended erm I said well have you been to see your personal tutor and she says I don't have one. So I think the support is there, just students aren't aware of it and its all told to them at induction but I don't think they listen because they think oh I'm an adult. I've done by degree I won't need that.
T: why do you think the personal tutor system is in place?
L: I think it tends to be to provide more pastoral support, more of a mentoring role and someone outside the discipline they are working in who they can turn to if they have any issues.
T: why do you think there is a notion of independence and expertise in postgraduate study?
L: I think there needs to be because that's what you are developing in to. although you are still a student, you are still on the same level as a graduate who has gone out to work and got that level of autonomy in their work. Erm so I think its difficult because you are a student but you are also a graduate.
T: do you feel like students think they are an expert?
L: by the end of it yes but obviously it takes a while to get there.
T: so how does the engineering discipline differ to other disciplines?
L: its harder (laughs). No its more challenging, its more diverse there are so many disciplines within engineering, it can be technical and analytical, it can be technical. Depending on where the research goes it could make it very uncomfortable if you are not an experimentalist if the research is drive down that route. Its male dominated and I don't

think that's a big different to a lot of other disciplines and there is still an old boys network there with the institutions. I turned up to do a public lecture once at the IMechy and this man say oh where's the chap doing this lecture then and he thought I was his secretary so there is that kind of bias in it.
T: how does that make you feel being a women in that environment?
L: I've never minded it, I was out last night with out students and there were 16 lads and me but now people harp on about women in engineering and its fine but now I can see how as a young female engineering is could be quite intimidating and restricting to be the only women in a room of blokes who can be quite blokey.
T: does the teaching differ to other disciplines?
L: there is not a lot of discussion in our lectures because they are learning facts so they are not learning critical appeals of subjective things, they are learning Newtons law so they are just facts.
T: what do you believe your role as supervisor is?
L: I suppose in the beginning, its technical advice, helping to shape the project, giving my expertise in the area. Facilitating them learning to be a researcher, so not giving answers but signposting where they are and being a bit of a mentor. I think it's really important and it's something I didn't have, like Issac is doing modelling that I don't understand it really but I help guide him in how we could do it but I don't actually know how he does the modelling but its about mentoring in terms of career planning and its that kind of final year project supervisor but less technical and more guidance.
T: how often do you meet with your student?
L: I see him once a week. We have a scheduled meeting once a week but we see each other every other day, passing in the lab and whatever.
T: how does that help, seeing him frequently.
L: well I think I know what he doing, but its not very formal. I mean I did have a student I saw her everyday but when she came to suspend she said she had no guidance because its not written down. I would rather someone know that they can knock on the door and me be available to them.
T: how much help and guidance do you believe you should provide to students?
L: I don't know how I would answer that without physical examples. I mean it's independent research so with Issac he just runs with it but if I think hes going off track I will say have you thought out about this. would this be exciting. With the other student she was expecting me to tell her what to do with every step of the way, I might as well have just done the work for her.
T: what do you think teaching and learning is at postgraduate level?

L: well I think its in those supervision and working collaboratively. I mean I go and do measurements with Issac because I want to stay involved in the research because its hard to stay involved when I have a management role and a teaching role but I want to stay involved with the research. I have imparted by knowledge on how to do measurements and how to apply them to his model but he has taken his model and run with it. And done more than I could possible contribute, I understand what he has done and why but not how. Its almost like peer learning and peer teaching because yes they are the same level of education, it's just the research they are being trained in. I supervise a project in a different school and the meetings are more prescriptive and instruction rather than guidance and to me it seems more like a final year project in that school rather than a PhD and the depth of work is totally different. I mean to me engineering is up here in terms of complexity of research and autonomy and the other school is prescriptive and I think if an engineering person was examining it, it wouldn't get past first base.
T: so do you think students should kind of look for their own solutions before jumping and asking you?
L: yes yes I do. Because I think that's the whole point of the PhD because you are learning to problem solve and I think that's the different between a successful student and an unsuccessful student. In grasping the need to be able to do that
T: do you think students make a shift to become postgraduate students?
L: I think they all have a wobble at the start and think what have I signed up for because it is pretty boring, all they are doing is reading. If they are an October starter around Christmas they start to see the possibilities but I don't really see a change. You can see people become a researcher and a really competent to find their own information and are really motivated. The ones that have been unsuccessful are the ones who haven't made that connection to be autonomous and think for themselves.
T: do you think anyone has the ability to be successful at postgraduate study?
L: I think you have to have a certain mindset probably, you can learn the skills but it's having that kind of determination and motivation but you definitely have to have something to be a postgraduate researcher and I don't think its for everybody. In fact people say to me oh you have a PhD you must be really clever and I say no I'm not really clever I just had the determination to do it. The nature of how you approach work in more important than the academic ability that you have.
T: do you think that when students say they are doing a PhD there is expectations from other people?
L: yes because even now people say oh you're a doctor and I'm like oh in engineering and they are like oh you must be really clever and I'm like no I just worked really hard. I don't think a lot of people know what PhD's are. We do and all the people that know us do

because you move in that circle but when you go out of that they don't know what a PhD is and how it links in with the world.
T: do you think students are viewed more as a colleague or a student?
L: that's hard there's a black hole where some supervisors view their students as colleagues but I don't think Issac views himself as my colleague but I do view him as an equal. But other students very much see the students as students and not use them but it's a very different relationship.
T: do you think its important for postgraduate students to socialise with other postgraduate students?
L: yes I do because they are all on the same journey and they are all going through the same things and they all have the same issues. I had a really big social group when doing my PhD and there were only about 20 of us and we all went drinking together and hung out together and I don't know if that happens now. I'm not aware of any specific societies for postgraduate student. I hope there are some because its really important to share that journey with people.
T: so how do you feel about students working while completing their PhD?
L: oh you just have to do it don't you. Particular if its not funded and you just manage it. You have to accommodate what's necessary, I would rather do something relevant so come see our subject area to do some teaching here and quite a few do teaching and its great for your CV. You just have to do it.
T: what does it mean to be an engineer?
L: it's the practical application of principles to a research problem that's makes an engineer.
T: at what point do you think a student would identify themselves as an engineer?
L: the minuet they walk through the door and some before. Our undergraduates identify themselves as soon as they get here and they are proud of that. Some might identify themselves as an engineer before they even get here because they might be on race teams or practical activities or they have been to college and done engineering. I'm sure some people are born believing they are engineers.
T: do you think doing other activities helps? Like being part of societies?
L: definitely I think it's the whole part of the university. I think there should be more social networks for staff as well because I think that's how communities grow and people are satisfied with their work. Having a staff room or a bar would really help. One thing that room (level 4 computer room) has done over there is give a social space which is really good. If they had a university wide PhD room would help as well. that kind of community feel and those societies help you stay sane.

Appendix 35 – Lecturer interview: Ian

T: what do you think attracts students to engineering?

I: I imagine some of them were attracted like me because they were interested in science, the application of science, I think some go into engineering because the career prospects are attractive in terms of employment and salaries.

Understanding how things work is in my mind is sort of applied science/engineering. The difference between science and engineering for me is that science is analytical so understanding how things work, how nature works, how laws of chemistry work. Its analytical, breaking things down into smaller units so you can understand them. Engineering has that element but it also has a creative element, a synthesizing element. Where you create something new that has not existed before. So that what distinguishes it for me, from science. I would say I am very analytical and not fantastically synthetic, I am more interested in university how things what already exist work. I could have equally been at home studying science, so I think people who like taking things apart and seeing how they work is one mind set, one interest, one skill. People who are innovators are more creative people want to design something that is better or new. People may be attracted for both or those reasons or maybe one. I was attracted for the first reason and not all engineers are creative, I am not but I am very analytical and good at understanding stuff.

T: do you think engineering is something they would have been interested in from a young age?

I: I suspect so yes. I think erm people that are interested in how things work, develop that interested really early on. They are children what destroy things are pull them to bits because they want to see what is inside. Take the toys to bits almost, like very young 5 or 6 years old, they want to dismantle things.

T: what would you say the advantages of studying engineering are as oppose to apprenticeships for instance?

I: well this is very topical as at the moment the government are wanting to introduce higher courses. There is a fundamental distinction between an engineer and a technician, they are not the same thing. The public get them muddled up. Technician do routine tasks, they execute tasks which have a set of instructions as associated with them which are well known. It is applying existing knowledge to a routine task. Engineers do one of two things or perhaps both, that is they understand how things work at a more fundamental level and use that knowledge to design new devices which haven't been created before or perhaps apply existing devices to new situations. So the old fashioned idea of an apprenticeship was to train a technician really. I mean degree level academic study did not use to be required and it is also by the same token when we train professional engineers on an academic route, they don't have the same skills that a trained technician would. They have

overlapping knowledge sets and slightly overlapping skill sets by they are not fully overlapping and it would be hard for an engineer to create an artefact with the skill and technique that a technician could. It would be equally hard for a technician to design a new artefact like an engineer would. They are quite separate types of jobs, you would never teach a boat load of physics to a technician.
T: why do you think the government are bringing that in?
I: I don't know. I am not sure.
T: do you think students who leave university are lacking?
I: I think some sort of industrial training is lacking. The truthful answer is probably more to do with employment statistics. That's just a guess
T: why do you think postgrad study is important?
I: I don't think it is important depending on what job they want to do. I don't think a PhD is for instance for most people who want a job in industry particularly useful. PhD's are for training in research. most engineers working in industry are not engaged in research, it doesn't mean to say they have a lesser function. Most CEO's of engineering companies don't have a PhD. The operational set of skills are arguable more important than research skills. There will always been a need in industry for a relatively small number to staff research and development labs, forward new products and so on but I cant ever see there being a small proportion of engineers being trained to PhD level and even when I say that there is a slight misunderstanding as it sounds as though a PhD is trained to a higher level and I don't think that is true, it is just an additional level. The knowledge and skills they get from a PhD don't enable them to do a normal engineering job any better. They are better trained to do a specific job in industry and that is a research job. I think somebody who goes into industry straight from a PhD will have a higher level of operational skills than somebody who goes to do a PhD.
T: what is it what you enjoy about research and teaching in engineering?
I: erm right so teaching first. I think I like teaching myself because I like organising knowledge. I like making connections between what might seem to be disparate areas of engineering. So it is not so much the process of teaching I enjoy, it is preparing material for students as during the process of preparing material I nearly always understand something better or in a new way or see a new aspect of it or make a new connection that I haven't made before. So the pleasure from teaching for me comes from the deepening of my own understanding as I teach. Erm I think actually the it is the same for research because I am analytical in terms of my strengths and interests. When I do research I clearly do understanding something as I do I do research on it I understand it better and deeper so it really is the same pleasure. Its simply deepening my understanding of various topics of engineering.

T: so the engineering drop out rate if fairly high, why do you think that is?
I: it sounds flippant and blab to just say because it is hard but I do genuinely think that is just part of it. I think some of it is just difficult to understand and it takes a certainly natural ability and an interest in engineering but it also really just takes grit and determination which not all students have. I think some just find it too onerous, there is an awful lot to learn. Some of it is really really difficult to understand. The process of going from not understanding something to understanding it is an uncomfortable psychological process. I still feel this myself when I am doing research or trying to find a new way of teaching something. That hurdle when you sit and you think and you try and understand and you try again and keep trying. It is uncomfortable, it is psychologically uncomfortable to go through. I mean the satisfaction what comes when you get over the hurdle, that is the pay off. To get to that point there is some painful stuff to go through and I think some of it is personality. Not everybody has the personality will do that. I think another reason why the drop out rate is high. Engineering in this country is not seen as a prestigious occupation, on the continent, in India to a certain degree in south America, engineering is seen as a very prestigious occupation, on par with a doctor or a lawyer. It is not seen in the same way in this country and that is partly because the general public don't understand the difference between technician and engineering. You know they will call the guy who fixes the washing machine or install the telephone an engineer. It is partly because we spell the word wrong, it comes from the work ingineer means ingenious, so on the continent they spell it with an I from its Latin routes I think. Whereas here we spell it with an E and we assume it is spanners and oily rags and it is to do with making engines work. So because it is not seen as particular prestigious occupation we don't necessarily recruit the most able students because they want to go into the most prestigious occupation so they study medicine or law. We do get some very very able students but we don't as a rule recruit the very very best like the medics do so we present them with a really tough challenge because the I think the discipline of engineering is harder than the pure science because they have to sort of understand science because of the analytical part but then the very best engineers have to have a creative element and have some flare and that combination is rare. Even the best academics, and I am one of them don't always have them in equal measure. Some have more design flare and some have more analytical ability, some have both and they are the high fliers. It is a tough discipline as some is difficult to understand, it requires a certain maturity. So for example in maths, you get some very good, almost autistic students who by the time they are 13 or 14 could do a study a maths degree and pass it successfully. But maths doesn't take that certain level of maturity, like you don't get someone who is 13 studying history because it requires a level or maturity to understand the concepts and it is the same with engineering. You sometimes have to make decisions, in science you simplify

until you understand. So the models and mathematical theories, you simplify everything until you understand. You cant do that in engineering because if you simplify things too much they just don't work in the actual way they do work. It is both more complex in general than undergraduate science and also if you are designing something, you sometimes have to take decisions without all the information you would like so you sometimes have to guess sometimes. That takes experience and maturity. This all adds to the challenge to students, they have to be analytical, they have to understand complex stuff, they have to have grit and determination to understand this complex material and to some extent got to be creative, be designers and that means they have to have a certain level of maturity rather than pure brilliance, they have to have maturity and experience to be good engineers and it is not a fantastically a prestigious occupation in this company. So we don't necessarily on average attract the best students so it is a challenge for them so they naturally fall by the way side.

T: do you think some students carry on with engineering if it is so challenging?

I: oh because they have the grit and determination they need and they have an objective, so for some of them it may be a job. It does in general provide secure employment. If you are a half decent engineer you can usually get a job somewhere which isn't badly paid. There is that motivation, you don't have to be brilliant to enjoy something and get some satisfaction and pleasure out of it.

T: what do you think the transition is like from undergraduate to postgraduate study for students?

I: erm I think there are challenges and the postgraduate experience and I think the main transition is mainly between taught and research based courses. I suspect the experience and the level of challenge if variable for engineering students and I expect a lot of that variability is down to the supervisor chosen and field of research. the range of supervisory styles varies enormously. Engineering students and I think science as well either end up loving their supervisor or hating them. The relationship is really quite binary. We are trying to standardise supervision to try and get some sort of handle on the quality of those sessions by recording what happens in them and so on. I suppose at one extreme think they are only there to bounce ideas off, other supervisors almost run the PhD project and define it and some students would hate that and feel like the supervisor is trying to take over and some will love it.

T: what do you think it is like for students who have never done research before as undergraduate study is quite structured?

I: well some get a little taste of research in their final year project, not always but most of the time there is a research element to it. there is a literature review. I think all students have the ability to search for literature in how to do something from undergraduate level

but in terms of doing research to find out something new then nobody has done before in some sense then some undergraduate get some experience of that and others don't. some will have experience of that and some wont. I think one of the difficulties of postgraduate students is loneliness. As a PhD you are adding to knowledge, therefore nobody can tell you the answer and you cant check it. some students are very nervous and lack confidence so some research students will come once a week and say have I done this right and can you check my calculations because as undergraduates we have almost trained them excessively these days to be given the confidence in their own solution and because they put pressure on us we give them the solutions so now they know if they are doing it right or not but when you are doing research you never know if you are doing it right because nobody else knows the answer so you cant check it. developing that self-confidence is saying I think I have done this correctly and have faith in the answer I have got erm is all part of the PhD I think.

T: engineering is much more structured, do you think students find it hard to flip to the flexibly of research?

I: I think that is true. There is a push now in engineering towards project based learning erm which is a bit more open ended. In other words you give a student a task, an object and then the student teaches themselves what they need to know in order to complete that task correctly and you hope they teach themselves all the stuff you would deliver to them in a traditional lecture. Erm but we are constrained in serval different ways, first of all we are constrained by the professional institutions for instance, they tend to say we don't really want all your degree to be coursework based. I think the IET insist overall 70% of the marks must come from formal examinations which sort of means project based learning has to be assessed in a different way. If you are giving someone a transition exam, you have to give them traditional preparation. So you know we are constrained by the way we deliver stuff. Also the amount, the scope of the material is absolutely huge, perhaps it is too large, perhaps we try and teach people too much. But because we do that, we cover a huge amount of material, one of the best ways to get that material across is a fast efficient way is the traditional lecture, it is an efficient way of learning. There are ideas in the engineering education to move away from the traditional way of teaching which has probably been around for 100 years to the more project based erm methods of learning. It becomes more difficult to produce a uniform product and I think industry do like a uniform product, I mean the student. when a company like Cummings down the road, interview a mechanical engineering, they expect them from day one to know their stuff. If everyone has learned through project based learning, people will learn through different sub sets of material. The student wont be such a standard product and it will be more difficult for companies and they will have to spend more time in the interview and selection process to find out exactly what

skills our customer has. This is a another problem we have, not just for engineering but for higher education generally, how are our customers. Are our customers the students who are paying the fees or are our customers industry in our case and the students are our product who we are producing for industry. Industry like the uniform product. They always say they are lacking in soft skills or lacking in design flare which would have been better developed through project work.
T: do you think students are expected to know certain bits of knowledge? So when I have been observing lectures someone may say you know this from a-level maths.
I: well I came into university as what would have been a BTEC student and I nearly failed my first year maths exam. After that I more or less caught up. Again this can link back to medicine or law, there is only one route into those. Some come in with a maths qualification but in general we have a wide spectrum of qualifications at the input stage. On the whole it sort of works but there are gaps in the knowledge that the student has to fill in themselves.
T: do you often approach other students to complete further study or do they come to you?
I: erm I tend not to sort of approach them myself. Some staff do target final year students who they think are very good and I think I would if I had more time. My students in general have come to me
T: what about the proposal system, students don't tend to come up with their own topic do they?
I: erm so again this varies very dramatically. I knew one professor at an American university who said he would never take a student who couldn't design their own project and that was his test, are they good enough to do a PhD. We just don't. I think 90% of UK academics in engineering either offer a project to a student they have designed themselves or at the very least design the project with the student rather than just saying design the project and I will give you as much help as I can. That is partly I think because members of staff in general are wanting to build their own research careers so they want students to work with them which will be helpful to build them a coherent body of research for their own promotion prospects. In the music department for example I am aware students publish by themselves, not with their supervisor and the academic staff publish single author papers but that is very hare in engineering, almost unheard of. In engineering and science as well it is almost universal that students publish with their supervisors, the supervisors almost manage their research and for helpful them in terms of helping them manage that research they get credited in the papers to help with their own careers. It would be very difficult to build a modern career in a university department in engineering if you didn't follow that process. The amount you are expected to publish is so high that you couldn't do it by yourself. I think so yes staff do come up with the proposals and I think students who do come up with their own proposals are almost always persuaded to adapt

