An unexpected journey: From Autoethnography to a Bourdieusian Analysis of Engineering Education

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Abstract

Who am I? I am a factory worker, who became a motor mechanic, an electronics technician, chartered engineer, project manager, university course director, associate dean and more recently a PhD student in education. I have a story to tell about lifelong learning from the perspective of the student, and a perspective on engineering education that is very different from many of my colleagues in academia. As my original research aim was to bring a different perspective to education, I also needed to take a different approach to research, and so I began my PhD with a grounded theory style approach, and a reflexive autoethnography of lifelong learning. Through my attempt to explore and justify my arguments for the autoethnographic method, I entered an epistemological rabbit hole that took me far away from the objective, quantitative world of engineering academia. However, through the autoethnographic process, I started to realise that my earlier experience of actually being a practising engineer was often qualitative and subjective, and seemed at odds with the quantitative, objective and theoretical world of engineering academia. I began to question why there was such an apparent disconnect between engineering education and practice, and this became the focus of part 2 of this thesis.

This PhD thesis is in two distinct parts. Part 1 contains the autoethnographic elements described above, that led unexpectedly to the focus on engineering education through a Bourdieusian lens, via a number of other possible themes including motivation, social class, and distance learning. I begin part 2 by connecting my autoethnographic description of the disconnect between engineering education and practice, to similar accounts in academic, industrial and institutional literature. My main contribution to knowledge is the application of Bourdieu's theories of social reproduction to an exploration of how this disconnect has been maintained. As Bourdieu has positioned habitus as embodied history, I explore how the historic development of engineering has led to the separation of education and practice into distinct fields, which have in turn influenced the habitus of the agents within those

fields. My main argument is that the habitus of the engineering academic is formed within a field where the valued forms of capital are based on scientific research and academic reputation, and this predisposes the academic to doxic beliefs about the nature of engineering that are not reflective of professional practice. However, I also contend that the engineering profession, in response to perceptions of societal attitudes to occupations and professions, also contributes to social reproduction through the cultural capital associated with academia and science.

Declaration

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own.

Two publications referenced in this thesis (Moffat, 2017a, 2017b) are work produced from this PhD, and links to these papers are provided in the reference list at the end of this thesis.

Signed: Date: 24/10/18

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Finally I would also like to thank my wife Dolores, for her patient support throughout. To my daughter Iona, born a year into this PhD programme; using me as a climbing frame might not have helped me progress the thesis, but did continually remind me of what is most important.

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Chapter 1: Introduction and reasons for this study

The layout of this thesis

This thesis investigates a potential disconnect between engineering education and practice, utilising a Bourdieusian analysis to explore how that disconnect is maintained. However, as the focus on engineering education emerged from an autoethnographic and grounded theory based approach, the thesis has been separated into two parts. The first part, comprising Chapters 2 and 3, is autoethnographic in nature and was written early in the PhD process. With the exception of some minor editing and condensing of Chapter 2, part 1 was completed by late 2014, and has been left unchanged since then. The reasons for this approach are discussed in more detail in Chapter 2, but centre around a requirement for honesty in autoethnography, capturing memory and experience at a particular moment in time, and possibly of most importance, the avoidance of temptations to revise earlier autoethnographic data to suit a later theory.

Chapter 2 is an unconventional methodology chapter, because it also contains autoethnographic data related to my epistemological journey from engineering to social science. As explained in Chapter 2, this is only the first part of my methodology, as the grounded theory aspects of my approach meant that further methodological decisions were made after the autoethnography and initial thematic analysis was complete. The thesis follows the Harvard referencing style, with single quotations for direct quotes from referenced material, allowing me to use double quotations for autoethnographic elements, to indicate either representations of spoken conversations, or my own internal thoughts, depending on context.

Part 2 in general takes a more conventional academic approach, but begins with a transitional chapter: Chapter 4 describes both the initial analysis of the autoethnography, and how I got from a broad autoethnography of learning to a focus on professional engineering education, before moving on to discuss the rationale for choosing a Bourdieusian approach to analysis and describing the methodological elements of this approach. The remaining chapters of part 2 comprise a Bourdieusian analysis of professional engineering education, and attempt to answer the question of why there appears to be such an explicit disconnect between engineering education and practice, and how this disconnect is maintained? There is no traditional literature review chapter in this thesis, in part because of the grounded theory approach, but academic and professional literature *is* reviewed throughout. A review of autoethnographic, methodological and related literature, was conducted for Chapter 2, ahead of completing the autoethnography in Chapter 3, and subsequent literature reviews were again conducted throughout the remainder of the PhD.

In terms of the autoethnographic elements of this PhD, there is a balance between positioning autoethnography as within research about learning and education, but still close to literature and story-telling. If I just wanted to tell an interesting story I would tell you about the time I got lost in the “wrong side” of Chicago, or that crazy Carnival night in Cologne, but however funny or interesting these stories might be, they are not particularly relevant to research in education. Perhaps the key difference between an autobiography about my life, and an autoethnography about an aspect of my life is ‘intent’ (Mereness, 2008, p. 30). I want my autoethnography to be an interesting story, I want it to be entertaining and accessible where possible, but that is not the main aim. My hope is that my experience will be useful to both insiders and outsiders (Ellis et al., 2010), where I would see insiders as learners from similar cultural and experiential groups to myself, and outsiders as those who have followed a different learning path but wish to understand those that they don’t identify with. I have taken a first person approach throughout this thesis, which is in keeping with the reflexive approach to both autoethnography and analysis, and a recognition of the subjectivity of much of what is contained within.

Ethical issues are considered throughout this thesis, but in particular, ethical issues related to autoethnography, interviews, informed consent and identity protection, are discussed in detail in Chapter 2. A key issue that recurs throughout is the author's vulnerability, firstly in exposing and publishing personal details of my own life, as well as the reputational and career risks of challenging an academic discipline in which I am in employed.

This thesis has taken an unusual approach, and this has resulted in an unconventional layout. Part 1, Chapters 2 and 3, are explicitly autoethnographic in nature and were finalised early in the PhD. Chapter 3, the autoethnography of learning, was intended to be the data that would be later analysed, in a grounded theory influenced approach. However, as is explained in more detail in part 2, it later became apparent that Chapter 2, the initial methodology, could also be considered part data, as in addition to being a methodology, it was also an account of my own epistemological journey. Part 2 is partly autoethnographic, but also includes literature reviews and formal analysis. The primary intention of the two parts, is to explicitly mark the point in the PhD when I moved on from a pure autoethnographic approach, from intentionally avoiding analysis and literature, towards a narrowed, structured formal analysis.

Chapter 4 is essentially the link between parts 1 and 2, the journey from being the researched, to the researcher. It necessarily mixes autoethnography, analysis and methodological elements, in order to describe how the autoethnography became data, and the process that led to the narrowed focus in engineering education. It is important to reinforce that while writing part 1, I did not know where the autoethnography would lead me. I knew nothing of Pierre Bourdieu or social theory at that point, and I didn't expect to focus on, and in fact initially resisted, the focus on engineering education.

The analysis described in Chapter 4, gradually led me to connect the epistemological issues explored in Chapter 2, my experience of engineering education in Chapter 3, post autoethnography literature surveys of engineering and engineering education, and a growing knowledge of social theory. I would contend that without the unusual route that I have followed, I may not have been able to put these seemingly disparate elements together. This is perhaps best visualised by the subway line analogy (inspired by Bourdieu in Denzin, 2014, p. 44) in the figure below. While the origin and destinations could be considered to be similar to the conventional routes into professional engineering and engineering academia, it's the additional stops along the way give me a very different perspective.

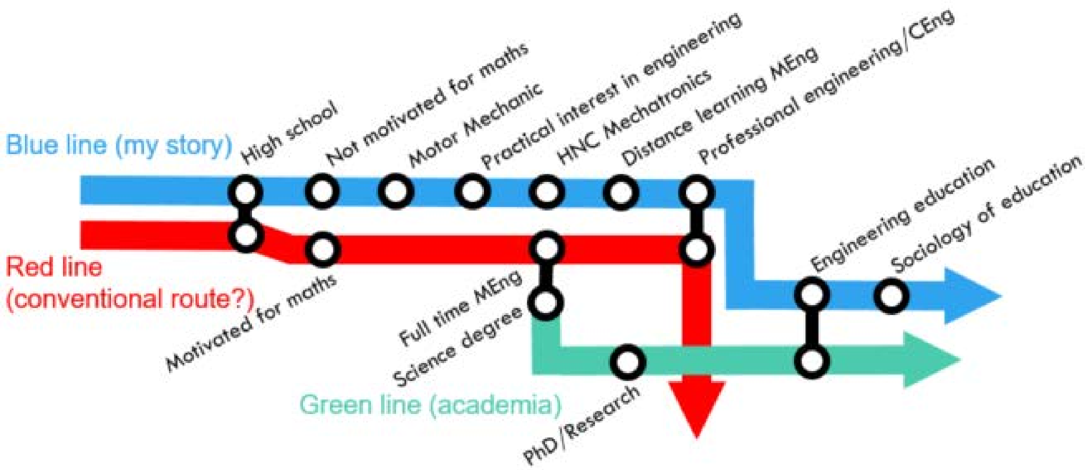

Figure 1-1: A journey of lifelong learning

Sources of data

As I have stated already, this is an unconventional thesis and the autoethnographic approach can lead to issues of terminology, in relation to the term "data". Autoethnography literature often refers to the autoethnography itself as data, and memories, alongside other things such as documents and records, as the sources of data (Wall, 2008). In this sense my autoethnography of learning, in Chapter 3, is a key source of data, and it was written with the intention that it would later be analysed as data. Interviews were also conducted during this PhD, and while the transcripts of these are also clearly data, as discussed at the end of Chapter 2, they have other functions relating to quality, credibility and as a mirror to reflect the autoethnography back from multiple perspectives. Although the interviews were intended to be data, the decision to focus on the theme of engineering education, later limited the ultimate significance of the interviews as data. If I had focussed on one of the other possible themes emerging from my autoethnography, such as social class, or motivation for learning, then I may have drawn more heavily from the interview data. However, as only one participant had any experience of engineering education, but no experience of engineering practice, then the impact of this data on the focus of Part 2 is limited.

However, throughout the thesis I occasionally refer to parts of the thesis and say that they could be “considered data”, or are “part data”. For clarification, when I say “part data”, I mean for example that parts of the chapter could be considered to be data, rather than the data itself is only part data. In particular this refers to Chapter 2, because as well as a methodology, this also became an unintentional autoethnography of my journey from engineering to social science. It is perhaps harder to think of this as data in the conventional sense, but taking a reflexive stance, it is also clear to me that this chapter has in retrospect, had a critical influence on the arguments later developed in Part 2. This is a close match to what Ellis describes as the natural analytic process inherent in the writing of an autoethnography, and that when people tell stories they ‘employ analytic techniques to interpret their worlds’ (2004, pp. 195–196).

Ellis is suggesting that stories are inherently theoretical and analytical, that there is a natural analysis that goes on in the writing and reading of a story. Much of the literature also states that autoethnographers need to be reflexive (e.g. Armstrong, 2008, p. 4; Ellis and Bochner, 2000; Muncey, 2010, pp. 91–92), and this leads me to constantly question how I am coming to my conclusions. I used a subjective, qualitative thematic analysis, and a quantitative word count to help identify the major themes from my chapter 3 autoethnography of learning, but as the engineering theme started to become the focus, and the research questions began to develop, I was obviously drawing from other sources and I needed to be conscious of this. I would have been starting to look at the literature, starting to think a bit more about my engineering experience specifically, and critically, I was being drawn back to the natural analysis inherent in the process of writing chapter 2. For example, because I was writing about epistemology in an autoethnographic style, I was personalising it and relating it to my experience. I would suggest that I was unconsciously analysing my experience of learning these new concepts, and relating them to my life experience. Although it was much later in the PhD that I started to refer to an 'epistemological disconnect' between engineering education and practice, this was clearly an analytical product of writing and referring back to that chapter.

In summary, I would suggest that in the context of this thesis there are three main forms of data. The first and the most obvious is the content of Chapter 3: An Autoethnography of Learning, which was intended to be data, was actively analysed, and is the origin of the engineering education theme which became the focus of Part 2. The second, is the interviews, which were intended to be supporting data, but have had limited impact on the themes explored in Part 2. The third, is the data in Chapter 2, and to a lesser extent in Chapter 4, which although it was not intended to be data, and was not formally analysed, it has in fact had a much more significant impact on the arguments made in this thesis.