that to something very close to the supervisors career trajectory. So you sort of join the same research path as your supervisor. That has been for a long time, I did the same with my PhD.
T: do you think undergraduate student prepares students for postgraduate study?
I: no I think there is a discontinuity but I would ask the question why should it because most students wont go on to do research so why would you design a degree for the 10% or less going on to do a PhD. You want the undergraduate to be fit for purpose for what most of them need or want. I think we could do better but we don't need to see the research career as something people aspire to. we shouldn't be designing our undergraduate degrees go into research.
T: so what is expected of PhD students as they come in and how does this change as the PhD progresses?
I: erm right well in my head, in my perfect world. In the first year you tell the student what to do week by week. In the second year the student develops more independence and comes to you are says I think we should go this way I think we should go that way. I think the direction shifts and you agree or advise the student against it and in the third year the student should be teaching the supervisor what is going on. The student should know more about the project than the supervisor does. The supervisor role is then to stop them going bonkers and a bit of sanity check on what they are doing. The student by the end of the PhD should know more about the project and the literature than the supervisor does.
T: what skills would you say students need to be good engineers and how are these taught?
I: erm that is difficult. There are so many different engineering jobs and functions which require so many skills. I think technical writing is a key skills in almost any area. If you're a genius you can do without anything else. Most successful engineering, there are two or three things they have got in common with each other. They may have no technical knowledge in common, one might be power, one might be mechanical. All successful engineers tend to have good communication skills, they can write technical English clearly, how things work, write papers and technical reports. They can present their work coherently and explain it orally. They can stand up and give a presentation. I think the best engineers have a certain self-confidence in proposing solutions and executing them so. In engineering it is rare there is only one solution. There are many solutions and I think when we train undergraduates we tend to say there is only one solution and erm then they come to do research and be mature engineers and if they still have that mind set and they can panic and often it doesn't matter which is the best solution, it matters if it works. Have the confidence to choose a solution and not worry as to if it is the best one but to have the confidence to think it is an acceptable solution. Self-confidence, I know what I am doing. We could have done this way but we chose this way with the constrains we have. As an

engineer you don't have the luxury of three months to think about the best solution. Your line manage wants a solution by next week, you have to choose something relatively quickly and have the grit and determination to pursue it. one definition of engineering from one of my old bosses is an engineer is someone who gets things done. Don't sit and think, you have to sit and think a bit but you have to do it as well. if you don't have all the answers to all the questions you would like you still have to do it.
T: how important would you say student relationships are between each other?
I: it is important to some, some students are social and would be unhappy if they didn't have a supportive network around them. Other students are antisocial.
T: at what point do you think students identify themselves as engineers?
I: I suppose strictly speaking I would say they are entitled to call themselves engineers when they graduate. In general engineering students are not that self-confidence. A small proportion are but generally they are not. I do say in the final year and in the project they say I am stuck with this how do I progress and I say remember you are three months away from graduating as a professional engineer. You are effectively an engineer so why are you asking me? you have to develop some self-confidence in your own solutions. This goes back to what I was saying. You don't want engineers who are never sure if they are right or not.
T: what would you describe the engineering community to be like?
I: (laughs) I have never thought of this. I think there is an engineering culture, we recognise each other as engineers. I do feel we have something in common with each other. We work a lot with each other, a lot of my friends are engineers, the people I socialise with. My wife is an engineer. I think is a reasonably friendly but it is a bit judgemental. When it comes to judging each others work we are very hard critics. We are critical of others work, that seems to be a norm
T: why do you think that is?
I: I don't know
T: would you say it is hostile?
I: I don't know if I would go as far as hostile, I think we are just academically critical of each other. When we referee other peoples papers we are critical
T: would you say it is competitive?
I: yes in academe. I think less so in industry. I think academe is brutally unhealthy, a lot of academics are unpleasant people as they are so competitive. The students like competing against each other, that is very friendly and supportive. I think engineering is the same as any other profession, friendly competition. The less attractive side of competition, career and prestige is very prounance in academic engineering.

Appendix 36 – Lecturer: Ian (Observation – MSc)

I came on his office at 9am and he said oh you are early.

He said I only have a small class, of about 4 so we just have the lecture here I my office. He prints out the PowerPoint slides for the students.

There is just me and Ian in the office and it is silent for about 10 minutes and then he says he is updating his unilearn site. He says he has been here 4 years and apparently now the university are updating their software systems so he will have to get use to it again.

9:13 he says sometimes they can be a bit late

9:19 Ian gets up and turns the TV on and says come on where are you (nobody has turned up yet). He says I have got the right date haven't I and then he checks his diary. He says they are usually 10 minutes late. Loads PowerPoint on TV on the table. Then goes back to laptop on unilearn.

9:24 a man comes on with a women who has brought him to the room, Ian asks why he is late. If it is because he is confused or just because he is generally running late, the student just mumbles something. Ian says do you know where the other students are, he says no. he says have you got their phone numbers and the boy says yes, he says well can you ring them then please – the boy doesn't.

9:27 another boy comes in and says hi and sits on chair.

9:30 another boy enters and says hi

Ian says can we please try and be on time because we have a lot to get through

He introduces the topic and asks if they have been introduced to this thing at undergraduate level. One says no, two say yes. Ian says well I am just going to rush through this.

One of the objectives on the PowerPoint from the lecture is to apple to real life problems – Ian throughout the lecture relates back and gives examples.

Ian says a few times do you understand this and they say yes.

Two of the boys make notes on occasions

Ian asks a maths based question and they all try to answer and get it wrong. He says come on guys you know this, you did this in your first year undergraduate statistics course. He answers the question and then gives another example to try and consolidate the knowledge.

One boy makes notes.

Ian asks another question and again they don't even try and attempt to answer it and he says look, its on the screen – one boy says the answer. Ian says did you not use the log tables when you were at school – expands on what a log table is. He then discusses this in terms on the relevance on the slides (three equations).

He says any questions, the way he is conveying things I would not dare say I have any questions or that I do not understand.

Discusses something and he says would you like me to write it down and show you. They say yes. After finished he says please tell you remember that now I have written it down.
He says I take it you are all familiar with sortation notation. One boy nods
Ian says oh gosh I can't do this mental arithmetic, can someone do it for me (laughs).
When discussing how to use terms he says we can either use the correct term and look eccentric or we can not use the correct term and look a bit more sloppy but not scare people.
When discussing how to work out an equation he says do you all know this, if not you better revise it because you can't always use a calculator.
He says I have put a gold start on this slide, that means it is not examinable but it is interesting. Skips past these two slides.
10:17 he says right you know enough about information technology to last you the rest of the year. He says I mean it is a broad topic and you could really do a PhD in it.
Next topic on PowerPoint, Ian says right lets take a 5 minute break.
They ask me some questions about what I am doing and they say I take way more notes than them another boy says yes this is hard. They say have you found out anything exciting about them (laughs). They ask how old I am and if I did a masters, they say wow you must be clever.
Ian comes back in and gives music examples of what the previous lecture was on. He says he is interested in music – he says it is nothing to really do with the course but it is interesting.
10:25 he says right we are going to start this heave mathematically sophisticated section to you will have to drag up material from the past to follow adequately but we can't teach every concept from scratch but if you get stuck just say and I will try and explain.
Asks questions – nobody knows answer and he starts to get annoyed and asks the same question again. He says oh come on, one boy answers.
A mathematician would say infinity but we as engineers are much more practical and so we wouldn't say this.
RC filter, we learn it in the first year (of undergraduate study) for the electrical engineers here.
Boy asks question and Ian answers, he says have you not come across that before?
So that's converlusion but if you cant remember and I don't have time to teach you it is in chapter 2 of the text book and I am hoping it will only be a refresher and not from scratch
He says this is engineering through and through. For all civil, electrical and mechanical etc, we all share the basic science but we also share the fact that we optimize things, we try and design by possible things and it involves trade offs – we have to let one thing slide a bit to

be more advantageous for another thing. He says this is a deep cultural aspect of engineering.
Only one boy making notes
I think this is mathematically sophisticated, tell me if you get lost, he says everyone ok so far? He turns to me and says are you ok so far and laughs.
Not much writing on slides in comparison to what he is discussing.
Refers back to previous lectures on numerous occasions. Does not try and make lectures interesting- can these lectures be made interesting?
He says that's it, well done for staying the course, the was tough. One boy said yes it was.
He says you can go and read it more slow pace in the text book now.

Appendix 37 – Lecturer: Ian (Observation – MSc)

4 students, all male.

9:05 I come into the room and Ian chats to be about some more observations I could do. He says I guess watching this teaching is a lot different to psychology.

He is rushing round sorting things out.

9:15 two students come in, one says hi to me as he was here last week. They sit talking about the work on the PowerPoint what is loaded.

Another boy enters and the doorbell rings, Ian says will one of you go and see if that is one of your colleagues.

Ian gives out the spec for the mini project but not the lecture notes like last week – nobody has them.

He says they are going through the 4th part of the mini project. One boy says why are we going through this when I've not even done the first part. Ian questions why he has not done the first part of the mini project and he says its difficult. Ian says its not too difficult but it is part of an the MSc course and it is a lot more challenging and the material comes at you a lot quicker pace than undergraduate.

He is talking about the mini project, saying they have to research ideas themselves. They have a list of areas to choose from and they have to look in more depth at them themselves.

He says you have to agree with the supervisor you chose what links with the topic as to what you are going to do.

9:30 boy comes in late

Ian talks about the history of one the topics the students can choose and he talks about who invented it. He says its completely irrelevant to an MSc but the history is interesting.

He says they need to put 30 hours a week on this project and not more or it means another part of the course will be lacking.

He says it often takes a lot longer and its harder to write a good short report than a longer one. He says we might relax the work count on this 4th part as it will be hard to discuss the topics in detail.

Student asks question about one of the topics they can choose, Ian discusses this. Student then asks how much % they go towards his final grade. 60% exam, 40% coursework.

The student then asks if deadline can be changed. Ian says I am very reluctant to change deadlines as head of department. I tell staff not to because it causes ciaos. If you have an EC then of course we can.

9:40 lecture starts. Goes through objectives – he says we are going to do this how I like to do things and do images rather than maths equations.

He says as always we start with the hypothetic transceiver and this is the aspect we are going to look at today (it's highlighted).
As he goes through something, he says you will all follow, he says this is simple integration. He says those of you that studied electronics so you will recognise these- he says if you don't recognise this its ok because this is a systems course, not an electronics course.
They move things on really quickly, lecture really fast paced. Nobody making notes just listening. One boy asks question and Ian answers.
Skips past some slides, he says right I am going to tell you how to do a matched filter and then say why to do it this way – one boy writes things down. Ian discusses the equation.
'I call that the amplitude of the filter'
'I don't want you to be distracted by the ISI at this point because we are not discussing it'.
So much to cover cant help that things overlap.
2 boys making notes as he goes through slides.
Content is so high, so many things to take in, just listening makes me feel confused so I can understand how students feel having to try and understand this.
'I am being very rigorous here'
Ian asks a question and then answers it himself straight after – doesn't even give the students time to answer. He does this a few times.
He says once it has been explained to you it is very easy and obvious to see why the equation is like it is.
'I am going to tell you the answer again first and try and convince you why this is the right answer through justification not through mathematics.'
Ian writes something down in a notebook to expand on what he is saying on the board.
Keeps referring to previous knowledge they must have learnt at undergraduate level – saying we can do … by doing.. cant we. Using terminology, expecting students to follow.
'ok so I'm hoping that argument is good enough to persuade you that is the right equation to design a matched filter'
On the break Ian asks how the MSc is going in general, they all say very hard. They say that Ian's module is the hardest and Ian says really. He laughs and says yes but it's the most interesting.
He says masters are the most difficult courses because people come from a range of backgrounds and some are bound to have a gap in their knowledge what they need to catch up on themselves, he says masters are by far the most difficult. The boys are talking about bits they are struggling on on the course and Ian says we will turn you into geniuses, he says learning is very interesting.
One boy says he wants to do a certain project and Ian says yes but you are a communication engineer so why do you want to do a power project when you are not doing

that and you don't have the background. He says I don't think an examiner will allow it. Another boy says well the project is under the electronics category so why cant he do it. Ian reads this and says oh yes it's the application so maybe I am wrong there.
There is one boy with a computer science background as oppose to engineering. Ian says engineers think in frequency domains, computer scientist think in time domains. Ian says his old PhD supervisor told him that. One students talks about how he has never done this before but all the other students in the group have probably covered this before but Ian says its because his background is different.
Ian asks a question and nobody answers, he says this is not a rhetorical question. Ian goes through the material again and asks the question again, one boy answers.
He says have you heard of auto correction before, electrical engineers will have, one boy says he hasn't but Ian does not take the time to explain it to him. He says this is in the textbook if you want to go and look at it.
He discusses classical engineering v's quantum mechanics in the 1920's. He says some very clever people discovered something about white noise, discusses this.
Gives summary of lecture and then supplementary reading.
Moves on to first part of next lecture as they have finished early. The boys have two two hour lectures with Ian with an hour gap in between. Ian says we are still going to look at the same bit of the receiver as before.
Ian says Perceval's theory have you all heard of it, cast your mind back to undergraduate study, it is a common sense theorem to engineers. He says he remembers his teacher teaching him this stuff because it has been around for 40 years. He says he remembers thinking and this question when he was being taught it and then discusses it.
He says after all that complicated stuff we have been talking about for an hour and a half we get this simple answer.
Discusses something and says to the boy as a computer scientist you will be aware of this – doesn't refer to him as an engineer.
As they have started on the next lecture Ian says are you sure you can keep your concentration, this is tough stuff. He says right lets have a break because this stuff is too difficult to go on and on and on.

Appendix 38 – Lecturer: Ian (Observation electrical engineering year 2)

Electrical principles 2

Before the lecture there are a few groups of people chatting. About half the people sat together, half sat alone. Some people chatting across room and some have got out of seat to chat.

Two boys near me are talking about an assignment, one of them is struggling with it and the other one says he will help him. He says 'we will try and get as good mark as we can on it, we will sort it'. This boy then turns round to a boy behind him and asks what grades he got on something, he says oh you are the teachers pet and laughs.

Students ask Ian when they are getting the marks back and he discusses.

He says this is such an important circuit we are going to devote a whole lecture to it. Bad news is a lot of maths, good news is a lot of the same was covered last week. There are not a lot of formulas to remember, not that you have to remember them because you get a formula sheet anyway.

I, like most engineers use… because we are more familiar with them. Even though it might make them more confusing – shows equation for doing this. he says it is just a matter of preference. He says teachers will teach you this easy way but if you are so familiar like me then you can use this. you don't have to remember a whole lot of new equations but it is harder but for me it rolls off my tongue, it is engraved in my heart. Good old fashioned stuff I know and love.

Identifies a formula as useful as it can be used on many occasions – describes it as 'golden formula'

Uses a lot of terminology

There are many different levels of understanding in science and engineering. You can design a good circuit without fully understanding impedance, he says you don't always fully understand circuits but you need level of understanding to do a good enough job. He says us as educators don't know the level of understanding each individual student will need for their future job. He says I am just trying to defend why we are teaching you things you may not feel you will need, we have to teach a broad range.

He says I have wrote a few ways of doing each equation, no one is better than the other, it's just what works for you.

Ian says I am going to work this out in my favourite way, as I said its not the easiest way but its my favourite.

Refers back to previous knowledge throughout

Not many people making notes or even looking like they are paying attention.

One of the things we are fairly interested in as electrical engineers is bandwidth frequencies.

The whole lecture has a focus of maths/equations throughout – they have to remember how to apply equations to examples.
You all learnt years ago that you can factorise them
Ian tires to work something out and says sorry I will have to think about that (laughs).
All the useful formulas that engineers remember and they do remember them but you do get a formula sheet even though I wish you wouldn't but we cave in to students but to be professional engineers you need to remember them because they are useful in so many areas.
After the two lectures you have a very good insight into electrical principles.
In the break students help each other out with the assignment + understanding work. I hear them talking (2 boys, one girl) and one boy says when Ian asks a question I just slump down in my chair. I will just google I hear them say, girl laughs and she says I just ask him.
Ian comes back and says now I can answer the question from before, he discusses the reason why he got confused.
He says I am going to skip over this analysis because it gets heavy and those of you who have a passion for maths you can read it in your own time.
When talking about impedance the maths doesn't get hard, just large so we simple it down by…
One boy asks question and Ian answers basically, does not go into detail with answer as if he should have already known it.
Brushes over things as if students should know. He says then we do a bit of substitution here and this is the answer. Doesn't discuss what substitution is.

Appendix 39 - Lecturer: Induction meeting for college students (Observation)

Not many students here – all come with parents
In design studio – other students around
Ian doing presentation for application visit day. He introduces himself as professor Ian Glover and says he is an electrical engineer and then goes boo as leigh is a mechanical engineer (laughs).
They say they encourage working together, group project work, they have industry standard technology when describing the design studio.
Says they have a heavy focus on research and so are at the front on industry and research meaning the lecturers are up to date.
All courses industry relevant. They have an advisory panel that says if the course is up to date and if students are getting the skills they need for industry. Says they keep on the right track and make sure they are teaching the correct thing.
All courses are accredited by IMechE – chartered professional qualification.
Full program – talks (subject talk, placement talk), lunch, tours, taster activities. Why so much effort to encourage students into engineering?
Placement program uni is award winning at the university of Huddersfield – staff see technical maturity as engineers when they come back from placement. The experience is and placement integral part of the degree.
Puts email sent to Ian from student on the end of lecture saying how much they enjoyed their experience of engineering at Huddersfield.

Leigh – subject leader for mechanical and automotive engineering.
Make sure degree fit for purpose, that you have the skills employers want/desire and we get that through ties with industry.
IMechE or IET both accredit degrees. Average salary for chartered engineer is £63,000
A lot of engineering courses have similar structure and it's the things you do outside this what makes a difference.
They say they do formula student, railway challenge – not just student competition but also against graduate engineers as well. says we are a competitive bunch in mechanical engineering.
Also do ICE – 24 hour design challenge. Multidisciplinary brief set to design and present idea to dragon den with chance to win £500. All competitive

1st year is basic physics, basic building blocks of engineering. 6 modules. Traditional lectures then go into lab and see how things work. She says people learn by doing and applying.
Engineering is a challenging subject but also very rewarding.
Learn how to talk to people with different skill set
Design process – as well as learning theory you also get practical skills.
Practical skills through some modules but also analytical skills through others.
50/50 exam and coursework.
Final year – courses deigned so you are continually building on your skills for industry.
Potential to work with research groups here to get skills you need.
Estimates we need another 2000 engineers. We have had people graduate + go on to a wide range of companies.
That is the beauty of engineering, the diversity of it. Engineers are in demand, excellent career prospects, pathway to future study, engineering rewarding + challenging.
Masters to specialise further. Extracurricular projects such as 24 hour project. not all universities do that.
Describe a student who she previously taught to be shy and reserved at the start of their studies to a confident engineer at end.
Relating things to real world experience
Asks students to go on own to get involved in a taster activity what a lecturer is doing some research on. Start as course means to go on.

Appendix 40 - Lecturer: Guest speak (Observation – 1st yr lecture)

1:15 says we have a guest speak from student support and guidance. They discuss how to come to them if they are struggling etc.
There is a guest speak from the turbo charger department doing a talk today on his research interests.
Lecturer asks boy to put laptop away and he says I have exams coming up. Lecturer says its not time to study, you need to listen.
The lecturer is not loaded, he says the file is quite big.
Lecturer introduces himself and talks about how he has research students and considers them to think about doing a PhD.
Leigh sits down on the front row to watch the talk
Around 80 students, 3 women
No students got any lecture notes printed out, barely anyone even got notebooks out
He says this information can be taken into various fields, not just wind turbines. For instance it can be used in forensic science and gives example of this.
Asks students question and two boys answer
1:40 lecture finally loads and second slide in a list of about 10 research areas he is interested in
Uses terminology
Discusses real life application – examples from industry he has seen
Lecture stopped working again so he asks if anyone has any questions
Boy asks a question – lecturer answers but not in a lot of detail. Boy asks a further question for clarification and boy answers this.
Another boy asks a question – lecturer answers
He says ok it is not working but I will mention a few other people we have worked with – he says if you mention me they will know you are from Huddersfield.
Leigh says right see you in a bit, make sure you go away and work on your PDP.