Who am I?

Autoethnography is clearly subjective and my autoethnographies are obviously based on my perceptions and my experiences. As discussed in more detail in Chapter 2, part of how autoethnography is received, and quality is assessed, is based on the credibility of the writer, along with transferability and usefulness. For this reason I believe it’s important for the reader to know who I am, so that they can make their own informed judgements about how my social and cultural background, my professional experiences etc. has influenced my observations, and to which scenarios my experiences might be transferable. Who I am now is also a sum, at least professionally speaking, of the experiences that will be described and analysed in the coming chapters. Another reason I think this is important is that I am telling my story retrospectively, so I am looking at my past life through the lens of my current situation, and as this is research and not fiction, I think it's important that a reader is aware from the outset of who his telling the story.

I was born and grew up in Scotland, as were all of my progenitors that I am aware of. My parents, as with many of their generation in Scotland would probably have been described as working class and no one in my immediate family, and as far as I am aware, my extended family, has had a university level education. I have lived and worked outside of Scotland which has certainly broadened my understanding and exposed me to people from different cultures, but in the main my professional and cultural experience is limited to English speaking countries (Scotland, Republic of Ireland and the USA). From the day I left high school at age 17, until a few years before beginning this PhD, I worked in industry so the majority of my working life has been industry based, always in jobs related to either practical or professional engineering. During the completion of this part-time PhD I have been working full time in engineering academic roles in a conventional university, although my work is primarily related to distance learning engineering students based in industry. This mini biography is clearly not comprehensive, but it is intended to inform the reader honestly of how my experience might influence or situate my story

Why I think I am a good subject for this study

'One of the most useful analytic phenomena are cases which seem to go against the pattern or are deviant in some way' (Potter, 1996, p. 20)

It has been suggested that autoethnography is a useful method for studying cases that deviate from the norm (Muncey, 2010, pp. xii, 4–6, 9 sometimes with reference to Potter 1996). As I came into this PhD with a feeling that my experience was quite different from my colleagues in engineering academia, the arguments made by Muncey were quite persuasive, and convinced me that autoethnography might have potential to capture experience that went against the grain. Potter doesn't suggest that deviant cases necessarily disconfirm the typical pattern, and that sometimes the problems observed in a deviant case can instead confirm 'why the standard pattern should take the form it does' (1996). I would suggest that the potential of autoethnography in the exploration of a deviant case may give voice to a silent minority, or even a 'silent majority' (Muncey, 2010, p. 6), whose voices are unrepresented, or for one reason or another could be missed by traditional forms of research. These alternative voices may challenge or support established patterns, but either way they offer a different perspective.

There are several reasons that I think of myself as such a *deviant case*. Firstly, I have not taken the traditional university route into professional engineering, having entered via a trades/technician route and a distance learning degree. It's also fairly uncommon for professional engineers working in industry to enter engineering academia. My disinterest in mathematics and physics at high school, also marks me out as an atypical engineering graduate. Each of these on their own are not particularly remarkable, but taken together this is a very unusual route, to the point that I am not personally aware of anyone else with a remotely similar path. Add to this the fact that very few engineering academics engage with engineering education research, even fewer with the sociology of education, and still fewer undertake a PhD in this discipline and engage with a method as distant from engineering academia as autoethnography. I felt that this put me in a position where I could make a unique contribution to knowledge.

In autoethnographic study of the self, the subject is also the researcher so I also had to consider why I believe I am ideally positioned at this particular point in my life to conduct this research. Firstly, I am now confident enough to tell the story, warts and all. Possibly through age, or experience, I am not particularly anxious about revealing my flaws as a learner, my sometimes less than altruistic reasons for learning, or to potentially discuss or highlight things that could be unpopular in engineering academia. Another thing that became more apparent to me as I explored the social sciences, was that I had given a lot of thought while I was learning as an adult, to why things are the way they are, the motivations and methods of teachers and other learners, or in fact human behaviour in general. On reflection I appear to have been, as discussed in the next chapter, a kind of unconscious ethnographer. The fact that I had wondered about these things for so long, without drawing any formal conclusions, meant that I had a lot of surprisingly fresh memories related to learning, which were brought back to the front of my mind by my relatively recent exposure to pedagogical literature. As I started the PhD I felt that the time was right because my memories of adult learning were still fresh, and as I was only starting to become involved in teaching, I hadn't yet lost my learner's perspective. Although I had started to study educational literature by this point, I was still tending to consider these concepts from my perspective as a learner, rather than as an educator.

Research questions and an unexpected journey

In the spirit of autoethnography taking an honest stand, I believe that I should also be clear about how the focus and research questions developed from the point where I started to write the autoethnography of learning, to the questions that informed the Bourdieusian analysis of part 2. In the early stages of my PhD my research questions and possible methodology were unclear, but when I reflected on my original motivation for doing a PhD in

Education, developed while following a Postgraduate Certificate in Advanced Academic Studies, I settled on the following questions.

What can I understand about the nature of learning from studying my own experience as a lifelong learner?

> *What motivated me to learn in the past, and what motivates me now?*
>
> *How do I learn and what affects the way that I learn?*
>
> *Can the above relate to others like me?*
>
> *What can I learn about how students learn and their attitudes to learning from my own experience?*

How can I, and others, use what I have learned in this process in my future career as an educator?

There questions were vague, but I was comfortable with this at that stage in the process, and it seemed to fit with the concept of autoethnography as an adventure which doesn't always have a clear destination (Muncey, 2010, p. 63). While I couldn't be sure about where this process would lead, having written the first draft of my narrative I wrote down some of the issues that I expected to be exploring:

- Why children who seem to be capable do not perform to their academic potential
- What can motivate someone to learn after leaving the compulsory educational system
- Educational methods from the perspective of the learner
- Distance and online learning methods from the perspective of the learner
- The conflicts between the student perspective and the educator perspective

I later considered that by writing the methodological chapter in the same style I could capture additional data about my experience of learning, as undertaking this thesis is a learning process itself. I started to see that there were side narratives about the process of learning how to conduct research in the social sciences, and the process of completing a PhD itself such as:

- Exposure to qualitative methods from the social sciences, contrasted with a working life in the quantitative world of Engineering and Science.
- The fact that I am learning about completely new concepts, while writing about learning, has made me very conscious of how I learn and what motivates me
- Some of the voices that I may represent, such as that of the apprentice mechanic, are probably unheard of within academic literature.

As I came towards the end of writing this thesis, and started to draft this chapter from some of the earlier notes written above, I was surprised myself about how far my research questions were evolving from the original form. It’s very clear from the original research questions and later notes above, that the autoethnography that I thought I was writing was about motivation for learning. I was starting to expect it to focus on why I went from being an unmotivated academic failure in high school, to a highly motivated, Masters distinction level student as an adult distance learner. As I will discuss in Chapter 4, as I came towards the end of the thematic analysis of my autoethnography and the subsequent interviews, I was starting to see two much stronger themes emerging, one which was related to social class and led me towards an exploration of social theory, and another relating to mathematics and engineering. I had been surprised during the thematic analysis to see the latter theme coming through so strongly, but there was a clear progression from mathematics being a subject that I considered to be “pointless” at school, then had to learn to a high level to get through a Master of Engineering degree, and then forgot very quickly after becoming a practising engineer. This difference between the aims of engineering education and reality of practice, combined with the epistemological differences that I had noted while writing Chapter 2, led me to ask the question:

> Why does there appear to be such a serious *disconnect between professional engineering education and practice?*

In seeking to answer the above question, it became enmeshed with the theme of social class and social theory, ideas of social reproduction that I had begun to explore and in particular the theory of practice developed by Pierre Bourdieu. This approach was appropriate, because my initial literature reviews had started to show that *the disconnect* between engineering education and practice had already been alluded to by others, and perhaps the more appropriate question was:

> *How is the disconnect between professional engineering education and practice maintained?*

So if autoethnography is about telling stories, the above is the short story version of my unexpected journey from a broad autoethnography of learning, to a Bourdieusian analysis of professional engineering education. What follows is the story in full…

Part 1

Chapter 2: An epistemological journey from engineering to autoethnography (methodology part 1)

Note: The original intention of this chapter was a methodology written in an autoethnographic style. It was drafted at the start of this PhD and prior to finalising the autoethnography of learning in Chapter 3. When later analysing my autoethnography of learning, I realised that this chapter was also part data, as it captured elements of my epistemological journey from engineering to social science, and on reflection formed the seed for my arguments about the epistemological differences between engineering education and practice. While there has been some later condensing and editing, what follows is a representation of my methodological research, thoughts and plans, as they stood prior to writing and analysing the autoethnography of learning. In order to retain an honest, autoethnographic record of this process, I have added nothing that I learned or considered after this point, and any methodological elements that I developed later are covered in Chapter 4.

A qualitative engineer?

My initial exposure to the social sciences, after 20+ years as an Engineer, was like arriving in a foreign country without any knowledge of the local culture or language, and trying to explain what I wanted to do and how I wanted to do it. Up until then my understanding of research was something that must be objective and quantitative. The epistemological journey that led me towards some of the most subjective forms of sociological research, uncovered beliefs that I had always held, and had often practised as an engineer, but had not previously had the vocabulary to express. This chapter is both the story of that journey, and my methodology.

Although my original motivation was to explore my own experience of learning, by the time I submitted my formal PhD proposal I was talking about a mixed methods (Johnson and Onwuegbuzie, 2004) approach. I later questioned whether this came in part from a perceived need for a quantitative, objective element, because of my perceptions that this was a necessary part of research, but as an outsider to social science a mixed methods approach also seemed logical. Having spent most of my working life as a practising engineer, I was used to taking a pragmatic approach, and mixed methods seemed to be about matching the method to the problem at hand. Including a qualitative element also appealed to my experience of engineering, where I felt that over reliance on quantitative methods sometimes led to questionable conclusions. The paper by Johnson & Onwuegbuzie (2004) was also my first exposure to the debate between interpretivist and positivist positions, and the incompatibility theory that they should not be mixed.

I realised early on that I needed “a crash course in the language of the locals” so in the first months of my PhD I took a number of classes on social science research methods and I found myself more drawn to the qualitative methods being described in the classes. I reflected on how often during my career as an engineer I had felt that statistics and data were being used to make decisions that were inherently flawed, because they did not take into account what I thought of as the “human factor”. Even when there was no human factor, for example with technology and machines, I could still recall examples of bad decisions that were based on quantitative data alone, that could have been improved if experience and local knowledge had been considered.

From attendance at the classes and some of my early reading about research methods in education (Punch, 2009) I was starting to get a better overview of the approaches available to me. After one class, I became quite keen on critical discourse analysis and using it to explore the interactions between learners and tutors in online forums, after another I considered interviews with learners and teachers in the distance learning course that I led. Along the way I also considered case studies (Yin, 2003) and ethnography (Davies, 2012), while still thinking about quantitative methods such as surveys with numeric answers. I found a lot of these qualitative methods very interesting, and at one point, at least in my mind, I was changing my proposed research method on a weekly basis. Part of the problem was that I was learning about an interesting method and trying to fit this to a problem, rather than starting with the question and matching this to the best method, but the real issue was the fact that my original research questions themselves were unclear and conflicted. However, as I read about terms like self-study (Pinnegar and Hamilton, 2009), narrative approaches (Sparkes, 1996), autobiography (Bullough and Pinnegar, 2001), ethnography (Davies, 2012) and autoethnography (Ellis et al., 2010), I started to remember that my initial motivation, was that I wanted to somehow write about and use my own experience of learning in my research.

Ontology and Epistemology

On reflection, I can see that I have long held a loose set of beliefs about how knowledge needs to be understood in the context of experience, but I had never thought about having an ontological or epistemological position. In fact, prior to the first year of my PhD programme, I don't think I had even come across those words and I certainly would not have been able to define them. A lecturer in one of the research classes I attended said something along the lines of; "you cannot decide your research method, until you have first understood your ontological position". I came back from that lecture with that phrase, and the concepts discussed, rolling around in my head, but if I am honest at that point I was still trying to remember which one was ontology and which one was epistemology. What I *had* taken away, was that there is a vocabulary for discussing the way that a person understands the world, how it exists and how knowledge is constructed. I found these concepts fascinating, but more importantly I saw this as a possible starting point, a way to go back to fundamentals to figure out my method.

Starting with ontology, I needed a definition that made sense to me and was contextual. I found it in the statement that ontology was related to the 'nature of social reality, claims about what exists, what it looks like, what units make it up and how these units interact with each other', or more succinctly what 'constitutes social reality' (Grix, 2002, p. 177). Considering Epistemology, I learned that this was related to the 'knowledge gathering process' (Grix, 2002, p. 177) and the 'relationship between the researcher and that being researched' (Yilmaz, 2013, p. 316). Ultimately, within the context of research I decided that my ontological position was my 'view of reality', or what could be known and understood, and my epistemological position was how I could know about it, or 'how one acquires knowledge' (Mack, 2010, p. 5).

When I considered this philosophically, I felt that I could see ontology and epistemology from both positivist and interpretivist viewpoints, depending on context, and whether or not I was dealing with a theoretical or realistic perspective. By context I mean that I see an objectivist approach being sensible when I consider the world from the point of view of my studies in the natural sciences, but when considering human beings I would tend towards the view that the world is socially constructed. This might seem obvious, particularly in the case of the natural sciences, but I also felt that there is a case for a more holistic view, particularly when considering how human beings and technology interact and affect each other. What I mean by a theoretical perspective is that although I believed that there may well be a 'single, tangible and fragmentable' reality (Yilmaz, 2013, p. 314), I don't believe that human beings, are currently capable of understanding it. This stems in part from my belief, in agreement with Mack (2010, p. 8), that 'all research is subjective' and that even the choice of paradigm is a subjective one. I thought; "Even if a researcher could escape their own subjectivity, could they escape the subjective bias of those awarding the funding, the participants, the publishers or even the readers of the published work?" However, my main issue with the idea of *mathematically modelling* human beings and society was the complexity and the number of factors that need to be taken into account. A borderline election voting intention could be changed by the weather, and the weather can be changed by so many factors that weather forecasters are still not able to reliably forecast more than a few days ahead. From an engineering perspective, my experience of Artificial Intelligence and Neural Networks showed that if computers are still struggling to accurately recognise and recreate human speech and handwriting, then they are no-where near capable of accurately representing the complexities of human society, of which speech and handwriting are just a small part.

In the middle of this epistemological exploration, an argument made by Smeyers and Depaepe (2010, p. 19) really resonated with me. They suggested that a problem with quantifying educational research is that it 'provides researchers with a strong incentive to focus on what they can measure statistically rather than what is important'. They referred to Abraham Kaplan's 1964 story about the drunk who 'is looking for lost car keys, not in the dark where he lost them, but under the streetlight where he can see better'. This paper, and that quote in particular, summed up my feelings about the misuse of statistical analysis, a method that I was very familiar with through my experience as a process engineer. While I continue to use and recognise the value of statistical and numerical analysis, I could also recall occasions where engineers were being guided by numerical data alone, without seeing what I would have referred to as "the bigger picture", or conversely being almost blind to what was right in front of them. Although unarticulated at the time, I clearly held epistemological beliefs that saw quantitative methods as insufficient to describe knowledge even in a supposedly mathematical discipline such as engineering, and even less so when people were involved. If asked how I viewed reality I would have said it was a "perception".

An unconscious ethnographer?

While this was all very interesting (at least to me), I had to pull myself back towards how it could guide my research. It had become apparent to me, that ontologically speaking, I agreed that reality is ‘subjective and multiple, as seen by the participants’ (Yilmaz, 2013, p. 316) and that reality is ‘forever changing’ (Grix, 2002, p. 177) as people change and new information becomes available. When I considered epistemology and how I tend to acquire knowledge, I felt that it was never enough for me to understand just the theory, I also want to understand how the theory connects to practice. This seemed to link to an awareness of my tendency to try to analyse the meaning behind social situations I have been a part of, or have observed, sometimes still thinking about these seemingly innocuous events many years later. I realised that all my life I have been observing and thinking about what people do, why they do it, what motivates them etc, and this had even been a feature of the way that I practised engineering. It was these observations and questions about educational practice that I had, particularly as a mature student, that were still rattling around in my head many years later, that led me into this PhD, and the concept of approaching it from the perspective of the learner.

I don’t remember the precise moment that I linked all of this to ethnography and autoethnography, but when I did I felt that in a way I have been an ethnographer all of my life. As an engineer who had previously been a technician, I often made positive practical use of the fact that I was considered by the technician group to be an ‘insider’ (Ellis et al., 2010, p. 3). I talked to them, found out what they thought, and made improvements based on this. I always looked at things for a long time and thought about what they were doing and why they were doing it. I remembered a specific success I had in industry fixing a recurring fault with a chemical delivery process where others using conventional methods of diagnosis had failed. My success was based on observing the machine, how the operators interacted with it etc., and ultimately implementing a custom solution that could not have been uncovered without the hours I spent observing the process. When the company I worked for at the time became enamoured with the ‘Lean Manufacturing’ (Independent.ie, 2008) methodology I found that my technique was a perfect match to what Lean called ‘going to the gemba’ or where the work happens (Flinchbaugh and Carlino, 2006). This wasn’t by design, I was just continuing to do what I always did; observe, understand, make changes, observe. When I thought about my affinity for *Lean* as an engineer, and my attraction to ethnography as a research technique, the connection was obvious. Lean could be considered ethnography and reflexivity in disguise, making its way into the quantitative world of engineering.

An understanding of where I stood epistemologically, gave me more confidence to describe what I wanted to do and why autoethnography might be the way to do it. From some short autoethnographic sections that I brought in to my supervisory meetings, and the encouragement to expand this, I found myself writing more about my life as a learner, going beyond my expected focus on distance learning. As the autoethnographic drafts grew, I realised that this was potentially becoming the focus of the PhD, and I would have to learn more about the method, both from the point of view of defending my approach, but also for advice on *how to do it*. What follows in the next section is the story of my finding autoethnography as a method, and my justification for using it.

First impressions of autoethnography

I arrived at autoethnography after first reading about self-study (Pinnegar and Hamilton, 2009), narrative approaches (Davies, 2012) and ethnography (Davies, 2012). This makes it sound much cleaner than it was, but these texts helped grow my confidence that studying the self could be considered a valid research method. I suspect that the reason terms like self-study and narrative caught my eye first, was that these terms are self-explanatory, whereas autoethnography is not. That may be why I am not completely clear on the moment when I first heard the term, or when I first started to refer to what I wanted to do as autoethnography, but somehow through the cloud of all the competing terms and methods autoethnography kept coming out as the most relevant to what I hoped to achieve. In particular the style attributed to Carolyn Ellis and her collaborators was becoming familiar (Ellis et al., 2010; Ellis and Bochner, 2000).

I had found this recurring word, ‘autoethnography’ in texts that seemed similar to what I wanted to do, but I wasn’t completely clear on the specific criteria or definition, and how it differed from self-study, autobiography, narrative etc. I paused for a moment and thought “why not do what I usually do when I am interested in a definition of something” and I typed “autoethnography definition” into google.

> **‘Autoethnography** is a form of self-reflection and writing that explores the researcher's personal experience and connects this autobiographical story to wider cultural, political, and social meanings and understandings.’

The above quote came from Wikipedia (2014) and was the first returned result. I thought, “this is a good description of what I want to do”. Staying on the same 1st page of search results I saw another link to a blog post where the author’s (Keefer, 2014) definition included the statement that autoethnography ‘acknowledges the power of the researcher to explore his or her own life **more closely than others are able**’. I have emboldened the part that really caught my eye; I thought; “who is better placed to explore the issues that have affected learners like me, than someone who experienced it first hand, i.e. me”. While recognising the concerns that some would have about referencing the freely editable Wikipedia, or randomly found blogs, I found this exercise useful, and the reason I include it is that it’s a real part of the story and is probably reflective of how many students in the information age research and check definitions. Keefer’s (2014) definition, while in agreement with the peer reviewed literature I had read up until then and later, was probably a clearer statement about autoethnography than I had come across before or since.

Moving on I knew that I would need to justify this method using peer reviewed literature, rather than definitions found on the internet. However, as will become evident from what follows, I did not find a clearer definition in the literature. What I found was abstraction, disagreement, reference to more terms that I didn't understand and I started to get frustrated with this. I was going back and forward on whether autoethnography was absolutely the correct term and what was the difference between autoethnography, self-study, narrative approaches etc. Part of my inner self rebelled with something along the lines of; "why do I have to give this a name; if telling my story yields something useful does the official name of the method used matter"? I thought "All this talk about making research accessible to voices that wouldn't otherwise be heard, and then silencing those voices because they are not conversant in the correct jargon"! This brought in a multitude of thoughts about whether the PhD process being mostly restricted to academic achievers, and also being the gateway to research, actually just ensures that the same voices are being heard regardless of the introduction of new methods such as autoethnography.

With my five-minute internal tantrum over, I was back to the reality that I would just have to get on with it and make sense of all these seeming contradictions in the literature. I took pencil and paper and stepped away from the literature, to think about what I actually wanted to achieve from this part of the research, and below was what I came up with:

> *I want to explore analytically my experience as a learner*
>
> *I want to relate my own story to the educational literature*
>
> *I want to find out if my experience is reflected in the experience of other students.*

I want to find out if there is anything that we can take from this to improve the student experience.

“So”, I thought, “going back to the idea that research should be led by the question not the method” (Grix, 2002), “maybe I don’t need to pigeonhole what I am doing, but it is *research* and I need to relate it to work that has gone before”. “I also need to make the reader comfortable that even though this is not the most conventional form of research, that I am following some conventions and building on the work of others”. So I set off to explore autoethnography to a deeper level than I had previously and I found myself being drawn into a world of philosophy that I found fascinating. Rather than being frustrated by having to read more about it, in the end I had to pull myself away from it, in order to get back to the focus of the research.

Returning to the academic literature I found Ellis *et al* (2010, p. 7) discussing autoethnographies as ‘personal narratives’ where authors ‘view themselves as the phenomenon’ and ‘invite readers to enter the author’s world’. I realised that this was a good match to what I was trying to achieve and the few pages I had drafted so far, but it also brought a realisation that I would have to be prepared to write something personal and that I would have no control over who might read it. Ellis et al. (2010) recognised that an individual not only implicates themselves by using personal experience, but also may ‘implicate others’ (2010, p. 8) such as colleagues, friends and relatives. At first I did not think that this would be very relevant, but as I started to write I realised that I often needed to refer to people as *a friend*, or *a tutor* and change contexts slightly to ensure that identities were protected, but there were always going to be characters that would be more difficult to protect, for example how do you hide the identity of a parent without changing the context completely? I knew that I would have to consider this in more detail prior to applying for university ethics approval, and I discuss both relational and procedural ethics in a later section in this chapter.

If I thought I had reached the end of my methodological exploration when I settled on autoethnography I was very wrong, and I instead found that as an emerging method there was little agreement on either the aims or style. Denzin (2014, p. 20) refers to the multiple definitions and aspirations of some of the leading autoethnographic researchers as ‘Apples and Oranges’ and says that Mills and Jones want to ‘rewrite history’, Anderson wants ‘analytic reflexivity’, Ellis wants to ‘embed the personal with the social’, Spry wants ‘critique the social situatedness of identity’, Neumann wants to ‘democratise’ and Jones and Denzin want to ‘move audiences to action’ (Denzin, 2014, p. 20), with Muncey (2010, p. 31) insisting that autoethnography should ‘attempt to subvert a dominant discourse’. In fact the ambiguity or developing use of the term ‘autoethnography’ was evident in the first page of Denzin’s (2014, p. vii) preface with the revelation that the previous edition of the same book was called interpretive *biography.* I knew that it was never going to be as simple as just getting a dictionary definition, but with so many conflicting views I needed to learn more about the concepts behind the disagreements. Much of this revolved around the degree to which some forms of autoethnography cross the boundaries between social science and art, and also the related concepts of truth and fiction.