Appendix 41 – Lecturer: Leigh (Observation 1st year lecture)

Mechanical engineering and science – properties of fluids.
While the lecture is starting there are a number of students discussing work; racing hobbies, the design challenge last month, peer reviews, placement.
Starts by asking students questions to remind themselves about last weeks lecture.
Students shout out answers.
Starts with what they are going to cover this lecture, about 6 different areas.
Says some of you will have done this in a-level chemistry or physics – this is just a reminder and then we are going to build on this.
Asks questions about this and a few people should out answer.
Covers laws of thermodynamics – discusses each law and expands on it and gives example.
She says if you have done GCSE physics you will know a bit about this.
Provides equation for 1st law of thermodynamics
Says sorry the lecture slides got put up late and thanks to Paul for spotting this. he is the only one who emailed me, I hope he's not the only one actually checking them. Paul laughs and says I will get beat up when I go out now, everyone laughs and his friends sat around him call him teachers pet.
Uses a lot of terminology.
Boy shouts out a question and Leigh answers this, she just expands more on point she just said and boy says 'oh so this is all part of that'
She asks another question and students shout out answer.
She says some of these things are related to this and we will brush over it because you should remember this from GCSE chemistry if you studied it separately.
She says if everyone ok with this, it was only a bit of revision.
Provides definition of next topic – ideal gas. Moves through this fairly quickly. Starts drawing on board to provide example of what she is discussing.
Provides equation for this topic and asks question if people know what the units are for the equation. She says I am presuming you have all seen this equation before.
Make sure you keep the units constant – get into good habits now.
Has everyone heard of Boyle's law. I think you all should have.
Asks a question but she answers it herself.
Now looking at Charle's law.
Asks them to work out an example using the equations they have just learnt. Only been learning presentation for 30 minutes and already expected to calculate.

Simplifies the equation for them by giving some tips and then starts to work it out herself in steps – fairly simple to follow.
Provides them with a video to introduce the next topic. Introduction to enthalpy. She says this is for those who have not been introduced to it before.
Quite a few people with notebooks out, making notes, look engaged.
Watches 5 minutes of video and she says so that should give you an idea of where this equation for enthalpy has come from.
I am just going to touch on this example of thermal energy for enthalpy if you want to know more you can watch the rest of the video.
Specific heat capacity is another constant you must be familiar with.
All this relates to enthalpy – provides equation for specific heat capacity.
Spends about half a minute on each slide – moves on very quick.
I will give you a second to copy that equation down because you will need it for the example you are going to do.
Asks them to answer the question quickly.
She says you need to answer these questions because it consolidates the knowledge and not doing it or waiting for me to give you the answer means you wont get much out of it yourself.
Asks them to talk her through how to work the equation out. Asks them if they think its important if they know the difference between T1 and T2, they all shout yes out.
Says there are some tutorial questions on unilearn but you can always come back to these examples and switch the numbers up in them and work them out again for yourself.
4:40 now moves on to another topic. She asks the students to write the equation down and then explains it. what they are used for etc.
3 minutes after she wants them to work an example out using these equations she has just covered.
Students start chatting to each other as they work this out.
Leigh walks round helping students
She then works through the example, 'do a simple re arrangement'.
One man asks where the equation has come from and she says from the two laws we covered earlier.
She asks them why she has added 273 to the temperature answer and the students shout out the answer.
4:55 moves on to last topic
Writes more equations on board what relate to the topic and explains what they are – these are not on the PowerPoint
One minute after this she asks them to work out another example using them.

She says I will give you until next week to answer it, so come in to the lecture next week with the answer.

Appendix 42 – Lecturer: Naeem (Observation – Meng)

Non-cartesian CMM errors – thermal errors

I come into the lecture and the room is silent apart from Cale and O Mason chatting about manufacturing the steering wheel. Things are getting a bit heated as cale is questioning why he has done what he is doing and what he has already done.

Two boys come in and they are chatting to a boy who is already here – they are talking about a report.

George and James come in together and they are also chatting.

There is some equations and working out on a board, lecturer reads this, clearly trying to understand and figure out what it is.

9:20 lecturer says we will cover what we have done since the first step since you might have forgot. Says dimensions area involved in all aspects of engineering and lists these.

Says if I am using my method and I am getting accurate results then why do I need to switch methods, well because its not standardised for trade.

You have done a lab on CMM – what CMM is and discusses types of CMM.

Says do you remember the video I showed you about CMM – he puts video on and explains it.

Draws on board to discuss video.

He says did you have a lab on…last week and they say yes. He says did you enjoy it and one girl says no. he asks why, is it because you didn't understand it or because it was boring. She says because it was boring, he laughs and says if you are going to be an engineer you have to be patient until you understand everything.

Discusses laser techniques, draws on board to explain it and says this can be useful for your assignment for this part…

Talks about the weaknesses of this method, none of this on lecture slides.

List of different errors on board (around 6). He says we have spoke about these errors before so we will quickly go over them in terms of the CMM. Clearly too much to cover errors in general.

Nobody has lecture slides printed out, not many people making notes but to be fair I don't know what they could even make notes on.

Says it is good to have rigid material but sometimes flexibly is good because rigid can crack but that's another area of research – doesn't cover this.

Draws on board to further explain something – if you have never done it, the try with a laser light on your hand and you will see the distance change but the angle will stay the same. Does it make sense, class say yes.

He says right thermal error, we all know of this, I will quickly go over it in terms of CMM.
Boy asks question and lecturer says no not much heat is coming from tool heat but if you do it for a long time it will.
Boy asks a question – he asks question what you can clearly see he knows what he is on about. This works like this…so does this mean it can be applied to this.. lecturer says yes I don't know why you would want to do it but you can do it.
Refers back to previous lecture slides and labs.
Asks a question and nobody answers, he says any guesses and someone answers. He says right what will you do with…
Some people shout out answer and they discuss ideas back and forth. He says you re all exactly right but you are not getting it in the direction I want, its not your fault. When I say you will be like oh yes – he discusses answer.
Discusses a lot of things what can go wrong in engineering and how to cope with these. Not exactly learning about being innovative and creative.
Girls asks question if there are any materials what don't bend with temperature. He says no all materials configure with temperature.
Boy asks question and lecturer says yes I am coming onto that.
When you get those machines, those engineers are really really competent and they know what they are doing.
Covers something and says this is like what you did with the cooling system.
It is generally accepted about temperature control areas that people place temperature sensors in places accessible to them but it works better to put them all over machines to control temperature.
If you mention thermal error index to people they will laugh because they have no idea what it is – discusses what it is.
Boy asks how he got an answer and he briefly explains like he should have already known the answer.
10:35 part two of lecture – CMM calibration
'do you understand artefact' – we have gone through this before but I want to make sure you understand. He discusses this and draws on board to explain. Not everyone can make artefacts, if you want to make them you have to be good at…
Covers something and says 'do you remember that – that's the geometric model, we have covered it before'
Gives brief summary of what he has covered today and then says please practice thermal error because it is extremely important for the exam so study and practice it.

Appendix 43 – Lecturer: Naeem (Observation – masters Meng)

9:10 I come into the room, some students are sat together, some not. Only two men chatting.

Cale comes in and is chatting to me about the lecture saying that are pretty fast paced.

George comes in and says I didn't know you were here, I said I wont understand anything and he says its ok we don't either.

Lecturer says where is everyone, is there any trips on or anything. Students say no, they have given up. Lecturer laughs and says oh they have given up or have they got bored, or maybe they just think they know it all after only 6 lectures.

Talks about last lecturer and asks if everyone understands – discusses this and asks a question. Some students at the front answer.

He says there was a lot of information from that lab for a project engineer and for your assignment.

Draws on board and asks students where the probe should be, he asks where it should go and the justification for this. James Clarke gives numerous answers, contradicting what other students have said. He says I will now tell you the answer and the reason why.

Not many people with notebooks out

Lecturer still chatting away at front, relating back to last weeks lecture and the lab – still not moved off title slide.

Still drawing diagram on board, he writes materials down what the students are saying and says I don't know but I am only taking what you said because you were in the lab last week not me.

Brings in thoughts about what companies do in terms of using machines. He asks a question about the lab last week and then a boy asks a question back – he answers this in a bit of detail.

A lot of people do not even look like they are paying attention.

9:35 he says if you go over to the temperature control labs, just for your own knowledge, you can ask them a few questions on how they keep it at that temperature constantly.

Goes through the topics you be discussed in the lecture, around 12 different ones.

First slide, he says this is basically what I have just gone through (when discussing previous lecture and lab).

9:40 lecturer says they will go through 4 methods of temperature because these are the main ones used in precision engineering.

Goes through the first method and then asks a question to students 'can you say what this is, its part of the terminology'. Student answers this and then he draws another diagram of temperature sensor for 1st method.

He says I don’t know if you knew but you should by now, that the computers also give off heat what will affect the environment.
Jumps onto another topic related to the disadvantages of the method being discussed and he draws an example/diagram on the board from electrical engineering.
He asks question and someone answers, he answers and says this is what you have been doing in the lab.
9:50 moves onto next method. ‘we all know from our bachelors that every equipment has resistance’.
Draws on board when it comes to advantages and disadvantages again.
You will find this information in data sheets what come with the sensor – make sure you always ask about .. when buying a sensor. Advice.
A lot of slides, only a few people have a copy of these.
Says if you type in one wire on google, this sensor will come up, it is the correct terminology.
10:05 finished going through 3 methods. Says now we will go through calibration ‘you must calibrate’ – discussed why this MUST be done.
Gives another example, real life example of calibration and demonstrates using a white board rubber and the wall.
He goes through another example of temperature gradients and says where would you put the sensor here (diagram example on board) and he says that is something to think about - does not answer or let students answer.
‘You can work out temperature changes using this equation’, does not go through equation or how to use it.
‘I said to you last week if you think it is a stupid idea still say it because it could be a great idea in the future – girl daren’t say her answer. She says it and he says absolutely right, well done.
10:25 says they have finished part A of the lecture.
‘We have talked about uncertainty in previous lectures’ – provides definition of this.
‘He says in other words, just do not trust anything until you calibrate it’ – students laugh.
‘you will have done that in your tutorial’
He says ‘you go through the uncertainties in industry by working with the customer, you then work with your colleagues to see if they can think of any uncertainties as well’.
‘this is what you did in your first lab’
2 boys leave lecturer early with all their belongings.
People walking in and out throughout the whole lecture – not many people seem fully engaged or bothered that they may be missing sections of the lecture.

Says anywhere in the world these methods and problems can be used – gives example of dashboard on a car – he says they don't have to just be used for precision engineering like you may think.
He says any questions – a man at the front asks a question and the students start chatting and packing their stuff away. Lecturer says can you listen because this student has a very good question.
A lady also then asks a question and this time he says 'well transmitter is electronic device, you know that, he starts drawing diagram on board. She asks another question about how will she know which temperature probe is which and he smiles and says 'it is wrote on it'

Appendix 44 – Lecturer: Naeem (observation – Meng)

I come into the room and there are a few people in here, some stay together chatting – these are not part of the course, just using the computer room.

He passes a sheet out and says to Cale, how come you are sat at the back, do you not like me. Cale says no I was in here before this started doing work.

The students not part of the course ask Cale what the tutorial is about and he explains to them what it is about and they ask a few questions.

Naeem says you don't need a computer, just a calculator.

12:18 he starts to explain what the lecture is about and he asks if everyone know what fine element analysis is – he says who doesn't know what this is, raise your hand. Nobody does so he starts explaining what they will be covering and he asks students questions while he does this and they shout out the answer. Trying to see what background knowledge they have before covering this practical?

He uses a folder to demonstrate what he is on about.

He then says I have passed some general information out if you all will have a read, I will give you one minute.

He literally gives them one minute and then starts to explain what finite element analysis is and draws on the board.

He says you can usually we do this but using this software means we can measure each individual element – he has an object already on the software to demonstrate this.

He adds some measurements onto the drawing he has done on the board and asks students to work something out using them.

He says what is the equation we need to use to work this out, one student shouts it out. He writes the equation on the board and starts putting numbers into the equation for them

He says right tell me what Q is. He walks round chatting to students about what they are doing.

He says whatever the value for Q you get, divide it by volume again and I will explain why later.

He asks if anyone has any answers so far and nobody replies, he continues to walk round.

One student shouts out answer. Students continue to work it out for themselves and one boy shouts where is the mass for it? Naeem says you must work that out, you must remember these basic equations because you will have to work it out yourself. He says come on, we are going into undergraduate now.

Someone shouts answer out and he says to the rest of the class, you can work out how you get the answer later.

Naeem says it is very important you have engineering capabilities and equipment and engineering software. He says you cant always take the results given without understanding

what is happening. Make sure you have initial information as that will make hr impact because you don't just want a pretty model. You have to understand the mechanics behind the software as sometimes the calculations and numbers you put in can be wrong or the modelling can also be wrong.
He says you can check calculations on software and says that is the first step to checking it. He checks their answers on the software and says we got the first one wrong it should have been 0.01, one boy shouts out, I got that answer right.
He then asks students to work the next thing out – they shout out the answer and he says yes you are all completely correct. He says this software allows you to see temperature gradients and they are all accurate.
He demonstrates how the program displays temperature change and says don't just go on colour change, check the magnitude. A student shouts out yes sure.
He then asks students to work out how much the object will expand. Cale gets notebook out to check how to do this from a previous practical.
Naeem says do you know the equation to work this out, one boy shouts out yes. He says ok tell the class and the boy says it and he says what about the simpler way and boy then says this as well – Naeem writes it on the board.
Naeem then asks what units need to go into it and they answer. One boy shouts answer out and he has forgot to convert units so he has got the answer wrong.
Someone else shouts answers out and how they have worked it out, it is wrong and Naeem says no we don't divide in this equation. Another boy shouts out how to work it out and he has done it correctly. Lecturer then checks answer on software and says they can confirm results correctly.
Naeem says engineering thinking, judgement and capability, you will be able to model it easily, you do hand calculations to check modelling is correct.
Naeem then puts the answer into a graph on the software.
He then discusses nexanedrm mesh and says these are basic things built into software and this one is more accurate then tetrahedral. What engineers do is see what areas can be broken down into nexahedrum but it depends how interested you are in accuracy.
Students asks questions about these methods and lecturer starts conversation about this.
Says we have covered the objectives and you should have already understood the hand working out from previous labs and lectures so that's why is says visualise and not understand modelling on the lecture.
Patent and publish it, when you have done a successful modelling and calculations.
When you visualise something you understand it better.
Student asks questions about how to model and he says you don't need to know because it wont be on the exam – he says you should have modelling modules anyway on how to do it

as student says he needs it for his final year project. Naeem says you are an MsC student so there is some expectations but solidworks is easy to follow and there are tutorials and videos on it but if you get stuck email me.

Appendix 45 – Lecturer: Qasim (Observation – tutorial undergrad)

Electrical principles

Students come in and are given a sheet off lecturer to start working through.

At this point there are only 3 students, nobody sat together, nobody chatting.

He says try and do question 1, 2, 3 and 4. He says 4 will take a lot of time but I expect everyone to get up to it. He says you will not be able to do 8 yet but should be able to answer up until question 7 at this point.

More people come in and he says you are allowed to look up your notes and I will go over question 4 at the end.

A lot of students on phones looking up equations.

He goes round and one boy says I am stuck on the black box, lecturer says it is on the lecture slides somewhere, you will have to have a look.

He asks where everyone is and a boy says maybe they are doing the voting thing, lecturer says what is it and boy replies I'm not sure I don't really have time.

Lecturer walking round not asking if anyone needs help.

One boy asks question and lecturer sits next to him and answers one question and then gets back up. Real lack of not wanting to overly help students.

Boy using calculator and sat just looking at work.

One boy puts hand up and asks question. Lecturer sits on seat next to him and discusses this. Lecturer says one thing and boy comes back and says so I need to find the frequency of this and then….

2 boys come in 25 minutes late

Another boy asks a question and he discusses this with lecturer. Boy says so my answer up to hear is fine, I need to change this. Lecturer says yes and walks off.

Lecturer says just one point, this is in CR and it needs converting to DB's. Lecturer asks them how they do this and one boy answers, lecturer says very good.

One boy comes and sits next to another boy and they start asking each other questions about the work.

Lecturer sits with boy who has a question and again he says he is stuck (same boy as before) but leaves him to solve it on his own.

4:50 one boy leaves tutorial.

Boy asks for further clarification – he is clearly struggling + finding it hard but the boy still persists on his own

Two boys asks each other how it is all going and they boy say 'all good' – this conversation is about the worksheet they are currently doing.

The boys then start talking about other assignments and the lecturer says come on.

Two of the boys go back to working the equation out and one boy tells the other boy what to submit into the calculator and then they start discussing how to work the equation out.
Lecturer still with same boy and he seems to finally understand.
Lecturer moves on to working with another boy and he writes/works out the equation on his worksheet demonstrating how to do it.
He stands up in front of the class and says right let me do this because not everyone is on the same page
He starts writing the equation on the board but does not say what is it do students can follow. He says right this is what you need to do, goes through it in steps, refers back to Ian Glovers lecture on the topic.
He says so you get this answer but it needs converting to DB's, how do you do this, answers question himself – does not give students chance.
He says right this is clear now, everyone if you get a question in the exam you can all do it now.
Boy questions part of the equation boy wrote on board. Lecturer proves him wrong by working out how he got to that part of the equation – working back a few steps. He did not bother in questioning how he got to that answer.
He says that finishes question 4. 1, 2 and 3 were all explanations, you can find in the notes and try doing questions 6, 6 and 7 at home. If you have any questions, email me.

Appendix 46 – Lecturer: Qasim (Observation – electrical engineering 3rd yr)

'Control systems'

I come into the room and there are already a number of students in the room.

There is a group of 5 boys chatting about work, there are also two boys together chatting, everyone else is silent.

He passes two sheets of equations round for students to take.

He says they are on week 29 but will cover a few slides from week 3

He starts drawing on the board, most people looked engaged as he discussed things + writing things down.

He asks a question and says everyone has done electronics, right? Students nod, a boy answers correctly, lecturer answers question himself.

He says ways they can test what they are covering is to go down to the lab and test it themselves by doing it.

Discusses terms which he has put on board – adding to graphs on whiteboard and then writes an equation down which works this out

I believe everyone knows why we work from the discrete domain, asks question and a boy answers this correctly.

Writes another equation down and discusses it, student gains some clarification on this and he says correct

Goes back to PowerPoint with graph on, asks a question and then answers it himself

Again I can see nobody with the lecture slides printed out

Writes back on whiteboard again and then asks student a question about it being used in terms of using it on graph – someone at front answers

He says I want someone from the back to answer

Works through more examples using symbol – discusses with students to come to answer.

He says how many of you can write equations one after going through it, some students raise an, they answer and he says great then moves on.

He draws a graph on board and asks students to work it out in terms of equation they have just learnt

Some students start chatting about working the equation out while lecturer walks round and checks, around 4/30

A lot of Asian + Chinese people in this lecture, I would say only 8 English

He starts to go through answer briefly

Moves on to next step and asks question – student answers

He then refers to one of the sheets given out to work out next equation. He says I want someone from back to answer. Boy answers and he gets it wrong, lecturer just says no and walks to back of room where a boy answers.
He says right lets re-cap the 3 steps for this equation – moves onto equation number 4.
He says it is very long so on the next slide they will convert it to make it easier to remember
Further adds to the equation they have just completed – he says 'and then this becomes easy'
I hope everyone can follow these steps, otherwise you should not be sat here. Especially now you are in 3rd year.
He asks them all to work equation out
Lecturer going round asking if students can do it, some say not sure and he spends no longer than a minute explaining it to them in no different terms than he did when presenting at the front of the class.
One boy struggling and lecturer goes through it with him briefly using notes which boy have taken down from the lecture
Goes through step by step with boy telling him which to do for each part of it. he leaves him to work it out on his own and he then starts chatting to his group of friends about how to work it out.
Talks through answers then writes it on whiteboard, says use first two columns on sheet
Lecturer vert fast paced, he says I wont expect you to do this in the exam but I want everyone to be able to do this. he says next week we will go through an easier way to do this.
He asks student a question but answers it himself.
Boys keep chatting and he keeps telling them to shut up.
Recaps on everything covered in lecture
Boy takes pic of whiteboard
Boy asks question about exam – lecturer answers
Moves to different lecture slides now – covers something and says 'right, everyone agrees with this right'.
Not many people look engaged now
He writes a few equations on board and asks what type they are
He says you knew what a type of function is if someone asks you? – some students say yes
He says I will upload these slides to unilearn so you don't have to write it down
A lot of people walking in and out of room – a lot of people chatting mid lecture, laughing etc. clearly not paying attention

Lecture is really hard to follow, difficult to see how things follow on + relevance of it to working/real world

'I hope we have already covered these slides'

Discusses assignment and asks class which controller they are designing and then asks why they are designing it.