Blurred boundaries, between art, science, truth and fiction

As I read more about autoethnography I found many authors suggesting that autoethnography *blurs* various boundaries (Anderson, 2006; Richardson, 2000). I was repeatedly reading arguments that autoethnography attempts to mix art and science (Muncey, 2010, p. 49) and ‘fractures the boundaries’ between social science and literature (Ellis and Bochner in Hunt, 2009, p. 4). This reminded me of a recent discussion I had with an engineering colleague about the separation of art, philosophy and science, and that fact that before the industrial revolution this separation was not always distinct. We had discussed the obvious examples like Leonardo Da Vinci and Benjamin Franklin, and the fact that our advanced engineering degrees were still Philosophy Doctorates (PhD), harking back to a time before disciplines were separated. Muncey (2010, p. 61) blames the later separation on the empiricist philosophy of John Locke but I speculated that it had as much to do with practical reasons. Historic figures spent a lifetime developing scientific concepts that are now a small part of the curriculum and the engineering body of knowledge is so great that it takes many years of study to learn what is already known, before a student can get to the point of contributing something new.

The more I read, the more I found references to art in autoethnographic literature. Ellis (1999, p. 669) states that autoethnography ‘seeks a fusion between science and literature’ and quotes Gregory Bateson; ‘you are partly blown by the winds of reality and partly an artist creating a composite out of the inner and outer events’. Armstrong (2008, p. 3) suggests that ‘unlike autobiography and life history’, autoethnography has been ‘conceptualised as performance’, and for Denzin performance is a recurring theme (Denzin, 2014). Muncey (2010, p. xiii) states that an autoethnography can be ‘text, performance, poetry, songs or art’ and in my review of published autoethnographies later in this chapter, there are many which take an artistic approach. Another blurred boundary that kept coming up in the literature on autoethnography was the boundary between truth and fiction. According to Mitra (2010), performance/fiction becomes highly interlinked with the research process and I found Burdell and Swadener (1999, p. 25) commenting on trends in educational writing towards redefining 'the role of the academic, in a way that moves beyond making claims of objective reality, or finding “the truth” ’.

When I discussed autoethnography with other PhD students and academics, a recurring question was “how would someone know that you are telling the truth”? My short defensive response was “how do you know your interview subjects are telling the truth”?, but my more measured response was that the historic facts of my life could be easily checked, such as courses taken, academic performance, companies worked for and so on, but many of the details and especially my thoughts and feelings could not. I would also remind my critic that this is no different from the answers given by research subjects in interviews and that ultimately the reader has to decide whether they find the subject's version of events, and the way that the researcher has presented them, to be credible. I often gave the example of a particular UK election where the quantitative exit poll predicted the wrong party would win, and the subsequent analysis speculated that in the privacy of the polling both, people made selfish choices that they might be embarrassed to admit to face to face. Ultimately a lot of this has to rest on the 'narrator's credibility' (Ellis et al., 2010, p. 10) and only the reader can make a judgement on that. Fortunately, in my case, once a reader has read my story they are likely to see that between my position in academia, and my registration as a professional engineer, that I would risk much by fabricating a story, and would have little to gain in comparison.

Ellis *et al* (2010) suggest that of more importance than whether a story is true is whether it is *possible,* and ultimately whether the telling of it is useful. This seemed only partly right to me, and although I could see that a certain amount of artistic licence might be necessary in autoethnography, I also felt strongly that the reader has the right to know the extent to which the story is based on real events. I found a much more in-depth argument about truth and fiction from Denzin (2014, pp. 13–15) culminating in the claim that 'all writing is fictional, made up out of things that could have happened or did happen' and arguing that it is necessary to 'do away with the distinction between fact and fiction'. Denzin (2014, p. 13) states that there are 'true fictions' which 'accord with the facts', and 'false fictions' that distort and misrepresent. He points to Jean Paul Satre's note that if an author believes in the existence of something, then its 'effects are real' (2014, p. 15). I reflect that I have long felt that truth is a portable concept, and a music album title that has stuck in my head is 'This Is My Truth Tell Me Yours' by the Manic Street Preachers (1998). This may have just been a catchy title to help sell records but as Denzin (2014, p. 55) says 'A story told is never the same as a story heard' and each reader of a story hears from an 'equally un-sharable position'. While this places a significant responsibility on a writer, it also reminded me that I have no control over how my story will be read and interpreted.

Reflecting on the link between art, fiction and autoethnography, I thought about the films ‘Platoon’ (Stone, 1987) and ‘All quiet on the western front’ (Milestone, 1930) that influenced me when I was a teenager. I believe these works of fiction contain certain truths about war, but I have never been a soldier in a war so how could I know? They answer is of course that I don’t, but as a viewer I believed that the story *could* be true and seemed *possible* (Ellis et al., 2010), and I knew that they were at least influenced by real experiences and events. These films drew me in to the emotional and personal aspects of war, and both focus on the *self* in the principle characters. This is something that a *factual* history cannot achieve because like most research, academic historians tend towards removing the self and considering only the dry facts. As anyone who studies history will know, this still does not prevent two historians from coming up with entirely different versions.

As I thought about the film ‘All quiet on the western front’ I remembered that my first exposure to this film was through education, in my O Grade history class. According to Burdell and Swadener (1999, p. 25), ‘personal narratives’, using artistic media ‘have long been used in education to evoke perspective taking, compassion, and critique’ and to ‘fracture the artificial closure of discourse’. The films discussed previously are at least based on historic events, but C.S. Lewis ‘The last battle’ (1956) which I read as a child is entirely fantasy and has influenced a loose set of beliefs that I have held about most aspects of human nature being universal. I also think often of one of the final scenes in the book where the dwarves believe that they are still tied up in a dark hut, when they are really in paradise. The sadness of that fictional scene, and the inability of the central character to convince them that it is fine wine, rather than dirty water that they are drinking, still makes me think sympathetically about people and the choices they make about how to view their own lives. Although this is pure fiction in the conventional sense, it seems to use its otherworldly setting to describe certain truths about human nature.

One day as I sat writing the draft of the above paragraphs about how art and science, and truth and fiction are interconnected, I thought again about some of the films and books I have mentioned above. I thought about the impact that these have had on me and my ability to empathise with others. I sat there pondering these connections with my music player set to shuffle and churning out random tracks in the background. In an unnerving coincidence the next track started to play and I heard the soft, steadily increasing volume and intensity of Barber's adagio (Music used in Platoon, Stone, 1987). This immediately took me to an image of William Defoe's *good* sergeant dying in an almost Christ like pose, which takes me to the images of the confused and frightened Vietnamese villagers, and the equally confused and frightened teenage soldiers, and the atrocities that result. This made me think of the other war film that I have already referenced, 'All quiet on the western front' (Milestone, 1930) and how it made me see the first world war from the perspective ordinary teenagers from *the other side*, not much older than I was when I watched it. "This is powerful stuff" I think, all these images, emotions and beliefs from a few minutes of music; "what if the power of this performance art and emotion could be harnessed in research and education, but with the added benefit of linking it to other types of research and the credibility and reliability ensured by the mechanisms in academia"?

What is a memory?

While recognising the value of art and fiction in autoethnography, beyond perhaps using an evocative approach, I was fairly clear that I wanted to keep my autoethnography as close as possible to real events. However, I also had to accept that these would be the events as I remember them, and so I felt that it was important to explore the literature around the subject of memory. As a starting point I considered memory as a 'reconstruction of past events in the present' (Muncey, 2010, p. 103) and that memory (2010, p. 105) and reality is not static or fixed (Yilmaz, 2013). I thought "if this is the case then it means that the memory that I have now of the events of yesterday is a different construction from the memory I have tomorrow of the same events", and this led to a subsequent question "but does being closer in time to an event, make it more valid?" I had to agree with Muncey (2010, p. 91) that it does not, and I considered how the context of a memory changes with time and with subsequent experience. My own autoethnography of learning will recall events that would have seemed insignificant the time, but with retrospect, current knowledge and experience, those same events are seen in the context of far reaching consequences. On the other side of the coin I thought about how memories of recent events can often be coloured by emotion and that retrospect can be as likely to add something as to take it away (Muncey, 2010, p. 91). As Pinnegar and Hamilton (2009, p. 23) put it, 'when we have a memory of a past event or retell a story of it, we bring it forward into the present moment, thus repositioning it on the landscape of our total lived experience'.

I thought about how time, experience and knowledge would colour my memories and I settled that I wanted to write the autoethnography and finish it with in a defined period of time. I thought about my original reason for doing this PhD, that while doing the PG Certificate I was seeing education from the perspective of a student, and I wanted to capture my autoethnography of learning before I started to lose this perspective. I also felt that reading more academic literature on the subject would colour my memories, and this relates directly to a grounded theory based approach to autoethnography (Pace, 2012) that I had started to become aware of, and will discuss in more detail later in this chapter.

As I thought about memory and its fallibility and the fact that it is impossible to report events in exactly the same way that they happened or were felt, (Ellis et al., 2010) I started to become concerned about the legitimacy of this. How could I be sure that my memories were accurate? As I explored the idea of research from memory versus notes taken in the near present I found Sanjek (1990, p. 93) referring to the term ‘headnotes’, and listing a number of anthropologists (Ottenberg, David, Ellen, Holy, Van Maanen, Mead, Sudarkasa) who have written about ‘headnotes’ without using the term explicitly. Wall describes headnotes as the memories, impressions and experiences from the field that would be difficult to effectively record through other means (Wall, 2008, p. 45), and that although ethnography is a product of both headnotes and field notes, ‘it might be that headnotes are more important’ (2008, p. 45). Citing a number of sources, Wall suggests that ‘unexpectedly’, headnotes can be ‘more reliable than field notes or other written records’, and while ‘field notes are written to aid memory’ they can ‘become a threat to it because they can contradict the remembered voices of the people from the field’. Wolf (1992, p. 87) was more cautious and warned that ‘headnotes are too easy to revise to suit some current theory’, but ironically on the same page, Wolf’s admission that field notes change ‘even while in the field’ reminds me that all field notes are headnotes to begin with. I thought “if this is the case then the question about memory then becomes how long after an event must field notes be written, in order for them to be considered valid? If I conduct an ethnography in the field and write field notes before an hour has passed, there has still been sufficient time for my mind to analyse and influence the memory of those events before they are written down”. A memory from 5 minutes before is still a memory and while the details are likely to be clearer, that doesn’t mean that it is any less subjective.

I found another irony in the concern about memory and its legitimacy being pointed out by Wall (2008). If I was to be interviewed by another researcher about my experiences as a learner, field notes were taken and records checked, then this would likely to be considered valid research, but if I write it down myself then questions are raised about legitimacy. Both approaches are based on the same set of memories, but in the former the legitimacy of those memories are ‘somehow transformed by another researcher’ (Wall, 2008).

The self and consciousness

Exploring the concept of memory in the literature also led me into discussions and references to *the self* and ideas about consciousness. I found Burdell and Swadener (1999, p. 25) stating that ‘personal narrative and autobiography are dependent on notions of "self" and "identity," which are both sites of contestation’. I thought “if I am to research my *self*, then I need to think about what this means”, but I quickly found myself delving into a branch of philosophy that could fill an entire thesis, rather than the few paragraphs that I could spare. I was drawn to Cooley’s 1902 theory of the looking glass self (In Muncey, 2010, pp. 11–12) where the self is reflected in the reactions of other people. This reminded me of the familiar ‘To see ourselves as others see us’ in the 1786 poem by Robert Burns (2000, p. 111) and brought me back again in my mind to the connections between art and science already discussed. I thought “here is a *truth* recorded in academic research from 100 years ago, that had already been recorded in art another 100 years before”. The looking glass analogy can also be considered in how a person views themselves and Romanyshyn (In Muncey, 2010, p. 11) says that the reflection in the mirror is not a visual double, but rather a character in a story. There is no ‘empirical I’ facing us in the mirror giving a true account (Denzin, 2014, p. 2) just a metaphorical character made up of a multitude of traces of experience mirrored in our consciousness (Muncey, 2010, p. 11).

If the self is ‘transient and illusive’ (Muncey, 2010, p. 11) and stories about the self are ‘half buried’ in consciousness and ‘overlaid with emotion’ (Romanyshyn in Muncey, 2010, p. 11) then this is potentially problematic for the *truth* of any stories that I tell about myself. However, if this concept is extended and consciousness itself is a metaphorical representation based on our experience, rather than a direct copy of the world (Jaynes, 1990, chap. 2), then the same issues apply to research I may do on others or anything that I interpret through my own consciousness. Ultimately I concluded that there is no ‘window into the inner life of a person’ (Denzin, 2014, p. 2) and whether we try to represent our own lives or the lives of others, a person's thoughts and feelings will always be filtered by the language and symbolism they use to represent it.