Students start packing up, he says hang on I still have 5 minutes left

Appendix 47 – Lecturer: Qasim (observation – practical undergraduate)

9:10 the practical is three hours long and in an electronics lab
There are students already here when I come in and two separate pairs which are chatting
A number of the boys go to the technicians store and ask the technician for numerous bits of equipment. The boys get wires as well which are on a rack in the room and start messing with these plugging them into machines etc.
9:18 a few more people come in and are chatting in another language
Boys getting up and down to wire rack as they are sorting their equipment
The lecturer comes in and also starts setting equipment up at the other side of the room, not spoken to students yet
9:20 the lecturer then goes round asking students to tick names of sheet from who's 'board' he has seen, he tells them not to leave until he has seen their board.
He goes round to one student who has already shown him his board and tells him what to do next – student says can I go and he says yes but when I say go I mean don't go home, make sure you are working.
9:24 students sill coming in and start getting their equipment straight away
Two students who were chatting when I first came in are chatting about lab books
People still walking round getting equipment
The lecturer takes students over to a workspace to individually test their 'boards'
Most of the students not working together on setting equipment up
The lecturer plugs the board into machines and tests them, he fills in sheets and provides them with advice on what to do next after the boards have passed the test
He makes the students set up their board themselves and he watches
Students keep going up and they keep watching when they are doing in individual testing – lecturer keeps telling them to move away
He says now I want you to go to computer lab and do .. … .. and then I want you to answer all these questions, all on the sheet of paper.
Next student he asks them to connect their board up, struggling a bit and so he steps in to help if they need it. he keeps referring back to a sheet all students have to do with their boards, it has graphs and numbers on. – he says your sheets needs scanning and putting into your report.
He has a report guideline and talks through some of the questions needed for the report and what he will put in each section.

Next by and he asks him if it works (his board) boy says yes
Says you need to discuss why you got these readings, amplitude etc
A girl comes up next and she sets up her board with no help. He asks if she has her graphs and she says yes I have printed three just in case. He says this is perfect and he goes through the assignment again and she asks numerous questions back such as how long/many pages the assignment needs to be and if she needs pictures.
Students were given a frequency they had to get their boards to achieve
As students bring board up, lecturer passes them some wires with clips on end that they need to plug into their board. He says what the wires are and then the students have to clip it onto the correct wire on the board
One boys board did not work and so he was sent away to correct it
Girl comes up and she has a broken wire on her board, lecturer asks why and she admits it was a mistake
Students asks question about reading they are getting on their graph, he asks what it means and lecturer explains and says it does not matter though, I am not interested in that reading.
Another girl comes up and her graph on the machine looks strange. He says are you sure you have connected it right, he re connects it himself and says no it is not working. He says go away and see what is wrong and I will come over and check it.
Students in line waiting for work to be checked, other students working in their board. A handful of students working together.
When students asked to attach wires, some refer ack to their notebooks with a diagram which they have of their boards.
A boy comes back from earlier who's board was not working – he smiles while the boy is explaining what went wrong. It works this time and he discusses assignment and then sends him away.
Lecturer fairly relaxed and laughing + joking with students
There is a technician walking round helping students who are going up to him asking him questions
After boys board been tested he asks if it is ok and lecturer says yes it is ok.
While lecturer testing some of the students still walking around chatting to each other about work
A boy comes over and sets his board up, lecturer not there but he comes over with a friend and so tells boy which wire is which like the lecturer did and boy puts wires on is board
Lecturer comes back and continues to tell boy about wires
This boy then demonstrates his circuit and lecturer says I will not keep your board, he says why I want it back.

Next boy comes up and lecturer says go on you set it up, you know what you are doing. Doesn't tell him which wires are which.
Boy cant set them up and so lecturer has to help
Again most people going round working together
A lot of people who he said to go away as they have demonstrated their board have not gone
Two people have not demonstrated but one boy says he has broken it and another girl cant get hers to work – they are waiting for technician assistance. Lecturer does not help her with this.
Another boy comes up and his board is not working – he says what you need to do is… then get some more part and work together to fix it. still doesn't work, he says there is something wrong with the circuit you need to go away.
A boy comes up and asks a question about the assignment, the lecturer answers abruptly.

Appendix 48 – Lecturer: Qasim – interview

T: what do you think attracts students to engineering?
Q: I think their liking towards maths and real time applications that's where they. Like for kids its like making lego and puzzles and those kids lean more towards engineering right
T: do you think that children not always know they are going to be engineers but that always have it in them sort of thing.
Q: yes I think it's a skill which keeps developing right. Like I said there are kids who like to play with lego and do puzzles and they are the kids who adopt engineering.
T: what do you think the advantages of studying engineering are?
Q: it depends you could do an apprenticeship and keep going ahead or you could join PhD and start being a researcher so you have both. Even there are engineers who try and make their own company so its your own preference really.
T: do you think there are any advantages of skills what students get from studying?
Q: I think three years which is the basic Batchelors degree or four years in some places, it gives them the appropriate skills to understand what their interest lies in because in engineering there are a number of different branches around it. even for us, electronics there are many fields. The three years degree allows them to understand the area they want to work in, that's why they need a degree.
T: do you think there are any advantages of student studying at postgraduate level?
Q: oh yes definitely. I did a postgraduate for two years. I believe the best part. For postgraduates I believe you have two types of kids, one who has just done bachelors and they go straight for PhD because they want to get more knowledge of what is happening to get a stronger base so they apply for postgraduate and the other is people who come from industry and they have been away from teaching and studies and they want to brush up their skills and to what is really happening and what is changing at the research level.
T: what is it what you enjoy about research and teaching in engineering?
Q: I love it right. I would do the same thing again. Research has its own benefits but teaching you can see the direct output there right. Delivering the lecture. Research you need to wait and then people get excited about it then you can get excited about it. it's a long process, teaching you get the feedback instantly.
T: why do you think the drop out rate in engineering is quite high?
Q: drop out rate is high?
T: yes it is the second or third highest discipline

Q: ok which is the first one?
T: computer science and medicine
Q: I don't know maybe think its easy work and then the maths scares them off. That maybe one of the things I believe. They think when they become an engineer they don't have to do maths and then for engineering every concept is based on maths. That maybe one of the reasons putting them off right, I believe that may be the main reasons and the skills in maths not may be that good.
T: if engineering is so hard why do you think a lot of people actually stick it out?
Q: its not that hard, its your interest right. I don't believe its hard and that's a shocker for me that it has such a high drop out rate.
T: what do you believe the transition from undergraduate to postgraduate is like for students?
Q: at undergraduate right they come to the university and are a little kiddish right and postgraduate they are more mature, more clear in their thinking, more clear what they want to do with their lives. That's the difference between the two. Postgraduate can do stuff for a couple of days, undergraduates would do it for a couple of hours and say its boring. I think that also comes with the age.
T: what do you think its like for students to do research who have never really done it before?
Q: I prefer students who haven't done their research before and do a masters first because they don't know if they like to do research until they have done 3 or 4 months. A masters degree allows you to do that and gives you an idea if you should do a PhD.
T: because engineering is quite structured do you think students then find it hard to have the flexibility to do research?
Q: yes it is something like this. topic A you can go research the findings but in engineering the difficult is that it is changing very quickly because two years ago it might not be the active area now. I did my PhD in 2009 and at that time and now you don't find any device with it on now and the challenge is to keep yourself adapted to all the new developments. When you are doing a PhD you are perusing towards a particular goal and you need to be very clear what you want to do. That's the thing which comes with the PhD because it is a large amount of hard work. Undergraduate and masters you do basic research, a PhD you have to develop something what hasn't been developed before. That's the difficult people find.
T: when you have had PhD students before, do they sent to come to you or do you pick students?
Q: both ways, sometimes the student comes and says they want to work in this area and you need to see if you are specialised to work in that area. The other way around is if you

want to do something but you don't have time so you get a good PhD student to follow in your footsteps and lead you to the research
T: what about the proposal system? Students apply for already step proposals
Q: the problem is in engineering because it changes so quickly, I only adverse projects which I want to supervisor and what I am interested in
T: what are you expectations of postgraduate students and how does it change as it goes along?
Q: firstly they need to be self-motivated, they will be working odd hours. When I was a PhD student it would be Friday night at 10pm and I would be sitting in my lab doing coding and that is the same for most PhD students. Call them and they will all be busy doing stuff in their labs right. So that brings in a lot of self-motivation otherwise you will be de-tagged. The second thing is you need to work really hard more so than in undergraduate. I think the average PhD student works 12-14 hours whereas the undergraduate may not even do 6. I think hard work and self-motivation that's two things they need.
T: do you think undergraduate study prepares students for postgraduate study?
Q; yes definitely. You cannot do a PhD if you don't do an undergraduate
T: but what about in terms of the skills they learn?
Q: oh right. Undergraduate the first and second year is to know more about what is happening, third year is where you get a liking more towards the undergraduate subjects. In first and second year they have labs and tutorials. Engineering degree helps them choose what they want to do.
T: do you feel students doing engineering degrees have a lot of expectations placed on them to already be knowledge of subjects?
Q: yes because I think engineering students are up there, the top merit goes to medicine then the second engineering right. So they are thought of already bright students there, so it puts a lot of pressure on them.
T: why do you think only a select few students decide to do postgraduate degrees?
Q: because some of them really want to go and work for industry and then come back for postgraduate. That's what I did and to polish my skills and them come back for my PhD right. Sometimes they go into industry because they don't need postgraduate to get well paid. The other area is because engineers like to be managers as well so they prefer to do postgraduate in business.
T: the timetable for undergraduate students is fuller than other disciplines, why do you think that is?
Q: because of the labs, they have to learn skills and sometimes engineering concepts are a little vague to understand so they need to go to the lab to practice them.
T: what skills would you say you need to be a good engineer?

Q: good knowledge of maths. Good technical skills. Coding skills which are any programming, that's another skill that is becoming very important with the development of stuff.
T: what are the structure of supervisor sessions?
Q: it depends on module to module. Generally with electronics every student was given a project and they needed to demonstrate part of it every month then they needed to write down the report and there are some courses where after the lecture you give them a tutorial sheet so they develop the skills they need.
T: when students are doing PhD's do you treat them more like colleagues or students?
Q: colleagues right.
T: in supervision sessions what do you think your role of supervisor is?
Q: in PhD student. I meet my students every week and it is a one hour meeting. When we first start it is just general then it becomes more technical and we discuss what is it the area and what they are planning to do next. After 2-3 weeks they become more technician. First I give them some reading to do and cross check they have done the reading correctly and they understand those concepts and then it starts more towards developing themselves and they come to you with a problem and you start dealing with the problem on a weekly basis.
T: do you think the student relationship is important in engineering?
Q: oh yes very very very important because firstly engineering is a little bore subject if you don't have a mathematical background and if you don't have good teacher relations it is good that students can approach you.
T: at what point do you think students identify themselves as engineers?
Q: it's a skill they get and they get the skill they can do it and then they want to design something or a faulty thing they want to fix and they realise they have the skills to do it.
T: what would you say an engineer is?
Q: very difficult question. The engineer is the one who follows his dreams, that's what I believe for myself. My dreams keep changing so he keeps following what he likes to do.
T: what would you describe the engineering community to be like?
Q: there are two big communities, the IEEE because engineering breaks down to mechanical, civil, electronics. Generally electronics is IEEE and we are all member of it and you become a member of it and you meet once or twice a year.
T: what do you do when you meet?
Q: in the meeting there are a few things. If it is a conference meeting you discuss the new ideas you have proposed and the standards which are coming in so these are the main points of interest
T: what about the community in terms of hostile, friendly

Q: it is mostly friendly, nice people right. Its mostly technical based in the meetings we discuss

T: is that something you have seen across the board in engineering, is most stuff focused on work?

Q: yes I think in engineering it is more focused on work. Doctors it is mostly focused on patients, us is mostly technology.

Appendix 49 – Lecturer: Simon (practical tutorial Meng)

He says we don't need computers today, just a notepad and calculator.
He says you need to follow very carefully on the board what I am doing.
Students start to copy things down.
He says this is exactly the same as what we did in the excel a couple of weeks ago but we are working it out manually.
Discusses where this procedure would be used
Discusses why they are focusing on convection as the main heat transfer
Talks students through step by step. We are going to do the manual process in two steps.
Talks through first step and what they need to calculate.
'if you remember what we did last time'
Works through equation and students ask questions. Lecturer says one way to remember this because visual memory is strong so if you visualise this graph in exams then…
Students asks question and simon goes through the step again + why they have worked it out in such a way.
He says the calculation to work out the area is quite simple – this is around 7 steps to work out the area of the shape.
He says I need someone quick with a calculator to give me the answer. Someone shouts answer out and he says very good.
Student asks question and lecturer discusses with students why something is worked out the way it is.
He says if you look at previous exam papers and practice it, it will really help because it is really simple just doing pie r squared really but its just the calculations what take time.
He gives a tip on how to remember the equation in the exam.
Boy asks if they will be told certain temperatures and densities etc in exam and lecturer says yes you are not expected to remember that.
Boy asks why more steps are carried out and simon says the more steps carried out, the more accurate it becomes. He talks through what the exam question will be like and says it wont be complicated, it will be very simple.
Girls asks how to work out the area – he works through it quickly and says there are plenty of examples to look at.
You need to focus less on working out area and more on temperature change because that's bit the focus of this.

He says you need to have clear steps and workings out in the exam so you can still get marks for this even if the answer is wrong. You should know this you have done many exams in your lifetime.
He says if you want to challenge yourself, make up a shape and work through the steps
Simon still working through the steps, when he writes equation on board students work answer out on calculator and shout them out.
Simon works an answer out and boy asks how h has done it. simon says you just add these and convert it to minutes and laughs.
Asks if there are any questions on that or any steps that they want him to go through again. They say no. simon sarcastically says that is good then and laughs.
Talks about mistakes which some students make
Simon gives a previous example of this in exam and student says oh why do you make it so hard, simon laughs.
You will have all worked area out before but you might not have done it for a while. Just refresh it in your memory.
If you are fully happy and think you have good notes you can go, if not I will stay around to ask a few questions if you have any. Two girls sat together ask a question, simon answers and she says yes I get it.
Some students working together about what has just been covered. About 7 alone out of 16.

Appendix 50 – Lecturer: Simon (practical tutorial Meng)

Simon comes up to me and says my main focus is research not teaching, just so you know.
Introduces to the class what they will be doing today, says last week we did this, this week we are looking at the opposite of that.
He has a lot of diagrams and graphs he has drawn on the whiteboard – says they will do calculations to work out how long it will take this object (one he has drawn) to cool down.
He says right we are going to put some headings in – on excel on computer. All students on their own computer, following. He says try and keep up.
He says most of you will have done this in your degree but hear is a reminder – he goes through the equation, explaining what it is.
The analogy I tend to use for this is… says how he usually works it out - gives example of filling bath up
He adds more columns onto the computer and the students follow. As he adds more things in he justifies why they need this by referring back to the diagrams and graphs on the whiteboard.
He goes through part of the equation – I remember the lecturer going through this this morning.
Still filling things in on computer – students having to follow.
Putting equations into spreadsheet and says don't forget to press F4 – he says we have talked about this before.
The steps he does are slow and he waits for people to follow
Boy very confused and does not get what he needs to be putting into the spreadsheet.
Simon says if you do not understand functions in excel you will need to follow Neeam's tutorial on basic spreadsheet functions.
Goes through it one last time with the boy.
After this he starts to work through the equation, flitting from whiteboard to spreadsheet
Very heavy maths involved – even though computer works it out for them, it is all about getting the right information into the equation and working out where this information comes from. He says you will have all done this in degrees – hopefully this will all come flooding back.
Writes formula on whiteboard and then shows them how to submit it to spreadsheet. Says it is often better to write it out first and them submit it into a spreadsheet.
Discussed the elements on the formula.

The same boy is still struggling, Simon says as long as you have written this formula down you can fill it in later – clearly holding the class behind and Simon doesn't have time for this.
He goes though something and says in the exam it wont be a complicated shape you will have to work out the temperature cooling time of.
He says if you are not familiar with these formulas them I would familiarise yourself. He says we don't have the time to do it today.
Goes though the steps of the formula fairly quick.
Looking at how long it will take for an object to cool down to 20c so it can be put on a CMN machine.
Gives example of cooling techniques used in rolls Royce.
Shows how he can change variable and what will happen + what the answer is + graph may look like if you have submitted some numbers in wrong.
Says they can take picture of whiteboard if they would like – nobody does
Boy asks if they get given the formula in the exam and Simon says no you have to remember it but he gives them some tips on how to remember it easily.
A boy says do we need to do all the calculations in the exam and Simon says no it will take too long, he gives an example of the sort of thing they will have to do.
He says feel free to have a play around with the parameters to see what happens.
The values of capacity and density of materials are all available on the website, he says we know the value of the materials for these.
Cale says this module is not that painful, he says it's not that technical. Its more just thinking outside the box.
Once Simon has gone a lot of the students still stay chatting and helping each other through the steps of the equation. Chatting about work.

Appendix 51 – Lecturer: Slav (Observation – Meng)

I come in and Josh H and Cale are discussing work. I hear josh ask Cale, how things are going etc.

Two other boys discussing the meeting they have just had with team Hawk, they then start talking about their night out again.

Josh B is talking with George and James about how much work he has to do at the moment. Says he just doesn't know where to start.

Although they are all part of separate teams, they do still talk to each other and sit with each other.

Some groups of students are discussing work, some the night out still.

Around 26 students and only half actually sat in pairs or groups, others alone.

Really strange that they all seem to get on but they still optionally choose to sit alone.

Lecturer comes in and says today we will have the most challenging lecture and explains why.

He talks about the tutorials they will be having and what they will be covering. They laugh about what they will cover and one boy says can we do supersonic of titanic. They all laugh.

Lecture provides more silly examples and says you can do whatever you want.

Lecturer says I am going to write this first before we start. He writes equation on board and asks students about it.

He then continues to write things down, asking what they are and students shout answers out and then he expands on what they have said by drawing diagrams on the board and explaining them. After one equation, he says that is the assumption here based on experiments. He says right, any questions so far, nobody asks. He says ok, next question.

He discusses the next topic on the board and writes the equation down while discussing it and says some new terms here and explains what they are and why they are like they are.

Then draws diagram on board to further expand – he uses the example of a car for this.

Writes more equations down and says you don't have to remember all of this, you just have to understand it. He then explains the equation with a diagram on the board.

A lot of students making notes off board as there is no power point presentation.

He writes a lot of substitutes and symbols for things and explains what they are.

Then says how they substitute things for things in equations to make things easier. 'it's simple right' he says this is the component form so you don't have to write this out all the time.