Ultimately I felt that these ideas about self were important and interesting but that it was important to remember that my study of self was intended as a way to represent others like me rather than just me. 'Self-study is a stance toward understanding the world' (Pinnegar and Hamilton, 2009, p. v), "is a very grand way of putting it" I thought, but what I'm trying to do here is much smaller and more specific. I'm recognising that my life, like all lives, is 'culturally and historically situated' (Gardner and Lane, 2010, p. 344) and I am trying to place my 'self within a social context' (Burdell and Swadener, 1999, p. 22). As Mills said (1959, in Bullough and Pinnegar, 2001, p. 14) 'human meaning of public issues must be revealed by relating them to personal troubles and to the problems of the individual life'. Bullough and Pinnegar put it nicely; 'The study is always of practice, but at the intersection of self and other' (Bullough and Pinnegar, 2001, p. 15). I can see a different perspective of myself by considering myself as others might see me, or by simply standing back and reflecting, but through empathy I can also think of someone else's world as my own (Muncey, 2010, p. 16).

Having considered concepts related to the boundaries between art and science, and truth and fiction, that autoethnography attempts to traverse, I rediscovered the above quote, coincidentally written by an academic, who also writes fiction:

'Books are not made to be believed, but to be subjected to inquiry. When we consider a book, we mustn't ask ourselves what it says but what it means...' (Eco, 2012, p. 307)

According to Carolyn Ellis (Ellis, 1999, p. 669) autoethnography should 'examine how human experience is endowed with meaning', but when I started to explore this concept, I found that like the concept of self, this was another vast subject that I can only scratch the surface of. I read things like ‘meaning is not static, it cannot be measured, but it is meaningful’ (Muncey, 2010, p. 11) and this seems to link to my previous readings about memory being a reconstruction of past events in the present. It made me think about the connections already discussed between art and science and that if meaning cannot be measured then perhaps that’s why art might be better placed to convey meaning through empathy and emotion. I read in Denzin (2014, p. 44) about Bourdieu’s comparison of life to a subway line, ‘where the stops have no meaning by themselves, only as parts of a larger structure’, and Plath’s statement that ‘autobiographical meanings of the self are fundamentally unstable and realised only through time and temporality’ (2014, p. 45). This seemed to confirm that that the self cannot be separated from the social, and that studying the events of my life through a significant window of time may actually have advantages in exploring the meaning of events and how they contribute to the whole.

Justifying autoethnography as a method

Coming back to autoethnography as a method I considered that much of the literature can seem quite defensive. Autoethnography is often referred to as experimental writing (Holt, 2003; Richards, 2012; Wall, 2008) so the proponents of autoethnography as a method are probably used to having to justify it in a way that might not seem necessary with more established methods. Autoethnography embraces the researcher’s experience and subjectivity instead of hiding from it, so in a way the main criticism of the method is also what its proponents consider to be its greatest strength.

I thought of Ellis’ (1999) story of the breast cancer survivor, now researching breast cancer survivors and assuring Ellis that she would keep her own experience out of the study in order to remain objective. It seemed obvious to Ellis (and to me) that this would be not only impossible, but also undesirable. I thought “what an advantage she has to be able to bring that empathy and insight into her interviews with the other women, but research conventions are teaching her to hide from it". This made me consider my own experience in education and the number of times that I felt distance learning students were being more candid and open with me, because they knew that I had worked in industry, or because I had been a distance learning student myself. Going further back I also remembered the advantage I had over other engineers because I had been a former technician. The technicians knew this, felt they could trust me and in turn, through empathy, I knew how to get the best out of them. In one of the first pages of Tessa Munceys book (2010) I read how she completed her PhD after 25 years of experience as a nurse and nurse educator, and that she could not separate that experience. Coincidentally I realised that I too had almost exactly 25 years of engineering-related and engineering education experience before starting this PhD, and felt that I could contribute much more if I used this experience rather than try to artificially separate myself from the process.

> *'There is a huge gap between the experience of living a normal life at this moment on the planet and the public narratives being offered to give a sense to that life'.* (Berger in Muncey, 2010, p. 3)

Muncey suggests (2010, p. xi) that as research often seeks to generalise in populations, there are some who are excluded because their complexity contributes too many variables and may distract from the study. She later (2010, p. 5) compares this to Potter's (1996, p. 20) assertion that 'some of the most useful analytical phenomena are cases that appear to go against the pattern in some way' and I thought "my education goes against the pattern in engineering, can this help me to represent others who go against the pattern"? Muncey goes on to give examples of people (2010, pp. 4–6) she met in her career, whose personality and stories don't seem to match the official reports, and refers to how her own personal experience of teenage pregnancy was at odds with accounts she read in academic literature.

Muncey gives a number of counter criticisms of 'conventional' research and suggests that the research world wants sanitised narratives (2010, p. 94), and has 'never been very successful in accepting new ideas that don't conform to received wisdom' (2010, p. 102). She talks about the irony of doing research to understand people, then viewing these people as 'devoid of any subjectivity' (2010, p. 6). While I felt that some of these criticisms were valid, I didn't come away from this thinking that all research should be subjective, but rather I thought "if some researchers are objective and distant and others are subjective and involved, surely that offers the opportunity to compare and contrast the findings of both and see the bigger picture from two different standpoints?" I found myself in agreement with Mitra (2010, p. 16) that autoethnography was a 'much needed extension', rather than a 'shift away from conventional social science'.

A recurring criticism of autoethnography is narcissism (Ellis et al., 2010, p. 11), self-indulgence and navel gazing (Hunt, 2009, p. 2), and self-absorption (Pearce, 2010, p. 4), so there was some irony when I later found a book review by Ellis (Ellis, 1998), devoting more than half of the review to a story about herself and her own book. I can see that she was trying to make a point, but I also wondered whether by being such a prolific author of autoethnographic texts, that self-indulgence was unintentionally creeping in and that this might be a real danger to guard against. As Apple (1996, in Burdell and Swadener, 1999) put it; 'such writing can serve the chilling function of simply saying, "but enough about you, let me tell you about me" '; which they suggest just ends up giving those who already have a voice further indulgence in their need for 'self-display'. However, Muncey (2010, p. 93) cites two responses to the charge of self-indulgence. The first from Mykhalovskiy is that far from being a solitary process, autoethnography is a social discourse with a readership and the real test of self-indulgence is if the reader finds anything of value in what is written. The second is from Sparkes who believes that this charge of self-indulgence can be traced back to a 'deep mistrust of the worth of the self' in academic writing.

There is a long list of criticisms levelled against autoethnography (Denzin, 2014, pp. 69–70) and when taken together some of these appear to be contradictory. Autoethnography has been criticised as being too focussed on narrative and not enough on performance (Denzin, 2014, p. 69), and for ‘being too artful and not scientific, or too scientific and not sufficiently artful’ (Ellis et al., 2010, p. 10). While some have criticised it as being ‘intellectually lazy’ (Delamont, 2008), others have argued that anyone who thinks it is ‘easier to write only about oneself’, has ‘not grasped the complexity’ of constructing and positioning it ‘within a framework that will be accepted by the audience it intends to reach (Muncey, 2010, p. XVi), while Wall’s (2008) ‘Easier Said than Done: Writing an Autoethnography’ is fairly self-explanatory. However, some of the harshest criticisms and disagreements come from *within* autoethnography as a broad field, and the following section explores this in more detail.

Analytic versus evocative autoethnography

Probably the most prominent debate that I came across in the literature on autoethnography (Denzin, 2014, pp. 20, 70; Muncey, 2010, pp. 35–36; Pace, 2012) is the debate between evocative or emotional autoethnographic methods often attributed to Carolyn Ellis and collaborators, and an *analytical autoethnography*, originally argued for by Anderson (2006). As these two approaches seemed to represent two ends of the spectrum of what is being called autoethnography, and thus the extremities of the approach that I could take, I felt it was important to give this debate some careful attention. The existence of this debate first came to my attention through Pace (2012) but it struck me while reading that there are as many similarities on both sides as there are differences. In the table below I have taken the main tenets of each approach, as described by Pace (2012) but also with reference to Ellis et al. (2010) and Anderson (Anderson, 2006), and shown key statements about each approach side by side where I felt that these statements are saying something very similar.

Evocative or emotional autoethnography	**Analytical autoethnography**
First-person style, author is the object of research	'Researcher is a complete member in the social world under study' (Anderson, 2006, p. 379)
'Writing positions the reader as an involved participant, rather than as a passive receiver' (Pace, 2012, p. 5).	
Narrative text is evocative, often disclosing hidden details of private life and highlighting emotional experience (Pace, 2012, p. 5).	'The researcher's self is visible within the narrative' (Pace, 2012, p. 5)
'The writing resembles a novel or biography' (Pace, 2012, p. 5) with a narrator	Writing should be 'explicitly or self-consciously analytic or committed to addressing general theoretical issues' (Anderson, 2006, p. 387)
'Unfolding over time rather than as snapshots' (Pace, 2012, p. 5)	
Researcher's life is studied along with the lives of other participants in a reflexive connection (Pace, 2012, p. 5).	'The researcher engages in dialogue with informants beyond the self' (Pace, 2012, p. 5). 'The researcher engages in analytic reflexivity, demonstrating an awareness of the reciprocal influence between themselves, their setting and their informants' (Pace, 2012, p. 5).
'Incorporate the ethnographer's experiences into the ethnographic descriptions and analysis of others (Ellis et al., 2010, p. 6).	'The researcher demonstrates a commitment to theoretical analysis, not just capturing what is going on in an individual life or socio-cultural environment' (Pace, 2012, p. 6).

Table 2.1: Comparison of autoethnographic styles (Anderson, 2006; Ellis et al., 2010; Pace, 2012)

Evocative autoethnography focusses on a narrative, evocative and emotional approach, and while Anderson (2006) does not seem to be critical of that in terms of style, the key difference is his insistence on theoretical analysis and awareness of reflexivity. I agreed with Ellis' response (Pace, 2012) that too much focus on analysis has the potential that the writer may lose a sense of self, and that when 'people tell stories' they naturally use 'analytic techniques to interpret their worlds' (2012, p. 3), but I was also personally very conscious of Anderson's need for reflexivity. I felt that where Anderson (2006) might being going too far was his insistence on the need for empirical data and traditional analysis as this seemed to contradict some of the strengths of autoethnography, and potentially just change it back into conventional research.

I hadn't really taken a side in this debate and found myself agreeing with points from both. I was originally influenced by, and had experienced the power of the evocative approach as a reader (Ellis, 1999; Ellis et al., 2010; Muncey, 2010; Wilson, 2011 etc), and I agreed with one of the main criticisms of Anderson (Ellis and Bochner 2006 in Pace, 2012, p. 4), that he failed to 'show us what this new form of autoethnography would look like'. However, my interpretation was not that Anderson wanted to create a new style of autoethnography, but that stronger analytical and theoretical connections might be made to the finished piece. An important contribution for me was the connection made by Pace (2012), in linking analytic autoethnography to grounded theory, and this was a very close fit to my previously discussed instinctive feeling that I should complete the autoethnographical content first, before surveying the related literature. According to Muncey (2010, p. 78) grounded theory is one of the few approaches where a justification is made for not looking at the literature first.

Mitra (2010) separates *doing* autoethnography and *being* an autoethnographer, with the former connected to method and rigour, and the latter to identity and distance. For Mitra *doing* requires consideration of how characters are presented, and how evocation and emotion are used, but being is linked to vulnerability and reflexivity. In this thesis I wanted to use the evocative style in my writing, but with restraint on the emotion and vulnerability which I felt must be 'essential to the argument' and not a 'decorative flourish' (Mitra, 2010, p. 14).

Published autoethnographies

Ironically, literature discussing and debating autoethnography as a method seemed to me to be more prevalent than actual autoethnographies themselves. I felt that I needed to read examples of autoethnographies in practice, both to get a sense of different approaches as well as what could be achieved through autoethnography. What follows is essentially a mini literature review of autoethnographies in various fields.