Says right that is the first complete, he says the second and third will be similar so if you understand this you will be ok. You don't have to remember all this because I don't either but you have to understand what is going on. We are trying to understand the physics.
25 minutes on 'first one'
Says right any questions, no ok, next one.
Lecturer asks question and someone answers, he says good and you say you don't understand CVT
Writes equation on board and students copy – he explains it then further adds to it.
Brings in example of when it can be used – ketchup.
10:50 discusses 'last one' – building on each equation as he goes.
Asks students question – nobody answers so he further expands question. Someone answers and lecturer says how do you know this though – he says because he (points to person next to me) told me. Both the students between then them explain why the answer in 6.
He then discusses this further by drawing on board.
Finished drawing on board and lecturer says we have 9 but we only need 6 – why? The same student who has answered all previous questions answers.
Lecturer then says we are all about to finish and become engineers and all of this are the components of the relevant stressors.
He says is this all clear, I think it is easy.
He then says all of these are estimated by hypotheses and not all of them are 100% true, they are just closure.
He says any questions so far, nobody asks any so he says ok have a 5 minute break.
One of the boys I know from the team hare comes up to me and says do you understand any of this (joking), I say no and he says it's ok we don't either.
They then talk about some funding the IMechE have given one university for the formula student project.
They then talk about how tired they are and how much work they have been doing (coming in on weekends). George talks about one assignment and says it is so boring, he just can't find the motivation to do it.
Lecture re-starts and he discusses different theories and the equations what come with them and further explains what they are etc. students copy this down and then lecturer says this is Boussines hypothesis and discusses what is it.
A student asks a question of why an equation looks a certain way and lecturer says instead of writing it like this, you can write it like this. Students never ask direct questions, always use background knowledge to gain clarification.

He asks a question and one boy answers. Lecturer says no. that answer is this and so another boy answers and he says yes but what about, just show me on the board, it is all on the board. He explains the question again and then asks it again. Nobody answers and so lecturer says when we model, what do we do? Still nobody answers so he answers it himself.
Further discusses the model and equations, rushes through it. It sounds like he is talking in a different language. He says I am trying to give you a real understand of it because you have to program yourself.
'you don't have to stick to constant values, but this are beyond masters level'
Talks about another model, how it was created and then provides an example and brings in current research going on in China around this model. He says this can be a PhD topic if you are thinking about it.
He says this works but not in all occasions, does not expand and what occasions it does not work.
Discusses last model and says this is designed for aerospace for those interested in that.
Says it is the same concept as the previous models but it just changes…
Student asks question as to if a certain model is the most accurate, lecturer says yes and explains why.
All of this is called… and uses hypotheses but RSM doesn't and explains a the man who invented this.
He explains the model and says I will write in shortened form (from what they learnt earlier) or it will be too long. I am not going to write all of this (equation), it is not important.
He says there is still an assumption here which is… But he explains why is it the best model and says you can try it.
He says I call it RSM but others call it RST so you need to always check.
Basically we have covered everything in terms of aerodynamics, you should be able to do all aerodynamics. I want to cover what can be done and cant in the labs next week.

Did he think the lecture would be hard because it was about assumption and hypotheses and not direct yes and no answer?

Appendix 52 - Lecturer: Slav (Practical – meng)

2:15 I come into the room and most people are sat in groups chatting. A few people have a lot of things already loaded up on their computer ready for the practical.
Slav comes in and starts talking the students through what they will be doing. He says what is the same as what they have previously done and what will change.
Slav says things they can try from what he has done and says to them you try it and see if it works.
Some students then start chatting again, some now working alone + not chatting.
I hear a few students talking about work
Slav goes round chatting to students and looking at what they are doing and answering questions what students are answering.
He is talking to one boy sat near me and explaining the results he has got in detail.
2:32 most students now working alone on computer on software and occasionally chatting.
Slav goes round chatting, talking about what they are doing and pointing stuff out to them + providing suggestions.
2:41 lecturer leaves them to it and works on his own computer
2:44 starts going back round talking with students, he goes through the results with some and takes over mouse from one boy.
Slav walks round and George + another boy are having problems with the software. Slav says have you done… George says yes and I did… and it's still doing it.
Slav clicks around on computer trying to figure out what is going on.
2:57 a lot of students start working together, sharing computers and helping solve each others problems. They only seem to be talking about work.
Slav walks round chatting to other students about what they have done and explaining results to them.
3:06 Slav comes up to a man sat near me and asks how he is doing. Man asks a question and slav says this time I am telling you what is right but as you get experience you can figure it out for yourself. Every time you try to analyse something…gives advice of how to do this.
Student then asks another question and says it is not related to this work. Slav answers this and writes down on the mans paper to explain. Man says ok so basically what you are saying is…. Slav says no and explains even more. Slav says it can change slightly with this percentage in engine design but it doesn't matter at this level (masters).
Man asks if they can use software they are using now, for the engine design Slav has just gone through with him. Slav says no it is just not possible, we cannot work it out. He says we have special thermodynamic software for that.

The boys don’t specifically go up to him and asks him questions, they wait for him to come up to them.
Everyone doing work, nobody on Facebook etc. all clearly see importance of doing this or they just enjoy it.

Appendix 53 – Lecturer: Slav (Observation Meng)

There is a group of around 4 students chatting about the F1 car – a lot of the students are chatting to each other as they come in – talking about work
James says to me if you thought Tuesday was hard then today will be off the scale
Lecturer walks into room, loads lecture and wipes writing off board – does not speak
He shows them a paper on unilearn which he says may help them with the assignment – provides them with an equation which he says they can use and explain what it is.
He says if you look here – measurable aero-thermo-dynamic parameters – you will definitely know all of these, there is a list of 8 topics to be covered in the lecture.
He asks a question and a boy answers, his answer is not what the lecturer wanted and the boy is clearly annoyed by this. another student answers and lecturer says very good – lecture demonstrates answer by drawing on board to explain it.
As he goes down list, he says we wont be talking about this because it is very easy. We wont be talking about this because it is very simply, if we have time we will discuss this.
Draws on board a table to discuss velocity, extremely fast paced. Explains things very quickly, then swiftly moves into next, wont wait behind if you cant keep up, feels almost like a race, a race against time.
Asks class a question- boy answers and he says of course but I want to know… another boy provides this more detailed answer correctly. It has to be the answer the lecturer wants – no deviation.
He discusses this answer in terms of equations on whiteboard and uses objects (water bottle) to demonstrate as well.
Diagrams on PowerPoint to also demonstrate this
Says any questions so far, boy asks one. Lecturer answers and draws on board again to answer this. 'normally we talk about it in terms of this because not everyone understands this'.
Lecturer answers and boy comes back with another question. Trying to explain why he thinks lecturer is answering question wrong, lecturer further expands on this point – it is like a constant debate.
He says right I am going to skip this slide because it is something you already know
Nobody has lecture slides printed out, some people making notes
Lecturer asks a question and a few people shout answer out. He asks another question and nobody answers, he says you cant be an engineer if you don't know units for CV – he says that's second year thermos and laughs.
A lot of people chatting while lecturer is, some people look engaged, some don't
I am going to skip this, it is too trivial

Moves onto next slide, already a lot of slides in already and only 10:40. He quickly discusses net slide and draws on board then says right next.
A lot of students chatting to each other about what is covered in the lecture slides, clearly trying to help each other because lecturer wont.
Again asks if anyone has anymore questions so far – he says no its clear. Gives brief summary of what they have covered so far 10:50
Lecturer moves on to next slide, starts drawing on board and spells green wrong, everyone laughs. Explains what Doppler effect is in 5 minutes, he says right lets talk about how to measure it.
He asks question but doesn't give time students to answer, he draws answer on board and turns round and says you have heard of this haven't you, one boy says yes.
He says that's it guys, that's LDV. He says do you get it, people nod. George and James are sat behind me chatting about this and how it is similar to other engineering concepts.
Boy asks a question and lecturer says hang on we will come to that.
Boy asks question when he has finished explaining and lecturer answers but he says you wont ever need to know that because you are an engineer, not a signal generator.
Does not refer how concepts relate to real life applications on many occasions
We have a break and I ask Cale if he is following this and he says some bits but others he will have to go away and read up on. O Mason talks to Cale and says this is heavy stuff, I think I will switch courses. They talk about the race care and ordering things for it off the internet.
Jake comes to speak to George and James behind us and he says I feel like my head is going to explore, do you? They say no its just a mixture between.. and… He walks off and they say I don't think that was the answer he wanted.
Lecturer starts back off break with video of re-cap on what he was discussing before break. He says this is an old system that's why it might look quite complex. Demonstrating how engineering has improved.
Asks if anyone has any questions – two boys make some comments about it – terns into discussion with lecturer.
He puts an equation on the board and asks class what the equation is – some students answer and he discusses it.
Tells them some info and says you don't need to remember that acronym
Draws on board – finishes explaining one topic after about 5 minutes and says that's it. he provides students a reference to read about it
If you don't know cross correlation you need to go away and refresh your memory. He says actually who knows about cross correlation, and a lot of people shake their head. He says

right ok lets go through the principle first. Briefly goes through it, says right if you don't remember then you will need to go through it yourself.
Flips between diagrams he has drawn on board and examples on whiteboard.
He says it is clear, this is straightforward
Lecturer carries on explaining this and one boy asks a question – he answers this and refers back to some research what another lecturer is doing.
He skips a few slides – then says we will cover spatial resolution briefly.
He says there is a nice explanation on unilearn of how to do this equation if you don't know how to do it but it is very easy.
If you want to know more than you can use this block diagram
Moves on to overall summary to bring everything they have covered to one.
A lot of images, diagrams and graphs on PowerPoint, very visual.

•The teaching in first year is knowledge transfer, as students build on their knowledge through the years and as they build on previous modules covered and already have some awareness of these they can start discussions with the lecturers when they learn new knowledge, not question and answer.

Appendix 54 – Masters KTP participation: Sean (Interview)

T: what is your MRes topic focus?

S: it's basically, the topic is based on the KTP, so for them I'm developing a thermal assessment service. Erm which is looking at micro level of a machine tool so the idea is to develop a displacement system tool and the reason for the displacement is because of the heat sources in a machine tool. The motors, the barring, anything that gets warm. Like you could say a human is 31.6 degrees. You touch something, technically that will increase in size, anything can cause a structure to move.

T: has that kind of working for another company?

S: basically what happened was my supervisor did the MRes and the KTP as well because it's a lot cheaper, it's only a few hundred pound for the year, I might even get it done in a year and what will happen is I will end up creating a profile for the KTP and I will basically submit that work and then all the development and the systems I will submit because it's like work related research if you will. So you are right there are times when I want to delve into research based stuff but my company supervisor will be like right you need to do testing on this. Your right it does have conflicts but to be honest every time I delve it takes time so I should just stick to be KTP to be honest.

T: would you rather it not be that way, would you rather the research be for you?

S: I suppose it depends as it something I have not really asked like how it is marked and how is it graded. I'm not sure how they grade it, like if you say I get a 1:1 it will put me in good stead for if I want to do further research so as long as the contents there I probably won't mind because. I've ended up looking at stuff in the future what I might want to do research is and it is not necessarily linked to this MRes but it just demonstrates that I have the skills to do research and you know what it involves.

T:do you think you will end up doing a PhD?

S: I think I will end up going that way it's just, I can see myself going that way. I only got a 2:1 when I did my MEng and I have been looking at finer PhD topics and there is a PhD what actually looks at mental health problems and developing engineering tools to help mental health and I have probably told you before that my mum suffers with mental health. And I have ended up looking into it and they are on about using cybernetics to control how the signals a provided from signs, smells etc go into the brain. And to be honest, my mum is the biggest problem I have never been able to solve because she suffers with anxiety really badly. It's really difficult, it's something that's a big part of how my personality is and for me to understand it better would really help so I think research would be good for this.

T: so how do you think having this MRes would influence your PhD?

S: I suppose it's more of a life thing. So when I was doing my MEng is amazing how personal things can impact on me. When I came out of the first year I was flying and in my

other years I was having a lot of personal issues I was fighting with and when I was doing the MEng I remember they said if you have any personal issues come and see us but I just battled through it. I suffered for it, I got a 2:1 but I always knew if I wanted to get a 1:1 I would need by mind totally cleared and it still isn't now. At the time I didn't know I wanted to do a PhD but after being in industry I am a bit disappointed and I have decided I want to do things that are useful to society if you know what I mean and businesses are all about making money and that's not for me. There's problems in the world and there is making money.

T: how was working in industry after getting your undergraduate degree?

S: I think there is possibly a knowledge gap, that was a big thing for me. I've said before there is a big different between what I think an engineer is and what industry think an engineer is and even if they do know, there is so much pressures to do other jobs and I think the whole system is a big floored to be honest. I don't know what to communicate it, for me I should be spending all my time developing scientifically proved new products. So for instance if a guy looked at that table for instance, he would know it needed to be that thick so he would make it that thick. He doesn't know what it has to be made that thick, he can't scientifically write it down and explain its because of various different stresses on it and it has this design line, he just knows because he has seen it in the physical world so I thinks he understands why it has to be like that. Then industry has gone that we have all these guys to know how to make all these things so suddenly they have the knowledge. So we just carry on with that so its just cheaper. Its cheaper to get someone to just build it this size than design it properly. I think that's influenced the way the systems work. Obviously for things like a plane dropping out of the sky, it's a bit dangerous if you know what I mean. I would say in industry I spent most of my time doing things what I didn't need my degree to do and I blame myself because I always expect the best for myself but in industry it makes me down, it's not good psychologically. It might not be the same for all industries, but particularly engineering. I have arguments with my dad because he's a mechanic and I have a plumber in my family and if you ask him to design one before he had ever seen one it would be a different thing. Its one them of them isn't it.

T: how is communication with the company you are working with now. Like communicating knowledge.

S: when I went to the company they already have some capability to implement the service. The idea to develop it further so it is more commercially viable. At the moment they have a cable system which can take like a day to assemble the sensor and you can have to put like 30 sensors into a machine and it is massive and like a big block of steel basically. So a lot of it, they know what they want developing, the communication is irrelevant. They know what they want just the wireless expert is at the uni and he needs to do some data

logging at the minute but getting the uni to do things is a nightmare. It's a totally different mentality, like I was saying to you with my mum with the mental health and anxiety. If a cup it out of place it will send her mad, so if someone asks me to do something it will send alarm bells of and I know I need to do it because of the way I've been brought up but at uni it's like I have a week before I have anytime to do it. So in terms of communication, they know what needs to be done, sometimes there is a difficulty is the customer understanding the problem. This particular service, I will try and keep it simple but sometimes like say this, it is 10m thick but it might have a tolerance of zero. So an engineer would know it's impossible to make something perfect, if you said a thousandth of a millimetre, so a micron, they will have tolerances what say zero. Now the practicality of that, you could have a 0.1 change in temperature and the error in that and the technology out there to do and tell that to the customer can always be tricky because there is always the argument that they can go it works, so do we need to. But as soon as you say it can make that part last longer so but they can say we have been doing it this way for all this time. If you can get someone to do it once and show that your part is more superior to someone else's you wont get that initial buying. It's all this customer side of it, and you could always argue that is the customer is not that clever what is the point.

T: do the engineers in industry differ to what you have seen in university?

S: erm yes they cant hang around as much, the university has a lot more research to do and so, they don't look as relaxed. I would say they don't have the level of we need to do this. They sort of say we have this idea lets look at this, where as in industry if you don't produce something, it's our job on the line at the end of the day. A researcher is just there to find something new out and if it ends up going to pot well I have spent a year doing something and that's that but in industry it's your job on the line do you know what I mean. That's something that I am against in industry but I always know from the start that lets say an average salary is 25 30 grand but you knew if you wanted to get to 40 50 you would need to make the company millions of pounds and there is a level of me that's like is that a fair way of working. There is a lot of things that are just not right with the system. I could talk about it for ever.

T: what about the characteristics of people in comparison from university to industry?

S: I would say in industry they seem a lot more stressed, it is more driven to meet goals, they are like I need to get this done but at uni its more like there is something more important to do so I will do this. I would say there is a lot more stress in industry.

T: did you always know you wanted to study engineering?

S: I would say when I left school I really liked science and I really liked maths and I want to know how the world works and my dad was a mechanic like I was saying and he was really into cars and I always say myself as sort of breaking numbers down rather than fixing

something manually. So I basically decided to go down an engineering route so I did a course and college and when I did that I thought yes this is really interesting and you always strive to want to know more and more. Its more progressive I would say, your not pushed down that route sort of thing. I was more intrigued to learn more about how the world works.
T: so did you do anything outside of college or university what was engineering based?
S: I suppose there was always times with my dad and fixing cars. I've always had that self-sufficiently mind because my dad can change tyres on his cars for instance and he has a garage on his house and he has a lot of equipment. My dad is very much if I can do it myself I will so I would say that, I do have an interest it that but it's very hard work. I am one them what's not a finisher. I have all these ideas that I write down, but the issue I always find is time. I look into stuff in that much depth that to get round to actually building it, it's an uphill struggle. Industry doesn't allow you time, you always do more hours because it's like saying you might have a project what's a month long and that's the deadline so if you realise you don't have enough time you are just expected to put the hours in to make it happen. No matter what, even if its working weekends but you wont be paid for that. But if you are a manual person and you are on site and stay you will be paid for overtime. If there is someone sat down thinking about things, how can you justify a salary for that.
T: do you think there is a problem defining engineering?
S: I would say yes. I am always defining it myself. For instance if I was to put into Wikipedia now and see what it is, which I will. My dad would say, when he was younger to fix the machines or whatever, he said he would have the knowledge because he knew how to fix it. I think people think engineers are someone who knows how the machine works but if you get in your car and you push the pedal and it goes forward and you might understand why it goes forward but that's not technical enough in my opinion. It's a fine line sometimes. Knowing the theoretical side of things is a different way of thinking. Its not knowing how it works, its knowing how to make it work.
T: where do you think that problem lies?
S: I think there is one element where commercially calling someone an engineer makes you be able to sell your services for more. I would say partially to do with money. If you send someone on site and call them an engineer they are willing to pay more than someone who just knows how to fix it and understands how it works. I think it is a commercial think. And I also think people don't really understand what an engineer does and I would say when I was at my last job. I remember when I was at uni, a doctor there, a solid mechanics guy, he would say the simple stuff you will never be asked to do but when you go in industry you will be asked the simple stuff. It's not like just dividing two figures together but it's

understanding what the figures mean. All the maths, its knowing why you are using it and what it means.
T: did you always know you wanted to study engineering?
S: like I say. I think it's a thirst for knowledge and I have been chatting to people in industry and I don't even regret studying engineering because I think what you learn from it is invaluable but actually studying it to make money is not the right way to do it. There are a lot easier ways to make money so just do a business degree or something. I don't think we are valued in this country, which is my opinion and it's a reason why a lot of them go to America. It says engineers design structures and systems. So design you are going to have to do scientific calculations and I suppose industry has gone get an engineer to design it and then have taken someone to take that knowledge and make it without any theoretical understanding of why it is like that.
T: do you think its because you don't need qualifications to claim to be an engineer?
S: I would definitely say you don't need to go to uni to read books and apply it. But I think you could say that about any course potentially. If you studied enough and did have any education and just self-taught and experiences would you say you could. In Germany and I think America, you cant call yourself an engineer without a degree but in this country there is a clear difference so I would say. I suppose the argument is I don't think that should be a defining factor. You don't need any course to say you can do it but you do need evidence, its difficult.
T: what persuaded you to study at postgraduate level?
S: I think coming out of industry and doing this KTP I think anything that's extra qualification and more the technical stuff, I don't need to be asked twice sort of thing. I want to do thinks where I am applying my knowledge not just 9-5 filling in documentation. Industry doesn't work like that. I would say if someone said they wanted to go into engineering for the money I would say don't go to uni to do it, just do an apprenticeship but I think a lot of people go into engineering because of the prestige of it. They want to do it for the money, do it for the life.
T: what do you think the advantages of studying at postgraduate level are?
S: I remember a teacher when I was doing the MEng and I remember him saying an MSc probably more valuable and I remember thinking I don't believe that but the MEng is heavily management but the MSc is technical for a level 7 so I would say it would allow me to show I can do a technical document at level 7 so I would say if you want to do a PhD or get more technical then its perfect.
T: what do you think the advantages of this are?