According to Bullough and Pinnegar (2001) most self-studies in education are narratives about becoming a teacher educator, and learning how to teach students. Conversely my autoethnography was going to be told from the student perspective, perhaps *learning to learn* (or in some cases not learning), and the intention was to later position this within the context of academic literature about learning, which could arguably be the teacher's perspective on learning. One of the first things I noticed as I started to explore the literature was that there was very little to be found about learning, and the one autoethnography that I found that was specifically about lifelong learning (Rajbhandari, 2011), while interesting and relevant, seemed to be an online submission without peer review or publication. It seemed to me that the majority of published autoethnography is focussed on either traumatic experiences (Denzin, 2014, pp. 4–5; Ellis, 1999; Hunt, 2009; Muncey, 2010, pp. 4–6; Richards, 2012) or are related to the artistic (Kruse, 2013; Muncey, 2010, pp. 133–144; Prendergast, 2003). Within the latter group I did find an autoethnography about an online learning experience (Kruse, 2013), and although this was in a music technology education journal there were some parallels to draw from this, in particular the technology aspect. It was also common to find autoethnographies that had some relation to nursing/nurse education (Gardner and Lane, 2010; Muncey, 2010) and healthcare (Freshwater et al., 2012). As I could find very little that was directly related to learning I instead focussed this section on autoethnographies in general and how they might relate to the development of my own method.

A good place to start is ‘Heartful Autoethnography’ by Carolyn Ellis (Ellis, 1999) because it has been the primary inspiration for at least one published autoethnographer (Muncey, 2010, p. 35) and is cited in much of the literature I read on the subject. I have mentioned this paper in a previous section but it is a powerful example of what autoethnography can express. The story contained within gave me a real insight into the emotions and realities in the life of someone that I could not otherwise have any hope of relating to, a woman recovering from breast cancer. Simultaneously I empathised with the same woman and the conflicts she felt between everything that she had been taught about objectivity and Ellis encouraging her to include her own experience in the study. This paper gave me some insight into ways in which autoethnography could be incorporated into research, and in particular how it could approach issues that might not be uncovered using traditional methods. I also had a connection with the characters in this story and a greater understanding of the issues than I had before. The paper was a good example what Ellis (1999) and others (Ellis et al., 2010; Pearce, 2010) mean when they say that autoethnography seeks ‘verisimilitude’; I don’t know that this story is true, and I am sure some of the details must have been changed in order to make the story flow, but there is *a truth* in this story that gave me more insight into an issue than I could have got from statistics or theoretical analysis. I believed that the story was possible and that the issues were real, reading this story *changed me a little*.

Another story that uses an evocative, emotional story, but this time in relation to teaching, is Kristin Wilsons (2011) ‘Opening Pandora's Box: An Autoethnographic Study of Teaching’. This was a collection of stories about a teacher’s experience with underprivileged adults, and the dilemmas of applying academic standards to people whose lives are so bad already, that to fail them could seem unthinkable. My greatest criticism of this paper was perhaps that it was overly evocative, interspersed with a mythological story about the god Apollo and Louis XIV, the sun king, in what was presumably an attempt to add drama. For me these stories about adult learners were evocative enough in their own right and I found the mythological story a distraction. When I think about this paper I only vaguely remember Apollo and the Sun King, but I *do* think about this teacher's realisation that her trying to save the 'black kid' (2011, p. 452) from the Ghetto was more about her than him, and her struggles with race/gender/class. One particular story in this paper, about how a woman learned to write Essay English by writing a series of stories about the tragic death of her husband, was particularly evocative. As I read I thought "this person's story would have been reduced to a number in a quantitative study". The power of the teacher-student relationship and emotional drivers for learning were made accessible to me as the reader or outsider, and I kept thinking about how difficult it would be to convey this pain and emotion with conventional research methods, where the researcher is detached from the subject. This paper had a lasting impact on me, and I again saw verisimilitude as the key indicator of quality.

Jewkes' (2012) argument for autoethnography in prison and criminology research provided an example of an environment where we rarely see an insider view, other than sensationalised and fictionalised accounts. Jewkes suggests that conducting ethnographic field work led to him being treated as 'one of us', or 'one of the lads', partly because he was not 'one of them' (2012, p. 67) (people who have authoritative power such as prison guards), and this led to an inevitable autoethnographic element. Jewkes suggests that autoethnography is not restricted to someone who is a natural 'insider', but could be used by someone who has gained the perspective of an insider through 'close acquaintance' (2012, p. 67). This concerned me, as I would argue that there is a great deal of difference between a researcher presenting their own thoughts and feelings about being in a certain environment, and presuming to understand the thoughts and feelings of those who can't escape it. However, I was persuaded by Jewkes' argument that prison research, which is mostly government-funded, has an almost political imperative to remain quantitative, and detached from the human, emotional element (2012, p. 65), perhaps to avoid the complexity of reconciling concepts of judgement, justice and punishment, with feelings of compassion for the perpetrators of criminal acts. This reminded me of

Muncey's (2010) discussion of the nurse Beverley Allitt who murdered patients in her care, and her argument that between the sanitised clinical narratives and the media portrayal as a demonic figure, no one seemed to think to ask Beverley why she did it. Both Muncey and Jewkes appear to be suggesting that autoethnography has the potential to fill a gap in the literature, by representing, without undue prejudice, the perspective of the individual concerned.

In 'they pass themselves by without wondering' Hunt (2009) argues for an autoethnographic element in EdD programmes, while also covering some of the issues in getting autoethnographic work published. She also discusses advice she was given, about how 'in career terms' autoethnography is 'not a good way to go' (2009, p. 2). She positions the paper as written 'in the shadow of' (2009, p. 1) the 2008 Research Assessment Exercise (RAE) and includes an excerpt from an emotional autoethnographic account (Sparkes in Hunt, 2009) of an experienced colleague who despite long service, excellent student feedback, innovative teaching and a strong publication record, is about to lose his job. In an echo of Jewkes' above criticism of criminology research, Hunt suggests that it is 'in the interests of the audit culture to exclude a methodology of the heart' (2009, p. 6).

I read the story of diagnosis, dialysis, transplantation and a life afterwards as a survivor, from the patients point of view (Richards, 2012). This was also an example of an entire PhD thesis using autoethnography as *the* methodology, as opposed to a method within a broader methodology. Autoethnography like this can potentially sit dangerously close to what Muncey calls the paperback 'misery memoir' (2010, p. 48). Muncey admits that the line between the two can be very thin, but at the same time distances autoethnography from this genre of literature which appeals to 'morbid fascination' and 'voyeurism' (2010, p. 48). There is more to Richard's thesis than this but the difference is not always easily definable, and it's not easy to determine from the outset what the purpose or conclusions of this thesis are, beyond the fact that it contains a very painful and emotional story. Probably the most relevant part of this thesis for me was the repeated positioning of this autoethnography as coming from the perspective of an insider, as opposed to an ethnographer who is an outsider observing a group from within. There is perhaps a difference between this autoethnographer, who I would argue like me, has a personal, insider story to explore, and the *professional* autoethnographers like Ellis etc, who are using the method to explore the lives of others. Richards discusses how some researchers talk about watching from the inside, but argues that they are not on the inside because ‘they could leave and I cannot’ (2012, p. 50), and argues throughout for insider views in research. Another thing that comes through is that for any story, there is always another story or stories, for her these included how her experience affected her family as well as the tragic stories of the donor and the donor’s family.

I also read an ‘Autoethnography of paint talks’ (Mereness, 2008) where the author discusses paint talks at her local church, her vision of a fusion between, and some of the conflicts she has experienced between art and religion. As well as a view into the world of someone I might struggle to understand, this thesis also made me think about things that the author probably hadn’t intended. It’s not common in academic research to hear a religious voice in the first person and the author repeatedly refers to her church as ‘fundamentalist’ without seeing any negative connotation in that word. My perception of that word brought me into this paper expecting to read a negative exposé and was surprised to find the author using it to describe an institution she sees in mostly a positive light. This was a Master’s thesis, not a peer reviewed publication, and this made me ponder whether a similar paper would be accepted by a reputable academic journal. I wondered whether, out of an understandable unwillingness to provide a platform for fundamentalist groups, academia might miss an opportunity to understand a social group from the insider perspective. If autoethnography is used only to present the perspective of experienced researchers, rather than capture the perspective of outsiders to academia, then it could just reinforce established views. I questioned whether its greater potential might be to capture the voice of those who currently do not have one, even if the views that voice expresses might be uncomfortable to hear.

I found two autoethnographic PhD thesis by mathematics teachers (Belbase, 2006; Stinson, Antony B., 2009) and a related paper (Belbase et al., 2013). Belbase discusses his teaching ‘metamorphosis’ from a ‘transmitter of knowledge’ (2013, p. 134) to and his ‘pedagogical metamorphosis’ (2006, p. 1) towards constructivist methods. I could relate his pedagogical journey to my own relatively recent experience of exposure to pedagogical concepts, as well as my student experience of traditional mathematics teaching, but I also learned another lesson from the Belbase paper. I almost dismissed this paper because of very poor grammar and English, before realising that this was clearly written by someone to whom English was not a first language. On further reading there were many insightful points, and this made me think about how intelligence is judged by the ways in which people communicate, and how everything from regional accents to the ability to write or speak according to certain conventions can have an enormous bearing on whether an individual’s voice or experience is heard. Remaining within the field of education I also reviewed an English professor’s experience as an adult online learner (Henning, 2012) and an autoethnography exploring the tutor/student relationship (Gardner and Lane, 2010).

Some autoethnographies were of interest, not because of their relevance but because they demonstrated a powerful ability to communicate experiences that might be impossible for me to otherwise understand. Three obvious examples came from stories written from a female perspective. The first was an exploration of sexism and ageism (Klinker and Todd, 2007), with two female academics discussing the commonalities in their mid-life decisions to enter academia in opposition to what they perceived as cultural expectations of women of their age. In ‘The crises and freedoms of researching your own life’ I found the combination of a daughter’s story about the loss of her mother at a young age and the resurgence of grief brought about by research into similar individuals (Pearce, 2010). A particularly well written and accessible story gave an account of the experience of a women in the male dominated sport of Golf (Douglas and Carless, 2008). It paints a picture of the locker room antics of older men from the perspective of a young female sports professional, but does so in an understated style. It's hard to describe what I mean by this but there were no ruined lives, no sudden realisation of their behaviour from the antagonists, it was just *another day at the office* for a female professional golfer. This appears to be a fictional story, but it has been based on one of the author's experiences and observations as a female professional golfer from the nineteen eighties on. With reference back to the earlier discussion on truth and fiction, and Denzin's arguments about *true fictions* and *false fictions*, this fictional account presented what I believed to be a true fiction and allows the reader to step for a moment into the shoes of the person affected.

Measuring quality

> *'There are three rules to writing the novel. Unfortunately, no one knows what they are'* (Maugham in Bullough and Pinnegar, 2001, p. 16).

The above quip, is a reminder of the relationship between autoethnography and art, and the fact that it is very difficult to define what makes good art, what makes a good story. Bullough and Pinnegar suggest that the same difficulty applies to assessing quality in autobiographical forms of research, what makes it 'worth reading', and admit that 'even as we pose this question we know our answer will not be fully satisfactory' (2001, p. 16). Potently aware that others would need to make an assessment of the quality of my autoethnography, quotes like this left me one part reassured that I was not the only one who was confused, and one part concerned that there were no defined and accepted guidelines to follow.

Common sense had already informed me that studying aspects of my own life would leave me wide open to criticism and while it was already clear that autoethnography in general was viewed as controversial, I had also read that personal narratives were often ‘the most controversial forms of autoethnography for traditional social scientists’ (Ellis et al., 2010, p. 7). It did not help with my peace of mind that even in literature that was pro-autoethnography the authors admitted it had been classified as an ‘outlaw genre’ (Burdell and Swadener, 1999, p. 25) and that because of its ‘problematic nature’ it is at the ‘boundaries of academic research’ (Holt, 2003, p. 18). Embarking on a part time PhD that would take up thousands of hours of my life was quite daunting, knowing that reviewers might feel that my approach was controversial or did not meet traditional standards of quality. It was very clear at this point that, while through my experience of engineering and the natural sciences I had a good understanding of how quality is measured in quantitative research, I needed to first explore how this translated to qualitative research, and then to autoethnography.

I attended a class on ‘Ensuring Quality in Qualitative Research’, which was partly based on an excerpt from the book ‘Managing Quality in Qualitative Research’ (Flick, 2008). This led me to explore the difficulty of translating the traditional quantitative measures of quality; reliability, validity and objectivity, to qualitative research and how these are revised by Flick (2008, pp. 19–21) and Yilmaz (2013) as Trustworthiness, Credibility, Conformability, Dependability and Transferability/Usefulness (both citing the influence of Lincoln and Guba, 1985). Although the book by Flick was a useful starting point, a thorough search of the book revealed no mention of autoethnography or self study, so it was clear that I would also have to consult autoethnography specific literature in parallel.