S: you can progress quicker and I think you are more likely to get into a role where you have more technical ability. I would say its critical, I would argue if someone has an MSc in that area, it opens so many doors.
T: what do you think the perception of people in industry is?
S: I think in industry, no matter what qualifications you have got. I am just thinking about another KTP associate, he has a PhD. He has come out of uni to get some work experience and he has started down where even if he had his undergraduate degree and starting from the base even though he has so much knowledge and having to work his way up. So I would say unless you apply for a job in that specific area, it wont make a huge amount of difference. Apart from having respect for you, its ok having knowledge in this specific area but engineering is so vast and when you apply for jobs you will be like well I don't have experience doing that on large scale and that's what industry is all about. Engineering is all about experience and that's why you end up with a skilled technician be favourited over an engineer and they think he has been doing it for 10 years and they value it more.
T: did you always know you wanted a career in engineering?
S: in my ideal world I would just work for myself and create stuff in my own time. I think I would be more valuable to society like that. Like I said in engineering you spend a lot of time communicating an engineering design to people. I would fiddle with stuff and develop stuff. I love the topic, its so broad and I am always thinking more and more and I will never understand everything in engineering. To be it's the best thing you could ever do. People do it because they love it, but its just so stressful.
T: what made you choose that career?
S: I would say like if you are the type of person what wants to know everything, that's sounds bad. If you want to understand how everything works and why it works that way and then its for you.
T: what were your perceptions of engineering before you started studying it?
S: erm that's a difficult questions but when I was growing up and my dad was always fixings cars and with the maths and everything I always just saw him as someone who fixed cars and I respect that but I never. They've never lived up to my expectations, I always thought they would be better than they were.
T: what were your perceptions of postgraduate study?
S: I always thought oh I have my MEng so I don't need to do it and I have that technical knowledge but then I see that you could do an MSc in anything. You can do it in one specific sector for the rest of your life, we still have a hell of a long way to go of things to develop. I didn't think it would be so valuable and I was chatting to people doing MSc and I didn't really rate them because they never seemed to know what they were doing, they just have knowledge in this specific area. I use to ask them questions at undergraduate because you

have a general knowledge there and I would expect them to understand it and they didn't but I see now their knowledge is in a specific area.
T: what did you expect learning to be like in postgraduate study?
S: I'm not doing any modules really so its difficult for me to say that and I heard people chatting and there are people who do there MSc who don't have undergraduate knowledge and they have to push them up. Its different with this subject because I have a lot of foundation knowledge, there are a lot of things I have had to learn to understand things to this level. It comes down to the person and if they spend a lot of time researching.
T: what was the application process like?
S: my supervisor mentioned it to the MSc and they said oh yes you can do it. It was really easy compared to the undergraduate stuff.
T: how did it come about?
S: I found in by innovate UK and universities can apply to the government for a funded grant for a project they want to fund. I found it by looking on the internet but even if you look at a job application you don't have a clue what the job is about really. Basically the university brainstorm ideas. The money comes out of my development plan.
T: do you work with any other students?
S: erm I don't really need to. I work with the uni to get jobs done and sometimes I need to work on machines so I could work with a student if they are using it at the same time but I suppose everyone has their own topics so. It is very much a solitude thing, it is difficult to communicate that. Its difficult to communicate everything and every stage and why you have done what you have done and then you become the knowledge base and the expert and you have to try and communicate that.
T: do you think undergraduate study prepares you for postgraduate study?
S: it depends on the topic. This particular topic I would say yes. Obviously someone might be a mechanical engineer but do his PhD in software engineering.
T: why do you think its important to get people into research?
S: there are more problems than we have resource. So if we could you should get clever resources to do research. even though there is a lot of people working on it, its never enough. There will always be a bigger demand, it's a nature of the topic area.
T: why is research in engineering important?
S: there are a lot of challengers.
T: why do you think only a select few people go into postgraduate study?
S: cost
T: do you think anyone could do it?
S: there are a lot of clever people what should do it.
T: what is the workload like so far?

S: I would say. Originally people tried to bog loads of stuff on me, that's what happens in engineering. Now I saw I am more in control and I know what the deadline is so I would say I am giving myself time to do it the right way. There is always a lot to do.
T: how often are you in university?
S: fluxes really. Originally it was only going to be once a week but I've been in a lot recently because I have some testing to do.
T: what other things do you do outside uni research related?
S: it's a hobby not a job so i'm always looking at the staff hub, new journals, trying to understand something new and there is google.
T: how often do you see your supervisor?
S: once a month for the KTP
T: is that the same for your work supervisor?
S: well he is based in sand batch and I would go down there and see him everyday but the traffics horrendous. He advised recently, because of where we are with the testing, he wants to try and see me once a week. So I can show him what I have been doing. I find it easier if someone isn't breathing down my neck.
T: what are the structure of the two supervisions like?
S: basically I am project manager and I go in with meeting minutes what I have sent out and I go in with my work plan. At uni an engineer will go in and create a simple sentence for each stage point and he knows there are a lot of technical stuff behind these points but he wont write it down because it's a waste of his time. But this MS project they want everything breaking down. It's a waste of my time I want to be developing and doing the technical stuff but in industry you end up spending all your time doing administration and telling people what to do.
T: do you discuss the same things in the supervisions?
S: we discuss the deadline and what we are going to do in the future. Are we on track and I'm meant to do something if things aren't getting done quick enough. In industry the skill of getting people to do things is valuable.
T: how much input do you have in comparison to those two?
S: I suppose the company in the customer so it comes down to what those want so I can suggest stuff but if they don't want it they wont. I have suggested certain things and he says if I am happy to do it, he is. I would say its my project and the direction is up to me and uni is the expert knowledge so its difficult to go against what they say.
T: what did you think the role of supervisor was?
S: I suppose before you assume if you don't understand something he will show you but a lot of it is more discussions and go and find the information out for yourself. But its like that

in industry as well, people don't have enough time, if you don't know and you're not willing to go and look you won't find out.
T: do you think that relationships important?
S: oh yes yes I would say even through industry as well, that communication between anybody is critical. If you're the smartest guy in the world but you cant get anyone to do anything then you will never get anywhere.
T: do you always feel you can ask for support first?
S: I think they want you to go and figure it out for yourself and I think if you don't know and you struggle it is difficult to ask sometimes for help. If you have a bad relationships the project will fail. If you have someone who gets angry and stuff you will find it hard to get people to do stuff. One of the things with the meeting minutes, I have to put the tasks and the dates they have to complete it by but why should I? they should be smart enough to know their task and write it down and put it in their calendar, they shouldn't need me to chase it up. At the end of the day everyone has things to do.
T: do you think your supervisor makes you feel more like a colleague or a student?
S: oh no he is good, he does make me feel like a colleague. You do feel like an engineer when you are doing research and people actually understand what you have done. You definitely feel better
T: do you meet or socialise with other postgraduate students?
S: I have been out for meals with a few other students so yes yes
T: do you think that's important?
S: yes I think if you want anything doing you have to build those bonds so they will do it because you're their mate sort of thing. If you are asking someone you don't know to do something, if you just know them as a colleague, its difficult.
T: in the computer room on level 4 its pretty silent, what do you think its like working in that environment?
S: better, it's the perfect environment. I personally find it really easy to get distracted, even with just a little bit of noise. Even just a slight bit of tapping or mumbling, it distracts me. I've been in there and I think I can feel myself thinking.
T: how is it not communicating though?
S: I think all the people in there I don't know their topic and it will be in a lot of detail so if they have a question they are better off going to their supervisor. So you do end up like being in the army, unless it's a technical thing not in a lot of detail. I think its better to have a deep drive into concentration but it would be nice to have a 5 minute chat.
T: do you think its important to have friendships?

S: oh yes yes I was very much a person where if I don't know I need to go and find out for myself but you soon realise like you say there are too many problems nobody can know all the answers.
T: what are people like in engineering?
S: I think they are quite protective of their work if you know what I mean. They are usually so busy that its difficult to find time to chat to them about a problem you are having. Its really difficult like you say, we should all be pushing towards making the world better but you naturally thing about your own goals and own projects and that will never change. That are really nice people, great people but they are overworked. You wouldn't do engineering if you weren't a nice person, you would do something easier.
T: do you think expectations are placed of people who do postgraduate study?
S: people are always expecting the best from them, they always want the best for them.
T: do you think you should be an expert?
S: oh yes they definitely do. We had a meeting with supervisors and customer and he was saying well oh you're the expert so you need to solve it. But you would argue that you always need to know more, in fact can you ever class yourself as an expert? I don't know. I always think I need to know more. I would say I know enough to be able to call myself an expert. There are certain things in a meeting what I know what they don't know but to apply it to industry I would need a lot of people to help me.
T: why do you think postgraduate study has a notion of independence?
S: I would argue though in my undergraduate degree we did projects and I chose what I was going to do and what the time frames were and things so I don't feel like its new to me so I have had to manage a project before so it's not overwhelming. I think that's why people rate an MSc because your doing something nobody else is doing so there is nothing to talk about so it is literally your own work and people like that and you can take it yourself and plan it.
T: has the topic changed while you have been research?
S: I suppose when this topic came up I had a vision of what I wanted to do with the research but the company would like be to just submit that work and I would say I do feel like. Its good what they are doing they are giving me some structure of what to do but if I was going to do it my way I think I would do it better.
T: do you think you have changed as a person while doing postgraduate study?
S: yes definitely. I would say I value myself more. Its given me a lot of confidence working with experts. I came out of uni I undervalued myself
T: would you refer to yourself as an engineer?
S: yes an engineer
T: what makes you be able to refer to yourself as that?

S: the ability to design something from scratch.
T: Would you call yourself that if you hadn't worked in industry before?
S: yes I could still call myself that. I think it's the theoretical knowledge to me. I suppose the defining factor is to scientifically design something and put on paper what I have done and why I have done it and being able to explain why I have done it that way makes me an engineer. And another engineer can look at it and say yes I can see why you have done it that way. Being able to make something work isn't an engineer, you have to be able to explain why it works.
T: what does it mean to study engineering?
S: It makes you feel good, I think that's one of the reasons you always want to progress and maybe why you would do a PhD. It's an interesting point because in engineering we have this thing where you be recognised as a professional engineer you become chartered. I have met people who are chartered and they have degrees but I don't rate them technically. A lot of people go into industry and become managers and they lose that technical knowledge. I have mates who are engineers on paper but don't really have the technical knowledge and to me are they really engineers? An engineer has to be able to design something and say why it has been designed that way. If I have a chat with them on an engineering subject I can see its not really grasped but it's a very hard subject.
T: do you think engineering is harder than other disciplines?
S: I think it's the hardest personally. I don't mean because I study it that's sort of thing but I have done a lot of research and you can do a maths or a science degree but the difficulty is applying it to the real world and that's why there is communication difficulties because you could be really clever but actually applying it to industry is a nightmare. You cant just be extremely smart but you have to be good with people as well and that is difficult.
T: do you think engineers are good with people?
S: I would say I think its difficult for me. I would say you could have the smartest guy in the world but someone needs to get that knowledge from him and transfer it then you could argue he is helping him to be better at his job but to be the best you have to communicate your ideas.
T: from what I have seen engineers find it hard to talk to people.
S: well that's the thing in reality an engineer is a really scientific person and usually scientific people are introverts, they like to be on their own, they like to study on their own and you know the actual critical thing for engineers is to take the critical knowledge and transfer it and you are asking him to do the opposite of how he studies do you know what I mean. That's why its so difficult. I did a test when I was at my last job and I have the introvert and extrovert characteristic, I had them both at the top on both. I would say the general population of engineers what to be on their own and study on their own. The critical

think in society, if that guy is really clever it wont go anywhere. They are not people people really.
T: What do you see engineers as?
S: someone who is extremely clever erm I think the difficulty is you have to be good at everything. Asking how I see them is asking how I see God. I think they have to be like that, I see them as someone how is scientific, always doing research, always making stuff, always testing stuff, calculating stuff and always transferring knowledge effectively. Its almost as if they have too much to do. Someone who is very busy.
T: do you do any other activities linked in with engineering?
S: erm no I do apply my knowledge to my house and stuff. I am trying to develop an efficient smokeless stove. I like to take the time to develop things on my own, it is an introvert thing. I have a lot of ideas for developments and writing things down and doing calculations and seeing if things would work.

Appendix 55 – Staff/PhD student: Isaac (Interview)

T: what is your PhD looking at?

I: I'm looking at human skin, so computational model to model human skin in relation to pressure formation.

T: what made you want to do that?

I: erm actually I wanted to do research in the medical field. So initially artificial hip joins but we didn't have any funding for that but we did for skin so.

T: did you do your undergraduate degree in engineer?

I: yes I did yes

T: when did you kind of decide you want to study engineering?

I: a level, when I was doing a-level

T: what attracted you to it?

I: firstly my dad suggested it to me because I was trying to do an English course in hong kong but I couldn't get there so he said I was probably better doing engineering.

T: what is it you like about engineering?

I: erm I don't like really traditional engineering stuff that's why I tend to do more medical stuff. My final year project I did was artificial hip joint and then I find the medical stuff interesting when I relates to the human body.

T: what is it what you don't like about the traditional engineering stuff?

I: I find it quite boring. If I am doing about a turbo charger I would find it really boring but when it relates to the human body I can relate myself to it so I find it interesting.

T: how was it studying your undergraduate degree as you will have covered a lot of traditional engineering. Did you find it quite hard?

I: erm not really because when we did undergraduate study, especially for the final year project and then it when I started to look at mathematical stuff and actually its not too bad as the medical stuff is not too hard because you don't have to prove it. you just read and understand it and that's fine.

T: when you were at school were you always good at typical engineering subjects?

I: because I have my a-level in hong kong that are of a much higher standard so I didn't do well in maths at hong kong so the maths was relatively easy for me here.

T: were you always interested when you were little in taking things apart or figuring out how things worked?

I: yes a little bit but not a lot

T: for you what does it mean to be an engineer?

I: erm I think engineering you need to be really good at problem solving. Scientists are just finding out new knowledge but engineering are more ethical and solving real life problem, that's how I see an engineer.

T: what persuaded you to do a PhD in engineering?
I: I decided to do a PhD when I did my first year here because my supervisor said what do you want to do when you finish here and I said I want to go back to hong kong and be a secondary school teacher and she said what do you want to teach and she said if you want to be a lecturer you need to do a PhD so why don't you do one and I said yes maybe. Because when I looked at it I didn't know Huddersfield did medical engineering and I didn't want to do traditional engineering but after a few years times and I found the medical stuff interesting so I carried on to do a PhD.
T: what do you think the advantages of doing a PhD are?
I: erm I quite enjoy it because in the mean time you can relax. I don't know how many people say it is relaxing doing a PhD but I find it relaxing but at the same time I know much more about the medical stuff what I have been interested in for a long time.
T: do you think you will stay in academia or go into industry?
I: I think I will stay in academia for the first few years after I graduate and then if there is an opportunity I will go to a medical company but eventually I want to be an academic again.
T: how do you think having a PhD will influence you working in industry?
I: erm I believe if I successfully obtain a PhD that will increase my opportunity to increase my opportunity to increase my research and get a higher position in a company. So because medical companies always have some novel or innovation products so the PhD is the first step into that.
T: how did you find the transition from undergraduate to postgraduate?
I: I found it quite smooth and not really hard because for my final year project I tried to do research and I found it not too different from a final year project to a PhD even though the scale is massively different but the way to do research is the same. Its still searching papers and looking what you want to do and find some way to do what you try to do so it is smooth, I didn't find it a problem.
T: did you have any good experiences, bad experience?
I: good experience will be actually up to now I don't see anything as a massive difficult in the PhD, everything comes step by step. At the very beginning I don't know what I am going to do because my supervisor said the funding has come from skin so anything to do with skin. We looked a different industries for skin so I didn't know what I was going to do with it but then actually reading papers I thought pressure ulcers are affecting a lot of people and at the moment I am only focusing on them. That is the first difficulty, being completely lost in the field. Building up the computational model can be challenging but then my supervisor provided me contacts and they can provide me with help. They can provide me useful idea of how to do it even though we are not doing the same thing and

that solved the problem of me building a computation model and now I am doing data collections to put into the model but we are just going down to Coventry to get some training on that. I think at different stages I got different challenges but I always had solutions so I was quite good.
T: in undergraduate study, the assessments were fairly rigid, in PhD it is not necessarily like that, did you find that transition hard?
I: not really. I found it quite sensible. Even when I did undergraduate I didn't see things as so rigid, I saw things as a logical answer. Its either logic because of this theory, this applies to the PhD, you see things logic then if it works then it works because of logic so I see that as quite straight forward.
T: what about in terms of your own personal opinions, thoughts, feelings.
I: first of all I don't document my stuff, like how things have influenced something else. The model when I was building it, I know what I am doing but I don't write down the key notes. I do believe I influence my research, I feel I contribute a lot to it. its not just what my supervisor found out, I tell them I want to do things this way for this sort of reason and she says yes give it a try.
T: that's the thing do you decide how you do things in a certain way? A lot of the time in engineering, the lab repots and things have structure.
I: I always do the things I find logical, I always go down the route I think is the right one.
T: what was your application process like?
I: it was fairly early in the PhD so I was heavily influenced by mu supervisor because she is more experienced in this area so I would ask her what would be the best thing to do or what the PhD would be like. At this point it will be vague and she told me what to put and then obviously when we go down the PhD it will be more specified and realistic. Much more of my work will contribute to it but at the start it was directed by my supervisor.
T: do you think the roles have switched now?
I: yes definitely. At the very beginning by supervisor said everything and find some papers on skin and you will find some direct and at that point I wasn't sure if I would get direction by reading papers and then I did actually find direction in pressure ulcers and we didn't actually come to a conclusion or make a decision explicitly but just because we found more papers and it was an interesting area and it was quite smooth there was no hassle or arguing.
T: what type of role does your supervisor take now?
I: now erm I would say I would be a bit guidance and supporting. She didn't ask me to do anything, so basically I just report what I have done and what I am going to do and if I have a problem to solve, lets say fixing a machine and if she has been using it for a while and she will try and fix it and she always provides support. Like a few months ago about

half a year before I tried to build up a computational model and I couldn't do it and she wasn't good at it either so she said I have a colleague who is really good at it so she gave me the contact. She is more about providing support than direction.
T: did you feel completing your undergraduate study prepared you for postgraduate study?
I: yes I think so. Especially for the final year of the undergraduate course because we need to do a lot of papers and in that sense it was similar to the PhD because you were not being told what to do. You don't have a lecture. In final year we were taught a lot in the lecture and so we had to search for papers so I found that educated me for the PhD. We were training to solve a problem independently. I think so may not be educated for it and some rely on the lecturer a lot but that is not what a PhD is about.
T: what skills do you think your undergraduate degree provided you with for your PhD and what skills do you think it didn't?
I: I would say in terms of helping students solve a problem independently, the undergraduate study helped this a lot. I would just say specific knowledge, PhD is different knowledge. We don't have that skills, or using equipment and research skills. I guess that's part of the PhD, you come across a field you don't know a lot about and then you work on it.
T: why do you think research in engineering is important?
I: for medical engineering you can improve life quality. There a loads of pressure ulcers so we are trying to reduce the numbers caused by medical equipment but at the moment we don't have any computational model so now we are trying to figure out if we can do one to predict that. It will have a great impact to reduce pressure ulcers.
T: why do you think not a lot of people do PhD's?
I: erm first of all because not just only me but some of my friends if you do a PhD you will probably just stay in academia or you will just go to do some kind of cutting edge technology company. If you want to work in a general industry don't do it there is no point. Not many people like doing research because it is vague and you don't know what you are doing so if you don't have a really specific idea of what you are doing you are lost in a big field because you don't know what to do. That it what I enjoy, when you say it is vague. If you have a specific task in your mind then it is relaxed and my has been a lot of task specific.
T: how important do you think the supervisor relationship is?
I: erm I think at the beginning it is really important but as the PhD goes along they become less important. If they have a problem they can go back to the supervisor and see if the problem is solvable but later on I would say not so important.
T: what would you say your workload has been like?
I: I found it ok, it is not a heavy workload, it is relaxing. Mainly I am just solving problems.