I started with objectivity because it seemed to be the most difficult to translate and according to Flick (2008, p. 15) there have been ‘hardly any attempts to apply this criterion to qualitative research’. Objectivity is defined as consistency of meaning (Flick, 2008, p. 15) or neutrality (Yilmaz, 2013) but as the antonym is subjectivity and proponents of autoethnography freely admit that the autoethnographic process is naturally subjective (Ellis et al., 2010) then it’s fairly clear that this term needs to be redefined if there is to be any autoethnography at all in academic research. Flick (2008, p. 15) wants two or more independent researchers to analyse the same data and come to the same conclusion. Although this does not fit directly, the concept can be altered to consider triangulation (Flick, 2008, p. 37; Yilmaz, 2013) through considering other perspectives, including the perspectives from academic literature. As most self-study research in education will obviously be from the perspective of the educator (Bullough and Pinnegar, 2001), and I am approaching this from the perspective of the learner, it would seem that there is little being risked by my potential lack of objectivity in any case, particularly as part of the point of autoethnography is to 'critically challenge taken for granted ways of knowing, ways of thinking, and ways of making sense of the world', and this brings 'the subjective and the objective together' (Armstrong, 2008, p. 1). In a sense it is this subjective, but alternative perspective that is a tool through traditional assumptions and dominant discourses can be challenged. Through connections to the literature and other perspectives I hoped in some way to offer 'fresh perspectives on established truths' (Bullough and Pinnegar, 2001, p. 18), and an 'inside look at the participants thinking and feeling' (2001, p. 19).

According to Denzin and Lincoln (1998, in Yilmaz, 2013) *reliability* in the traditional sense is 'pointless' but even some other terms Yilmaz uses such as consistency and dependability don't seem to be a natural fit to a subjective study of an individual. An alternative definition of reliability given by Yilmaz (2013) is the extent to which the study provides an understanding of the situation. Validity is related to the accuracy of the data and Yilmaz (2013) states that some researchers define validity as the extent to which the account represents the participants' views, but also argues that the concept of validity can be both irrelevant and misleading. Yilmaz separates validity into internal validity which can be considered in terms of truth value or credibility, and external validity which can be related to applicability, generalizability and transferability.

External validity is related to generalisability (Yilmaz, 2013) and Ellis (in Pace, 2012, p. 3) says that it is possible to generalise from autoethnography but not in the conventional way. Generalisability is instead tested by readers ‘as they determine if the story speaks to them about their experience or about the lives of others they know’, and according to Ellis ‘the autoethnographer does not privilege traditional analysis and generalisation’ (in Pace, 2012, p. 3). What Ellis seemed to be describing is what Yilmaz (2013) calls transferability, or what elsewhere Ellis (1999) refers to as usefulness. Transferability/usefulness is much easier to relate to in autoethnography, and to my mind this is one of the main goals of this approach. The initial reason for exploring autoethnography was that as someone with a very different background to the majority of my academic colleagues, I felt that I could perhaps help them to understand students with similar backgrounds or motivations to me. One perspective from the literature (Ellis et al., 2010, p. 10) is that autoethnography can be judged on whether ‘it helps readers communicate with others different from themselves’, improves the lives of other participants and simply whether it is a means to a useful end.

It seemed to me that there was a very cyclic or overlapping relationship between validity, reliability and objectivity when applied to qualitative research and in particular to autoethnography. According to Ellis *et al* (2010) reliability is related to the narrator’s credibility, which according to Yilmaz (2013) is a measure of validity, and if objectivity is a useful concept at all in autoethnography then it’s clearly also linked to the narrator’s credibility. While I found many of the concepts above to be useful, they were clearly not complete in terms of criteria with which to evaluate autoethnography, and I found myself drawn to Kelly’s (in Muncey, 2010, p. 19) statement that ‘good research is not its validity or its reliability; it is its viability, its fertility in the business of living’.

I clearly needed to consult discussions on quality that related specifically to autoethnography and while Denzin (2014, p. 70) was in agreement with Flick and Yilmaz that like other qualitative work autoethnography cannot be judged by the traditional positivist criteria, Holt (2003, p. 19) went further stating that autoethnography does not fit well with even the ‘traditional criteria used to judge qualitative enquiries’. According to Bullough and Pinnegar ‘self-study researchers face unique methodological challenges’ and that the acknowledgement of ‘self may sometimes cause difficulty in evaluating quality’, but that this does not bring with it an ‘excuse from rigour’ (2001, p. 15). On the other hand Sparkes (in Holt, 2003, p. 26) hopes that reviewers will resist the ‘temptation to seek universal, foundational criteria’ and Holt goes on to suggest that these criteria should not be established in advance of reading, but rather selected and based on the nature of the piece being evaluated. Muncey (2010, p. 91) suggests that she has ‘come to think of the appropriate criteria for evaluation as akin to the gut reaction’. Part of me worries that this could be seen as “make this up as we go along”, but while these statements are not particularly helpful, they do perhaps highlight the fact that autoethnography is an emerging method, and if as discussed earlier in this chapter, there is little agreement on what autoethnography is, there is even less likely to be agreement on what constitutes quality in autoethnography.

Holt (2003) uses an account of the peer review process to explore perceptions of quality in autoethnographic research, and her exasperation that despite following the advice of the autoethnographic methodology experts, the reviewers were intent on using traditional criteria. Holt suggests that these were really criticisms of autoethnography as a whole rather than the paper, and concludes there is a ‘significant degree of academic suspicion’ about autoethnography while also expressing sympathy for the reviewers due to the ‘lack of guidance’ on how to evaluate an autoethnographic work (2003, p. 25). However, one of the main controversies highlighted in this paper is the ‘self as a source of data’ (2003, p. 24), and in particular where this is the ‘exclusive use of the self’ (2003, p. 25), but as I will discuss in the next section I don’t intend to restrict my study to only my perspective.

Ellis *et al* (2010, p. 10) states that 'for autoethnographers, validity means that a work seeks verisimilitude' giving the reader an experience that is 'lifelike, believable, and possible' enabling them to 'enter the subjective world of the teller - to see the world from her or his point of view'. Bullough & Pinnegar extend this by stating that self-studies should 'ring true', 'enable connection' and 'promote insight and interpretation' (2001, p. 16). For Muncey the equivalent term is 'resonance', or whether the story, using the metaphor of a song, resonates with the reader (2010, p. 91). As the self is being questioned, and the argument is verisimilitude rather than a conventional notion of factuality, I found myself asking "would it matter whether my story is true"? I suspect the only real answer to this is that it would matter to me, because unlike many other autoethnographic texts it's not really my intention to create a story that primarily conveys emotion, my intention is to explore the realities of learning from a different perspective. So while this discussion is important to autoethnography in general, the debate around fictionalised forms of autoethnography is in my case, largely redundant.

As both researcher and subject the 'narrator's credibility' is critical (Ellis et al., 2010, p. 10) and the 'author must take an honest stand' (2001, p. 16), but while I know that I am taking an honest stand, it is also clearly important that the reader *believes* that I am. I hoped that this would be achieved naturally because my story will take a *warts and all* approach, discussing my failings as well as my successes, and showing that my approach to learning has more often been motivated by self-interest, than any idealistic goals of learning. To some extent I would expect my current position in an academic institution and as an engineering professional would lend some weight to my credibility, and related to this the fact that I would risk much by fabricating a story and trying to publish it as research. However, ultimately, the question of my credibility can only be answered by the reader, and I accept that my story may seem credible to some, and lacking in credibility to others, but as the main points of my story can be verified, I would suspect that rather than the truth of my story, it's really the causes and impact of events, rather than the events themselves, that will be questioned.

Despite the fact that the narrator's credibility is likely to be important to many readers, it might be more important that the story rings true, as for many it will be the story itself, not the author that is important. However, I would argue that for autoethnography to be considered as research, its usefulness is the most important indicator of quality. Without criticising other forms of autoethnography, I would want my autoethnography to lead to something, to have a purpose beyond an evocative story that brings the reader into my experience. According to Bullough and Pinnegar, in education there is an 'obligation to seek to improve the learning situation not only for the self but for the other' (2001, p. 17) and this remains a very important part of why I chose to do this in the first place. Measures of usefulness include whether 'it helps readers communicate with others different from themselves', improves the lives of other participants and simply whether it is a means to a useful end (Ellis et al., 2010, p. 10). The question an autoethnographer must ask is 'how useful is the story?' or 'to what uses might the story be put?' (Ellis et al., 2010, p. 10).

In a paper about 'accommodating an autoethnographic PhD' in a 'traditional business school', Doloriert and Sambrook (2011) suggest that quality is demonstrated either through the process of *doing* autoethnography, or by the finished article itself dependent on different autoethnographic styles. I related this to my discussion in an earlier section on analytic versus evocative autoethnography; where the analytic style might focus more on the process, and the evocative style on the impact of the product on the reader. For the approach in this thesis I believed that quality should be demonstrated in both *doing* where I would need to apply honesty, reflexivity, and fairness in the representation of other perspectives and characters in the story, and in the final product which is where I would need to demonstrate transferability, usefulness and the credibility of my story to the reader.

Multiple perspectives

A story told is never the same as a story heard (Denzin, 2014, p. 55)

'No ethnographic work - not even autoethnography - is a warrant to generalize from an "N of one." ' (Anderson, 2006, p. 386)

One of the main things that I took from my investigation on quality was the concept that quality in autoethnography is defined by the reader and how it impacted others. I also noted that the main criticism of the method was the use of self as the main or only data source. This criticism seemed in part to miss the point of autoethnography which is to connect the personal to the cultural, and also potentially categorises all autoethnography as the same. I thought of Mitra's (2010, p. 11) statements that although autoethnography 'necessarily privileges' the narrator, it also creates a 'co-performance text' through dialogue between 'researcher, researched and audience' (Denzin in Mitra, 2010, p. 11) and Mooney's (in Bullough and Pinnegar, 2001, p. 15) assertion that self-study focusses 'on the space between self and the practice engaged in'. I also felt that self as the data source was a less valid criticism of the analytic and grounded theory based autoethnographic styles that I was leaning towards (Anderson, 2006; Pace, 2012) and have discussed previously, that promote the connection of autoethnography to literature and analysis.

Using the self as the main data source, as well as the concepts of credibility, generalizability, transferability discussed in the previous sections were at the forefront of my mind when I was exposed to a study of multiple perspectives on a single event (Santoro, 2014). This described an event experienced by 3 pre-service teachers on an international study trip. The differing and contradictory versions of the event showed how different people who experience the same event view this in a different way and reinforced the idea that while my own experience is valid, its most useful when compared and contrasted against others. This made me think of the different perspectives I have held and would be exploring in my autoethnography, such student, teacher, technician, engineer etc, but also made me think about the different perspectives of those related to my story.

I considered that if I am going to write an autoethnography that spans most of my life, that I would have to take into account the different perspectives and even personalities that I have had at different times in my life, and be honest about both the positive and negative aspects of them. I would also need to consider other perspectives and compare and contrast them to my own. I decided that the best way to do this was to incorporate other people's stories, or other people's responses to my story, into the thesis and consider how these different perspectives relate to each other. Another source of different perspectives is the academic literature and it was my intention to review the literature and how what is known in the literature about learning relates to real life as I have experienced it.

Ethics

> *'Language can never contain a whole person, so every act of writing a person's life is inevitably a violation'* (Josselson in Ellis, 2007, p. 6)

As I approached the end of writing this chapter I was also in parallel drafting my autoethnography of learning in the next chapter, and had begun to think about ethical approval. I had been considering interviews to gain the alternative perspectives discussed previously and I would clearly need ethical approval for these, but this was a fairly standard process of adult informed consent. What I hadn't considered was how ethics related to the autoethnography itself. In telling a life story there is also the issue of people who feature in the story, and even those who do not and are implicated by relation such as family, colleagues and institutions. I thought "do I need to gain informed consent of everyone who is connected to the story? Is that even possible?" It would clearly be impractical to gain the informed consent of everyone who might be connected to a thirty year story of learning and I turned again to the literature to explore these dilemmas.