T: so how does it work, you solve one problem and you move on to the next?
I: yes basically. So at each stage I set myself a task and at each stage I would have one or maybe a few problems to solve in each task. So I would solve it one by one, or if I am stuck on one I will solve the next one then come back to it.
T: so you have broken the PhD down into tasks?
I: yes yes I found that will be more achievable and realist. If you break it down then it is sensible and more motivated because if you do a PhD in three years you wont know what stage you are that would be confusing so I said three stages. At the moment I am in the first stage and moving on into the second stage and when you look back and think I have finished one third of the PhD it is quite encouraging.
T: do you meet with any other postgraduate students?
I: not always
T: do you think that having relationships with other students is important for learning?
I: not for learning, for sociable. You cant just lock yourself in the room and work for 24 hours. I joined the water ball team but it is not related to my studies.
T: do you tend to work at home or university?
I: it depends on what work I am trying to do. If I am doing computational model stuff I go to my lab because I have a computer there and it is quite powerful computer. Computational model requires high end models but if I am writing a paper I will go home because it is less distraction. I prefer working from home but sometimes I have to go back to the lab.
T: how often do you work on your PhD.
I: basically I come in everyday. I do 9 till 4 or 5
T: do you feel there are expectations placed on you because you are doing a PhD?
I: not really I don't think so. Nobody tells me I should do certain things because I'm a PhD student. a lot of friends joke around saying because you are doing a lot of things you should know a lot of stuff in engineering. None of them are serious
T: if you have a problem do you feel you could always ask for help?
I: I always try and solve it on my own at first but if I really couldn't do it I will always ask someone.
T: do you feel like you should be or that you will be an expert in your area?
I: I think I will be. Because PhD you have to find some novelty in your area so I feel I will be an expert in modelling pressure ulcers. Its not a massive area but at least in that little area I will be.
T: do you feel like you have changed while doing your PhD?
I: not that I have noticed. Only my subject knowledge growth in that area
T: what do you say you need to know to be an engineer?

I: finding ways to solve a problem. An engineer is a like a problem solver for real life problems so if you need to be an engineer you need to solve some problems. You need to find ways and not be afraid to solve problems.
T: would you describe yourself as an engineer?
I: yes I would
T: at what point did you see yourself as an engineer?
I: after I graduated from my undergraduate course.
T: how come?
I: first of all because I finished an engineer degree so I could be an engineer and I was confident in solving some engineering problems
T: do you do any other activities linked in with engineering?
I: no I don't do anything else
T: how important in being an engineer?
I: I think it is really important because new technology is always coming from research and if it is a real life problem it is usually coming from engineering. Engineering play a huge contribution to the world.
T: I have read a lot of papers on engineering being objective, competitive, impersonal, masculine. Would you say it is?
I: yes engineering is quite impersonal, research is other fields like art. Engineering is more about right and wrong answer so it is impersonal so no matter who does it we still have the same result. Engineering should be objective.
T: what about competitive and masculine?
I: no I don't think it is masculine, maybe in the past but not now. Competitive definitely it is. Engineering result, the funding is limited and everyone is competing. Engineering has a lot of funding because it has real life applications so a lot of people are willing to fund it. engineer provides you with technology to make money from it.
T: what about being competitive with other companies coming up with ideas and also at undergraduate you would do projects?
I: it is competitive because everyone is trying to get a good grade and this year I need to teach some tutorial groups and mark assignments and sometimes the students will come to you and ask for feedback and not because it is a low grade or whatever but because why my friends have a higher grade than me. you are not interested because you have a low grade but because it's a comparison.
T: what other skills would you say other skills you need to be a good engineering?
I: I would say team work and communication are really important because as a PhD student you are training to solve a problem independently. In the real world you cant solve the

problem alone and you need to talk to other people as there are experts in different areas. A few engineering fields need to sit down and solve a problem.
T: what would you describe the community of engineering to be like?
I: I never go out and experience it in the UK and Hong Kong but in the university they are helpful for each other. I'm not just sure if it is because they know my supervisor or if it is just because they are willing to help but everyone I ask, I just ask them about things and they will help with certain things.
T: do you think it's a sociable topic?
I: yes because there is a lot on common to discuss and our research centre go out and have a drink and we always have a lot to talk about but it is not always about engineering but I guess it is engineering what brings them together.

Appendix 56 – Staff/PhD student: Christian (Interview)

T: what is your PhD topic focused on?

C: so I am working in ultra precision engineering which is the centre for precision technologies, the CPT and I am focusing on manufacturing, manufacturing ultra surfaces. So there we go. Some very small engineering.

T: what made you choose that?

C: a bit of a coincidence. I was originally on a placement scheme with BA systems and I was going to go on to their graduate scheme but my supervisor for my bachelors, Prof. Liam Blunt erm he basically mentioned there was so funded PhD's on offer and I originally applied for one on ballistics as that's what I had done by undergrad on and what I had done in my placement but that had already gone so I looked through the list and picked the one what looked most interesting as I just wanted to do research.

T: has anyone in your family studied higher education?

C: nope nobody

T: did you do a masters?

C: yes I did the MEng so it was direct entry to masters.

T: at what part of your education did you decide you wanted to study engineering?/

C: well this is where I differ from a lot of engineering students. I came originally to do a music degree and started by degree in music, figured I didn't want to be a music teacher. I took a full term off to figure that out and had a bit of a crisis but I was working as a maintenance technician at next so I was working in engineering and someone pointed out that you are pretty good at that and there are pretty much guaranteed jobs so why don't you do that.

T: so at school were you interested in the maths and the sciences?

C: yep. So I did two sets of A-levels as I wanted to join the navy first so I did maths, physics and chemistry first but I wear contact lenses so my eye sight wasn't good enough so I couldn't get in so that sort of kicked me back but I always liked music so I went to another college and did music, media and archaeology. So yes I have done both sides, the maths and then the creative stuff. Music is a passion not a job and I wanted to do something what was employable really.

T: what persuaded you to do it at a PhD level?

C: I have always been interested in doing research. I don't consider myself to be an academic but I do a lot of academic work but I do enjoy a lot of industry research and focused research and when I was at BA systems I asked them, they had a department called the advanced technology centre where they do all the really weird, really cool research, fun research but you pretty much need a PhD to join them. Its just a passion for industrial research.

T: what do you think the advantages are of doing a PhD in engineering?
C: that's a bit of a funny one. By experiences in industry is that it is not a great advantage actually. In general everyday engineering stuff and when I started by PhD I actually realised how many people have a PhD who I didn't know about because most engineers wont use the title of doctor because people assume you're an academic and don't have any practical inclination. Its useful in industrial research, like BA systems and rolls Royce, the big blue chips, it is useful in that role but in production engineering and general manufacturing its not really useful at all. But as research is my interest.
T: so do you want a career in academic or industry?
C: I'm not enjoying academia and much as I enjoy industry. I really enjoyed working at BA system and I really like focused research. I like to have a problem, solve it and move onto the next one. Rather than the academic method, see what happens when you do this.
T: what was your perceptions of engineering before you started studying it?
C: pretty good, I probably fit into the STEM tribe I was telling you about. I'm a bit of a geek, I always loved star trek and engineering programs in general so I suppose engineering did always fit in there. I always played with lego, still play with lego now, its so much fun. Erm but yes
T: did you do a lot of things outside college and school to do with engineering?
C: yes I have always liked to research science stuff, science clubs in school, science trips whenever they were on offer, that type of stuff yes.
T: what was the application process like to postgraduate study?
C: it was pretty much pick off a list. I had a very good relationship with my supervisor and it is a SRC funded project and I get paid a salary. There was a title given with the aims and I just had to write how I would approach this, so it was two pages of A4. In a way it was easier than expected.
T: how do you feel applying for an already set project?
C: erm in a way it fits what I like to do which is industrial research, like here is a problem, find a solution. The idea of coming up with your own problem, I'm not sure I would be as good at that and it's not as structured and I am a bit of a cynic and I would think do I do the one my supervisor is most likely to like to I get it or do I pick the thing I'm most interested in that nobody else likes so in a way I think picking from a list is easier for me. always about pleasing people – nothing can be wrong.
T: do you think that's why the university do it like that for PhD's?
C: I suspect so in a way. Now coming towards the end of my PhD and I know I am going to leave work for someone else to do. In engineering you start a big group project and everyone does little packages and it's nice for students to come in finish that little package and then leave work for the next student and I suspect that's why it is designed that way.

T: do you think that undergraduate study or your masters prepared you for you PhD?
C: in some ways yes, so the technical side of it. the maths and physics and technical knowledge yes but in other ways I found that the PhD was not directed which I found. I like that my supervisor lets me get one and doesn't tell me what to do, I know that some supervisors do. I like being allowed to pursued things my own way. But it is a bit of a change from knowing exactly what you want to do on a day to day basis to pass, to having to figure out exactly what you are suppose to be doing next.
T: why do you think research in engineering is important?
C: easy answer for that one, engineering is all about progress. I mean the IMechE's slogan is improving the world through engineering and it's always to improve what you have got, so I think research is core to engineering. Without research, engineering would stagnate and not go anywhere.
T: what about engineering's importance in terms of the world?
C:: arrrhh I would with a lot of kids and this is what I always point out. Engineering impacts everything, everything in the modern world. The challengers I do when I go into schools is, I ask them to find a product in the room what hasn't been engineers and they can have a mars bar and they cant ever. If you have some art and craft bowls what someone has scraped out then maybe but it a classroom it is impossible. Everything is manufactured, the world would not exist without engineering because you just could not produce things at the rate they need producing. Engineering is pretty important, I would say that though I'm an engineer (laughs).
T: so why do you think only a select few people do into postgraduate study in engineering?
C: few reasons, the job offers you get with a bachelors or especially a masters are pretty good if you are an engineer. Obviously you have to take a pay cut to do a PhD. Its not like in science where if you want to be a professional scientist and again academic posts, it is possible to get an industrial research post without a PhD. Research posts are not the bulk of engineering, people don't realise how many engineers there are in the world compared to other professions. I think there are 200,000 doctors in the UK and there are 700,000 professional engineers. They work in manufacturing, production, analysis, things like that. I think the right proportion of engineers go into research actually.
T: what is supervision like?
C: my supervisor is great. He is really fair, if I have a problem I can ask, we have erm, for the first few years a meeting was when I bumped into him in the corridor or I saw him somewhere else and we would have once a month a formal meeting but now we have formed a research group and we meet once a month and its just kind of like what you doing, any problems. He doesn't tell me what to do, he kind of suggests things but it is up to me if I want to do it.

T: what about the research group, how is that formed, what is it about?
C: within the CPT, the bulk on the work is in measurement. So they work on techniques, using measurements to quantify different things like surfaces but we have about 4 PhD students and then we have Zen who is the research supervisor and then Liam who is the director and we have about 6 people who are responsible for precise measurement and we have a few machines down there and we have just sort of clustered together because we all have shared interests.
T: how is it working with students with the same interests?
C: we try and help other departments, so the measurement guy sometimes needs artefacts to measure so we help them by manufacturing what they need. So that's very insular within our group but I do offer to help outside our group but very few people take us up on our offer. I don't think many people know what capabilities we have got so in terms of working with other students we don't do a lot outside the CPT.
T: why do you think that is?
C: probably because most of them don't know what we do. The measurement side, given that is the biggest thing so some people want stuff doing but the manufacturing side most people don't know we exist, we have only been going as a formal research group for 8-9 months.
T: what kind of things do you do as a research group?
C: its all about manufacture. We always have parties for PhD birthdays and we have meals as a group or drinks so that's always nice. We also go to conferences as big groups and we try to do as many collaborations with as many universities as we can. And we apply to the Santander fund numerous times and its where Zen our researcher, he did his degree in China so we are going there this year.
T: so do you think the supervisor relationship is important?
C: oh yes, I know some PhD supervisors who are very directive and always wanting to know what you are doing. You have to both get out of it what you want and with Liam it works perfectly. We have similar personalities and we really get on.
T: does he make you feel more like a colleague or a student?
C: probably more like a colleague to be honest. He asks me to do favours for the group and its not like just sit down you're a student. He lets me do tours and things because obviously I like talking about science and engineering, sort of that kind of thing.
T: do you meet or socialise with postgraduate students?
C: outside of our research group probably not that much, outside engineering not really.
T: the connections you have made in the engineering department, would you say the relationships are solely education based?

C: we talk a bit about family and friends and my girlfriend sometimes come out with us and we talk a bit about hobbies but obviously a lot of these are engineering based so. Its probably more engineering based than anything else.
T: what would you describe students in engineering to be like?
C: I do a bit of lecturing as well and I do find that students fall into three distinct groups, this might turn into a bit of a rant but the very extreme, the top 20% of students are really passionate about engineering, they are keen, they want to get on, they ask questions and they tend to be the stereotypical engineers. They tend to be very into science, maths and heavy engineering. Then there is a group of students at university that should have done a more vocational thing like an apprenticeship. Its not because they are not academically bright, they are just not academically interested, they want to do practical things. There is a big group in the middle, they have done engineering because it is employable, they like science a bit, they are not that passionate about it but again probably engineering personality type wise. There is probably an engineering personality type I would say.
T: what would you describe that to be like??
C: quite introverted, analytical, very high science, you are probably already aware there are some research saying engineers score higher on the autistic spectrum and I think it is probably true of engineering. Erm you know they tend to pal around with themselves, detail orientated people, not the easier people to get along with, big egos a lot of the time. Erm they are problem solvers but problem solvers in terms of structured organisation. Like rules and regulations but in many ways quite creative. I have just set the first years a project to build a car out of lolly pops and all sorts so there is creativity in there but its less artistic creativity and more creativity aimed at problem solving.
T: so do you do a lot of work at university or at home?
C: I do a lot of the research work like the practical side and the reading etc at university then I tend to my write up at home. I cant write before 6 o'clock in the evening, I just get distracted before this and I cant concentrate.
T: when you are doing your undergraduate teaching, what sort of methods are used?
C: a mixed of seminars, lectures, practical's really. So for the engineering drawing one, the module is called engineering, communication and materials and the bit I look at is how you communicate ideas in engineering. So its one week lecture and one week tutorial. So one week we set a assignment then the next week we come back and assess the assignment and we give feedback and pointers. I think engineering is important in that and you cant learn everything in a classroom, it is all about the application so we need to mix it up. Practically doing and applying the theory because that's the test in engineering, its not just knowing the theory, its using it as well.
T: why do you think postgraduate study has a notion of independence?

C: in our research group that does not apply. In our meetings we talk about what we have been doing and the problems we have been having then as a group we come up with solutions for that problem or ideas for how they could solve them. We do a lot of group solving. Obviously they are all individual projects but there is a large shared knowledge base. It has to be independent work but when we write papers, I will credit everyone in the research group because we chuck ideas around all the time. We have a big white board what is full of stretches and we say oh what do you think of this. we work really well as a group. I think it would be really hard to not work as a group actually because you can get stuck on a particular thing and if someone doesn't come along and say why that idea might not work or show you why you have got stuck then you can be working on something for a long time. I think group work is important.
T: do you think you are an expert or should be an expert?
C: erm probably I am on the upward curve of a graph now and I am starting to realise I know more than I thought I knew and the more you know the more you realise what you don't know. So I am coming to terms with this and getting the confidence to admit that you don't know something if you don't know it. its coming to terms with the fact that you know more than your supervisor. If they ask what's this and you can answer the question, I am growing in confidence at the minute.
T: how has your PhD progressed or changed?
C: it has pretty much stayed the same. There are some bits we have dropped off because we think there is enough work in one bit for a PhD and we just don't have enough time. My machine is broken again and it has been for a very long time so that has been another delay. As problems have cropped up I have had to overcome these so they have taken the place of the bits what were dropped.
T: so have you published any work so far?
C: conference papers, I haven't done a journal paper just yet. There are a couple of things I am working on what I want to do paper son but I have done a couple of conference papers and poster presentations.
T: how was there?
C: I didn't find it too bad. I think its quite neat actually to do an experiment and then write it up as a conference paper as they are quite short. The one that we use, the Usten international conference and they only require two pages. It's a thing with engineering that you have to be concise. Concise report writing is a skill in engineering and it is something I have always been good at so writing a two pages paper is not really that stressful. You tend to find you have more to say than you really want.
T: do you feel you have changed while doing the PhD?

C: yes definitely. In some ways more than the technical sides of thing but I have joined, well not joined because I was already a member but I have become more active in it with schools and policy and politics and the sort of how engineering impacts upon society. In the way I have gone beyond the engineering stereotype of being heavily orientated, geeky, analytical, maths person and I have found I have a real interest in engineering governance, engineering policy and how engineering grows as a profession. I don't think that would have happened by doing into a technical career in industry which is odd because a PhD should make you more technical but I have found it shifts my focus.
T: what made you join that group initially?
C: erm basically they put an advert out. Ever since I was in BA I have always enjoyed going into schools and promoting engineering to school kids but they put a post out saying they wanted a educational body to site on that board and I just chanced by arm at it and it was the first three months of my PhD and I wasn't really doing that much and progressively I have just taken on more responsibilities, mostly in education. So I basically did it to kill time before my PhD got started and because I was interested it in.
T: do you have any other commitments outside your studies?
C: yes so I have my teaching commitments, the IMechE commitments so they employ me as a project manager for report writing and research. I keep saying I am not an academic but because I am at uni they think I am. I sit on six boards of the IMechE, mostly education related and I have also become a trustee of a charity which is the IMechE support network, their benevolent fund so they support members through hard times and that's why I have become more interested in governance because I am the director of a company effectively. which has been really interesting. They are all engineering related in a way but they are not practical engineering and problem solving, they are engineering as a profession.
T: how does all that fit in with your PhD, how do you have time for everything?
C: I don't is the honest answer. I think I would have got my PhD finished if I hadn't have taken on more responsibilities but I think it would have been more boring. At the minute I like the balance of heavy technical PhD and none technical other stuff. If I had just gone hard core on the technical for the three years I would have found it really hard, in fact I don't think I would have stuck it out. My supervisor is really good and he lets me have the time to do all these commitments.
T: would you describe yourself as an engineer?
C: yes absolutely
T: what gives you that role?
C: I think for me engineering is mindset. You know I see myself a problem solver and a practical person. Even though I have done a PhD I would never call myself a scientist you know. I always think of myself as an engineer. Even though I look at the policy side of

things, I still think of myself as an engineer because its still the engineering approach to problem, solution, idea. I think that's what its all about, it's the engineering mindset of having a problem, finding a solution and improving on things.
T: when did you feel like you were an engineer?
C: probably on my placement year. The first couple of years I would have said I was studying engineering and in my placement year I really loved it and I really got into it and I just loved it and it showed me that's what I want to do and after that I would probably tell people I was an engineer.
T: what would you describe the community of engineering to be like?
C: in many ways engineers are a little bit egotistical so if you sat through any meeting of the IMechE pretty much someone at some point will say engineers aren't respected enough and I think engineers do have this problem. They need to be wanted and appreciated. I think engineering is important but I think they do feel the need to be valued and that's what brings them together a lot of the time. Engineers will often club together and they like to promote the idea of changing the world and driving it forward but it's a bit egotistical in a way. I think engineers find it easier to get on with other engineers because they have the same mindset they are analytical they find it easy to talk to them and they can geek out if you like and really get into heavy engineering. I think there is an engineering subculture if you like but there are also the different branches. I work closely with the electrical engineering and the civils because they do have their own communities but even within then there are friendly banter. Like I will say the electricals is like witch craft because I'm a mechanical engineer. Even within engineering there are separate subgroups but even professional engineering they have their own clique if you would like.
T: do you think there is a problem with defining engineering?
C: erm again this is a popular topic what has been talked about for year and years, longer than I have been at the IMechE and everyone thinks they know what an engineer does, they fix a car. From my point of view, in the UK everyone thinks an engineer works with machines and I don't think you can change that. They want to protect the title of engineer. The same way in Germany, if you work with machines you are a technician, if you have qualifications you are an engineer and there are hundreds of people in the UK who want that same protection of the title of engineer and they want to distance themselves from unqualified technician roles. It doesn't bother me to be honest.
T: what type of knowledge would you say you have to have to call yourself an engineer?
C: since I have been with the intuition my opinion of that has changed quite a bit. My undergraduate I would say maths, physics, you need to be good at analysis, you need to be a logical thinker. I still think that is true for some aspects of engineering, like a structural engineer. But there are also many other aspects of engineering like a sales engineer, you

need to be good at communication and a lot of engineers aren't that good at communication. I would say engineers from lots of different backgrounds and you will see that in the five tribes that engineers are very good at one thing but when it comes to a holistic subject, they can have lots of short falls. Like I say the engineer mindset of problem solution and that problem can be technical but also soft like people problems. And looking at a problem from problem to solution is what makes an engineer.
T: what contribution do you think your research will have?
C: I would like to think a good contribution. Surface manufacturing is a hot topic at the minute and there is a lot of benefit of micro manufacturing and making things smaller. After my PhD and looking at making it cheaper, practically I have accepted it might not make a massive difference to the world.
T: did you always identify yourself as being an engineer?
C: I suspect for a lot of my life yes and when I couldn't join the navy I had sort of feel out with it and I didn't want to do it anymore and I wanted to be a creative person and be the best music producer but that's not what I wanted to do as a job. At school I didn't really know what an engineer was but I would say I liked science and problem solving so yes I just wouldn't have put the two and two together to say that is engineering
T: how come you are interested in doing research which looks at like the social aspect of engineering?
C: erm so originally when I was going into schools, I love promotion and it and science and everything and I like seeing kids getting enthused about it and after joining the young members board they actually have an education strategy board and that's where I met peter who is the author of five tribes and we sort of got into research and it made me rethink my approach to how we attract kids and it made me realise most engineers are guilt of this but we promote engineering to people who are more like us, our own interests and we only promote only certain sides of engineering across. Like most kids wont know about medical engineering but this has the highest level of female engineers at 25%, way above the average of 8%. It just made me realise the way we promote and communicate engineering and the way go in and think one side fits all. A lot of engineers just go in and promote what they are as engineers and say if your like me you can be an engineer. Well that's great and not every kid if like you. Its just about improving STEM outreach.
T: what about the lack of women in engineering – why do you think that is?
C: a mixture of reasons to be honest, I have done a lot of research for the report I am writing for the IMechE and first of all I don't think we promote the social benefit of engineering. So there is a lot of research what says, and it is very debatable and various people have opinions and it says women are more interested in helping people, men are more interested in things. I think for a large extent that holds true and I think for a lot of

women they don't associate engineering with helping people, they associate with things because that's how we promote it in schools. We go into schools and we show them the cool stuff we have built, we show them windmills and turbines and cars and engineering at the minute is associated with things and until you can provide that engineering is about changing lives for people you wont really attract more women. As my research has shown, engineering is a very very hostile environment for women. Its part of the problem with the engineering personality type, they don't realise they can be hostile at times and they don't like differences of thought. They don't like people who don't think like they do from my experience and I fit into that and that can put women off as well. like I said the retention is terrible but it comes down to different treatment. A lot of people have their own theories but mine is that it is just a hostile environment. I go to a lot of events for WISE and WESE events and there were about 200 women there and about 5 males and the shoe was definitely on the other foot. I think males should have to stand in a room full of women engineers because you will realise you don't belong. It's a funny one. Have you heard of unconscious demotion?

T: no

C: that's a phenomenon we have found as well which is that when female engineers. The average female engineer is more proficient than male engineers and the reason for that is that because its self-selecting because it's the cream of women who stick it out so they are the cream of the crop. Erm but they all report the same sort of things and the guys assume they are the secretary or the marketing lady and they are assumed not to be technical professionals. It winds them down over time, a female engineer is very intelligent and very capable but if you are putting up with that crap of course you will bugger off. But its hard to get rid of those institutional things. The other thing we have found is that people are keen to keep women engineers and they get positive bias. There are women only engineering prizes but women don't value prizes and awards like men do. Men like to be competitive and show they are the best. Women aren't that bothered and I like working with women engineers because you don't have to spend the first hour of a meeting having a contest about who's the best. The other thing is that a lot of women who win them say they feel really awkward because men say you only women that because you're a women, I couldn't even apply. It reinforces that women aren't as good and that they need a separate category to win.

Sometimes it's a prime evil contest about who's the boss. When I was a shop fitter and it was very much hands on practical engineering and they were all apprenticeship trained, old school engineers and when you first started they would give you no end of abuse and if you once complained about it you would be a wuss, you were no good and you just had to take it and eventually you are accepted when you bully them and they bully you back. It's a

hostile environment, not just for women but men as well. for anyone who doesn't fit in with what engineering is. The women who do well are the ones who fit in with the lad culture. In engineering its that you need to toughen up and change your personality to fit in with engineering and you have to become one of the lads.
Engineers as so big headed, they think they are so superior and this thing that engineers should be paid as much as doctors and lawyers. There are t-shirts what say I'm an engineer lets just assume I'm right.
Engineering is a cut throat profession, there is always competition to be chief engineer, to be the boss. Engineering role models, you look at who is technically the best.
Engineering is all about competitions, I mean I love competitions myself. It is a competitive profession, the bragging rights on things. Engineers are primed to rip each other to shreds and it is good in one way because its about survival of the fittest and the best idea goes forward so you are primed to look at things and see if it is the best it could be. If you make a mistake you will be ripped to shreds. I like being challenged and I don't mind criticism if it means I can improve but I do say this is a very harsh environment to people.
Although it is so competitive, teams will help each other out. They can batter each other in presentations but then after will go out for a drink.

Appendix 57 – Staff/PhD student: David (interview)

T: when did you first kind of get into engineering?

D: erm probably when I was about 19-20 as a hobbyist, I build sort of audio stuff mainly and when I was 25 I started my undergrad degree but it was in electronics and music tec but I was better at electronics so I moved onto electronic engineering.

T: what attracted you to it?

D: mosaicism (laughs) erm its fun making stuff, its creative. I like building things yes I mean the specific thing I do is analogue electronics and there are not many people who do it anymore, as far as I am aware I am the only one who does it here. That specifically is what interested me, signals and circuits.

T: when you were younger were you always interested in that sort of stuff and good at maths etc?

D: erm yes, I was ok at physics. I did GCSE electronics and I failed, that's my guilt secret. I wasn't good at maths and I didn't do very well at GCSE and I don't have any a-levels. I came as a mature student. maths it's a lot more interesting if you apply it to something useful and that is how I learnt it.

T: why did you think it was important to get an education in engineering?

D: it is not applicable to do an apprenticeship in engineering anymore. It used to be the way and that is how it should be done, it should be taught as an apprenticeship but there is a lot to learn. Electronics is a hard discipline to an apprenticeship would run for a long time. To become a technician maybe an apprenticeship is the way to go but to get a job in engineering you need a degree and most ask for the masters now as well.

T: why did you decide to do a PhD?

D: I was offered. I did well on my undergrad, I got 91.5% average and erm my final year project supervisor wanted me to do a PhD. I was lucky I got a fee waiver and got funded. at the time I thought it was a good opportunity to continue learning but I am not sure I feel like that now.

T: what makes you not agree now?

D: for engineering I mean I didn't really know much about PhD's. I did read up a bit about what they entailed. If you are going to progress as an engineer, it is self-learning but it helps to be guided by someone from your field who knows more than you do. I am lucky with my PhD as most I see are very specific and that is not a good thing, being an expert in engineering in something so specific. It isn't a good idea but if that thing goes obsolete, all your knowledge is a waste of time. There are other things as well, you have to have multiple skills, my knowledge is broad. I wouldn't say am I an expert in anything but I am competent in a number of disciplines. Erm and most of my heroes, the guys who did world

changing things, like unbelievable designers probably didn't have undergrad degrees and just did it.
T: do you think you have got things out of your degree what have been beneficial though?
D: oh yes yes, I certainly figured out what I wanted to do within electronics, there were a lot of other skills I learnt like programming and there is still I will never use again but that is with any education, your bachelor degree is broad and you move into something specific. There are plenty of things I learnt. Many of my skills are self-learnt. So prototyping in particular, I learnt off my own back, just practice.
T: what do you think you have got out of doing a PhD?
D: shorter life expectancy (laughs). I certainly don't regret doing it and I never thought I would do one and I am surprised I am doing one. It helps me work out what I actually want to do and it has given my time to look at things I am interested in and what I want to know and what I think will be useful down the line. I think it is just more self-learning, I think a PhD is just self-learning. My skills have got a lot better, my analysis skills, practical skills, common sense.
T: how did you kind of choose the topic your PhD is on?
D: I didn't. how I came into it was strange, it just happened I was at the right place at the right time. At the time my supervisor didn't have any funding available and I wouldn't have done it without funding. The research I am doing, part of it came out of my final year project. I didn't choose it, what I have done it my choice. It is what engineering is like, you are solving a specific problem, you don't choose the problem. You have a problem and you have to solve it so yes
T: erm so for you what does it mean to be an engineer?
D: erm I am not sure I can answer that. Erm I think engineering is misconstrued. I don't think many people realise what it actually involved. If I was to define what an electronic engineer means for me is good analysis skills, good practical skills. The ability to look at something, a product and design around it to some sort of specification. Creative, it is a lot more creative than people think. Apply theory to practice.
T: so how does creative fit into engineering as it seems to be fairly right or wrong answers from what I have seen?
D: there is always a right or wrong answer for most things technically. Its not right or wrong, its right or stupid. Who ever said there was no such thing as a stupid question is wrong, I could show you some of the undergrads I have taught. When you get down to the nitty gritty bits, there are so many ways to doing things, different circuits, different techniques. Engineering is always a compromise, it is to which one you move closer to.
T: would you say there are a big difference between electrical and mechanical engineers? The mentality

D: erm yes I think there are differences between engineers in general, a lot of it you are putting your own personality into it. I mean most engineers I know, the good ones are bloody nuts. Mechanical engineers tend to mainly just work on CAD whereas electronics cant really do that. In my experience electronic guys tend to be more practical, I don't use stimulators. I would rather just build it and mess around with it till it works as well as it should.
T: what kind of career are you wanting after your PhD?
D: I'm not sure. I am pretty positive it wont be an academic one.
T: how come not academic?
D: erm probably need to be careful what I say but on the broader sense what you find in academia in engineering, most of the academics I know. Unless you work really really hard you will find it hard to keep up with technology and your time wont be spent building things anymore, you will be you know teaching and even if you are involved in research you wont do anything hands on as you will have your researchers and that is not what I want. I want to keep hands on, making stuff and designing stuff.
T: how was the transition to postgraduate study? Did you have good experiences, bad experiences?
D: both really. It was a lot slower starting than I thought it would be. You don't hit the ground running, you spend 6-12 months thinking about what you are doing. I went part time last February but the first year was just sort of. It was hard figuring out what I was meant to be doing and sort of trying to find other things, the research I am doing. You could say it is a good or bad thing because there is not much published in it, there is scope to do a lot of things. you don't have that much material to criticise. It was slow paced for 6 months and then I kind of got into it a bit and it was a break from the stress of final year for a bit. I came straight from my bachelors, I didn't do a masters which is what most people do in engineering actually, they do one or the other.
T: did you feel like undergraduate study prepared you for your PhD?
D: a little bit, not that much. It did in the sense that you develop your basic skills in a lot of different areas and then erm you have a starting point. It is difficult to teach, engineering is a 4 year degree anywhere else. In 3 years you are limited in what you can teach and especially getting into specific things in different subjects so you are limited and there are certain things you are just not taught. It is unsurprising, it would take a 15 year course to learn enough to prepare you for doing it. I think the main thing is just the actual act or researching and looking things up, where to look for information. I mean now I don't read a lot of research articles as usually a lot of them I either don't find interesting or I don't think it has been well done. That is just how I look at it. I wouldn't do anything I am not

interested in. most of the stuff I read is books or application notes from companies or specific engineers I like.
T: did you find the mind set of going from something taught with structure to research and flexible difficult to adjust to?
D: in some respect it was a bit of a shock. One of the first thing I did was do the TAPP course as my supervisor asked me to take some final year students which was strange as I had only just finished final year myself. I ended up doing some lecturing. I did a placement year and I did some work when I finished my undergrad degree before starting my PhD on something very similar to my PhD and when I went part time I went back to that company.
T: from some of the students is it fairly directive in undergrad
D: it is in some respects, for electrical engineers you keep a log book and it is a working diary, it is a record of what has been done on a project and when you leave a company that is handed over. There are a lot of good reasons for doing it. typically in engineering you don't stay in a place that long, you only stay for two or three years and then move somewhere else. You might design something and carry on and then look at something and think why did I do that. You forget what something is and you want to look back. When writing a report you do get a structure and sections you need in and the types of things you should include in them and this is how many marks you get for each section.
T: so because a PhD is flexible and sort of choosing which direction you wanted to follow difficult?
D: no I found it liberating, as an undergrad you are told what to do and you come to the other side. Depending on the research group or supervisor you have, some are demanding and they will tell you what to do, others don't. I would never have gone for a supervisor who tells me what to do and I am lucky I don't and he has a lot of respect for it. in that sense, it is liberating. I mean there are times when it has been pretty stressful and I have has a lot of pressure on me but a lot of the time I am able to just get on with it.
T: so what is your supervision like?
D: generally what we do, we have a meeting once a week we have a meeting for the project but that is because I am employed as a research assistant as well. everyone would say what they are us to what they were going to do. I would see my supervisor nearly every day and I would say what I am doing, what results I have got, send him results over. Just discuss, when I get something done I go and speak to him.
T: how do you think that helps because I only see my supervisor once a month?
D: erm in my opinion I think it is better to not have many students. My supervisor on has 3-4 students and when I need to speak to him, it is just to have a bit of a chat or talk about something more general than research but when we do talk about research it is far more flexible. When we do talk about research I can disagree with him, which I do often. Which is

fine you know if you supervisor thinks you should do something and you think it is a waste of time you should be able to say.
T: how do you think being in a research group has helped?
D: I don't think it has at all. It is nice to work on a project, in all honestly I am definitely the only analogue engineer. We would have meetings and it was just to see if I had got the circuit running but there are not many to help me
T: is it hard to work on something nobody else really works on?
D: it is frustrating when something is going wrong and you try loads of things. it is trial and error. I have a box of circuits what I call circuit heaven then is just filling up with circuits which I designed and didn't work or didn't work well enough to I put in the box and started again. So yes it can be stressful and very lonely erm you can end up feeling isolated when you are trying to do something and you cant figure it out and there is nobody to ask.
T: do you think engineering in general is lonely and isolating?
D: it depends where you work. I think some companies I can imagine yes there is a lot of pressure. I think it is probably more stressful. I know mates who have gone into a company and not long finished uni and they have responsibilities placed and them and nobody really to help. I had a mate who started at a company and he was the only electronic engineer and he isn't there anymore. as an engineer when you first come out of uni you should be shadowing someone and learning how to do it. a lot of electrical engineering is just trips and tricks, things what get taken for granted. You look at a circuit on paper and implementing it is a lot, you just learn it.
T: do you think there is a lot of expectations placed on engineering students?
D: when I first started I bought the maths books which are made for engineering degrees and I just started working my way through it so yes in reality you should just get up to speed. I once in my second year I asked him a question after class as I didn't understand it that well and he sort of went through and afterwards said do you understand and I said sort of and he said well if you don't understand it you should be here. So I didn't complain, I didn't say anything and I opened up the book and I did it. that's how I think you should handle it, if you don't know anything go and find it out. Learning is a self-taught process. You don't learn by listening, you learn by doing. A lot of the undergrads aren't up to speed, it is easy to say we were never taught it but some of the stuff they shouldn't have to be taught. Some of the stuff they ask and I just think I don't know why you are here, I don't know why you want to do electronics because by the sounds of it you will never make an engineer. The kind of skills students are coming out with now, industry aren't happy. There is a deficit of engineers and there has been for years. It isn't getting filled and I think a lot of it is what is happening at university level and they are not getting pushed enough to do it so I mean yes there are times when expectations are involved but there are some stuff you

should just know. I mean the main thing in engineering is that you have to be interested in it, it is a must. I mean industry is harder than university
T: why do you think people stick it out if it is so hard?
D: I have thought about quitting most times. I mean it is rough, there is pressure but it is also rewarding. When you design and build something and you look at it and think I did that, it is rewarding, there is no feeling like it. that is probably why I stick to it and it is probably like that for everyone. It pays well but it is long hours. Nobody asks you to do the long hours but you just have to because you have to get the work done. I imagine there is a high suicide rate in engineers, some people stick it out because they enjoy it, its all they do. I mean I know engineers who just do it all the time and they don't do anything else.
T: do you feel as though you should be or that you are an expert?
D: no erm I am definitely not an expert. As soon as you start thinking you are an expert or great at something you will stop trying to be good at it, that's how I treat electronics. There is too much to be an expert, you can be an expert in one little thing but I would rather be good in a broader field. There is that pressure now, if you are a member of the IET, they require you to do 30 hours a year of professional development and they require you to log online what you have done. Reading, books, training courses otherwise they chase after you about your membership.
T: would you describe yourself as an engineer?
D: I suppose so.
T: at what point would you say you were an engineer?
D: probably the past year. I certainly didn't think I was an engineer coming out of my undergrad. I think probably when I went part time and I was working as an engineer, I felt like an engineer was an engineer. I have never felt like I have been good at much and it was the same with electronics, I felt like a con man and I think a few guys feel like this and I started a PhD and I felt like I shouldn't be here. But when you talk to other engineers and you know more than then and they ask you something and you know the answer and you think I am not too bad.
T: I have read a lot of papers of engineering being objective, competitive, impersonal, masculine. Are they things you have seen?
D: yes. Analytical is a given, you have to analyse stuff and look at a circuit, if you cant analyse a circuit how can you design one? It is competitive in that a lot of companies are trying to make parts and that sort of thing.
T: aside from the knowledge would you say there are other skills engineers need?
D: yes it is stuff I don't really like. I have never been good at communicating with people. Team work, I would say I am ok but I can get frustrated with people. I mean I have had interviews and they always say give us a time you have worked well as a team and I always

think what does that have to do with engineering. What bearing does that matter, it is about design but I guess they need to know you will be cooperative and not ignore people. Communication in multiple ways like report writing and log books and stuff like that. I mean that is the stuff I think is important.
T: what would you describe the engineering community to be like?
D: most good engineers I know are weird like me and I think you have got to be. Once you realise what you will be doing and to stick it out you have to be bonkers. You learn all this information and to learn more and work hours and hours and hours. I think a lot of people who come into engineering are misled.
T: would you say it is friendly?
D: it's a lot of banter. You have to take some grief and I have given it. you will get this piss taken out of you quite a bit. When you get frustrated when you are doing something, one of the biggest things I learnt in engineering is that you have to be patient. You cant just smash it to bits. It is male oriented but it is fun, most of the guys I work with we have a laugh you know.