Ellis states that as well as procedural ethics (review boards etc) and ethics in practice (things that come up in the field), that autoethnographers need to also pay close attention to 'relational ethics' which she says is closely related to an 'ethics of care' (Ellis, 2007, p. 4). Ellis suggests that practical and relationship issues are not normally the focus of review boards which are 'grounded on the premise that research is being done on strangers with whom we have no prior relationships' (2007, p. 5). Ellis (2007) discusses her own ethical conflicts and failures in relation to ethnographic research in traditional fishing communities. She notes how as a young researcher she became friends with people in the local community and made the mistake of considering her research and subsequent book to be her story about them, rather than *their story*. This paper goes into the complexities and conflicts between being truthful with the reader, and being true to the story and the protection of the people who are being studied.

As discussed above, practical and relational ethics are primarily my responsibility, and a key piece of advice that Ellis (2007, p. 25) gives is to 'assume everyone in your story will read it'. I expanded this advice into some questions I could ask myself about my autoethnographic stories:

> Who in this story could realistically be identified?
>
> If they are identifiable, are they likely to read the thesis or connect it to themselves?
>
> Will they see themselves in a positive or negative light?
>
> Should I give them the opportunity to offer their own perspective?

When I considered how these questions relate to my story, I reflected that the only characters who might be viewed in a negative light in my autoethnography, are perhaps teachers from my years of compulsory schooling. It would be very difficult and highly unlikely that these individuals could be linked to me, and even if they were I am very clear that these were my perceptions as a child. In general, any implied criticism in my autoethnography is directed at systems and social attitudes, rather than individuals. However, my parents are a particular exception to this as, barring publication under pseudonym it would be impossible for me to protect their identities, and even publishing under a pseudonym they would still recognise themselves in the thesis. While I don't think anything in my autoethnography is likely to reflect badly on them, I cannot presume that they will feel the same, so I felt it was important to allow them to read the autoethnography, and to offer them the chance to participate and respond if they wished.

Tolich (2010) criticises a number of seminal autoethnographic texts and questions whether informed consent was truly possible for the terminally ill relations in these stories. Verging on contradiction, he also criticises Ellis, in choosing to leave out certain parts of the story of her terminally ill mother. The point appears to be that Ellis should not be picking and choosing which parts she is comfortable with sharing, but I would argue that even an autoethnographic researcher is also a vulnerable individual in such a situation and has a right to protect themselves as well as having a responsibility to others. I would suggest that Tolich may be making the same mistake that was once made in trying to apply traditional quantitative quality criterion to qualitative work, by trying to apply standard ethical guidelines to autoethnography. As with the former it doesn't always directly translate, but that doesn't detract from the fact that he also makes some very well considered, valid, and sometimes courageous points by suggesting that published academic work, by respected autoethnographers, does not meet standard ethical guidelines. A very reasonable point that Tolich makes is that while autoethnography and autobiography are similar, the latter is not research and so is not bound by ethical concerns. However, the analogy made is that while Mandella's character assassination of his guards is justified in biography, it is not in research. I am not completely convinced by this argument, as autoethnography is clearly an exploration of experiences as *perceived* by the writer, and does not, or should not, presume to represent how others perceived the same events.

Wall (2008) discusses the ethical conundrums of writing an autoethnography about adoption. While the justification of autoethnography is based on the fact that the individual does not exist apart from their social context, it's this very connection that makes it impossible to speak for yourself, without speaking for others. Although she has the consent of her son, she worries about whether this is 'truly informed' (Wall, 2008, p. 50), while at the same time feeling that using a pseudonym creates an inauthentic illusion of protection (Wall in Muncey, 2010, p. 106; Wall, 2008). Muncey also discusses how anonymity can create a 'false illusion of protection' (2010, p. 106) and describes two occasions when she was anonymised against her will in published texts. Muncey felt silenced and rails against publishers and ethics committees taking it upon themselves 'to create a protection that isn't always warranted' or desired by the individual they are trying to protect (2010, p. 89 and 106).

In interesting question that arose in my exploration of ethics, is whether an autoethnographer *owns a story,* just because they tell it (Chang, 2016; Tolich, 2010). In the previously discussed criticisms of Ellis and Richardson (in Tolich, 2010), the terminally ill relations were central characters, and I would agree that the issue of informed consent is critical, and may not have been achieved. In contrast, my autoethnography is about me, I am always the central character and I would be much more justified in arguing that this is "my story". There is clearly a tradeoff in autoethnography between the requirement for 'fairness' and that the various perspectives of participants is given equal consideration (Lincoln and Guba in Yilmaz, 2013, p. 320), with the reality that autoethnography '*necessarily* privileges' the narrator (Denzin in Mitra, 2010, p. 11).

This brought me to a final aspect of ethics for autoethnography that I have touched on briefly, but that is also not a typical consideration in ethics, that of the author's vulnerability. Tolich (2010) describes a situation where a genuinely thoughtful reviewer cautions an author about publishing an autoethnography, because of the possible damage to her career by going public about her depression. Muncey (2010, p. 106) also advises vulnerable researchers to ensure that they have adequate support mechanisms. While these issues don't seem directly relevant to me, it is possible that I could cause damage to my career or professional reputation by revealing things about myself, or even by engaging with a controversial qualitative method such as autoethnography while working in the very quantitative, objective academic discipline of engineering. However, coming back to the proposition that "it is my story to tell", it's also reasonable to assert that it is my decision regarding whether or not to tell it. I think that the important thing is that I have reflected on the potential impact to me, and that I feel secure enough personally and professionally to withstand any potential negative impact.

Settling on *my* autoethnographic methodology

In trying to understand, and to justify autoethnography I have explored the boundaries between art and science, and truth and fiction. I have touched briefly on the concepts of self, consciousness, memory and meaning. An exploration of the literature on autoethnography has shown that there is much disagreement about the method, even from those who support it. As I have no prior investment in any particular style, my concern was with developing a methodology to fit the situation at hand, and in this section I have summarised how I had planned to conduct this PhD based on the previous discussion in this chapter.

For the purposes of this particular study I didn't feel that there was a need to go overboard with the evocative or emotional nature of the writing. There are no stories here of terminal illnesses so I don't feel a need to create a drama where there is none, and the very artistic style of writing exhibited by for example Wilson (2011), would as discussed earlier detract, rather than add to the story. However, I did feel that some of the aspects of my autoethnography could benefit from introducing a more evocative approach in the final draft to try to bring the reader further into my story. I felt that the emotive approach was useful in creating an accessible story that others, from outside of the academic word could read, and it also helped me to immerse myself in my memories.

While I understand the feeling that fictionalised or embellished accounts can be useful in autoethnographic research, I felt that from an ethical point of view it's important to distinguish between the two, and make it obvious to the reader when an account is deliberately fictionalised, or hypothetical, vague, embellished, biased etc. I also needed to be clear that what is presented in the next chapter is *my truth*. It's based on my memories of my life in most cases constructed years after the events, and coloured by the experiences I have had after the events took place, and if I am describing a hypothetical or less well remembered situation I planned to make this clear to the reader. The amount of time that has passed since some of these experiences might appear problematic, but on the other hand it's only by virtue of the experiences I have had since that I can see the significance of past events, and if it wasn't for the perspective gained by later experience I wouldn't have been motivated to complete this PhD in the first place.

When writing the first draft of my *autoethnography of learning* I had intended it to be a relatively small part of the thesis. As it grew in size and I started to worry that it was becoming too big, I realised I had to make some difficult decisions about what to include. On reading the first draft one of my supervisors commented that there was very little mention of my family and the part they played in my learning and decisions, and there were certainly other important factors that had been left out due to time. Reading the literature had also made me think of my-*self* as researcher and whether I was presenting a true account of my-*self* as subject. I considered the impact of my exposure to religion as a teenager, and a later period of my life where I was involved in a network marketing scheme. Both of these were significant in terms of their impact on learning, but I had not mentioned them in my first draft. I questioned whether I had subconsciously avoided these aspects and wondered if I should explore whether there were other things that I might have left out for reasons other than time. Ultimately there would be limitations on how much I could fit in to a story covering this length of time, and I needed to remain focused on the experience of learning.

From the literature I can see that judging quality in autoethnography is still an uncertain process, but that the general consensus is that the quality of autoethnography is judged by its impact on the reader and whether it is useful. I was still left struggling a little with this concept: “how can ***I*** tell if it has impact on the reader?” The fact that this is a PhD means that there is a natural readership and feedback through the supervisory and review process and it was only through positive feedback from my supervisors about my writing style that I had reached the point of writing the first full draft of the autobiographical text in the first place. After reading this draft one of my supervisors had commented that she thought that I “reacted to emotion” in relation to learning. This stuck in my head as I didn’t think this was the case at all, but it reminded me as discussed previously in this chapter, that the story I am telling may not be the same story that is heard by the reader. I decided that to address the issues already discussed around credibility, transferability and self as data, that I would actively seek these alternative perspectives, and that I could do this by interviewing people who could relate in some way to my story.

From the point where I first decided to take an autoethnographic approach I had a conviction that I had to write and finalise my story before moving on to the literature review and analysis. It was important to me that, as this is the data that the thesis is built on it should stand on its own, as recorded at a particular point in time, and not be edited to suit theories that I may develop in my later discussion with others or educational literature. I found it difficult to justify this before returning in greater depth to the literature on autoethnography but I perceived support for this position from four different sources.

1. Muncey’s description of autoethnography as an adventure (2010, p. 63) without a clear destination. The analogy she gave was in setting

out on a journey with a rough idea of the destination but not 'hidebound by expectations' on where I would end up.

2. The concept discussed previously of how memory is not static, but rather something that is constructed in the present. I can't write the entire story in a day, but I felt that it was important to contain this within a point in time, and for me that time is early 2014. In 2014 a number of things were in the process of changing for me and the more I became involved in teaching and management the further I knew the perspective of *me the learner* would drift. As a part-time PhD it won't be finished until at the very earliest 2017, so grounding my story in my 2014 perspective may also give me the opportunity to consider if and how my perspective has changed in the following years.
3. The suggestion from Pace (2012, p. 8), in part quoting Ellis, that by focussing on telling the story first, then later framing it with an analysis of the literature, the evocation and emotion of the narrative can be preserved. This way the story is not affected by analysis, which is instead focussed on 'accepted theoretical notions' within the literature and challenging the literature from the perspective of experience.
4. It has been said that it's hard to finish an autoethnography (Wall, 2008). I have found myself that this process is iterative and that as I remember things and start to write, the process of writing causes me to remember more, or to think of things that are related, and this will go on indefinitely unless at some point I draw a line under it.

Although I wanted to *write* in something akin to the evocative style of Ellis et al (2010), I was much more heavily influenced by Anderson (2006) and Pace (2012) in terms of how the autoethnography should fit into the PhD and the research process as a whole. I agreed with the need for analysis and connections to literature argued for by Anderson, and Pace's proposals for autoethnography to sit within a grounded theory approach, convinced me that it would be appropriate for me to distance myself from the analysis until after the autoethnography was complete. I knew that this post autoethnography analysis would involve a literature review, and I planned to interview some people who had read the autoethnography, but beyond this I made no solid plans about what the post autoethnography focus would be, or the analysis would be conducted.

I outlined the following summarised plan for the first part of the PhD and thesis:

1. Return to my *autoethnography of learning* and finalise this. What follows in Chapter 3 is my story of lifelong learning as *reconstructed from my memory* and as written in 2014.
2. The next step would be to ask some participants to read the autoethnography while making notes in the margins of any thoughts or feelings they had while reading the story.
3. I planned to complete semi-structured interviews with each participant separately. I did not finalise the participants until after the autoethnography was complete, and for the reasons outlined previously above I chose:
    a. My parents: Although they do not feature prominently as characters in the autoethnography, they are clearly relevant to my story and have witnessed in particular my early experiences of learning, and they were also likely to have a different perspective on these events. As it is impossible to hide their identities, their inclusion in this process was also designed to go some way towards informed consent, by allowing them to read and either respond, or object to anything that they disagreed with in my representation. By conducting these interviews first I would be able to gain a sense of whether there was anything contained within the autoethnography that would be uncomfortable for my parents, prior to it being read by others.
    b. Someone who attended the same high school. The intention here was to gain the perspective of someone from the same

school, similar social background etc, but who has followed a very different path since leaving school.

    c. A recent full time engineering degree graduate. As it was becoming clear that much of my education after leaving school was directed towards a career in professional engineering, I also took the opportunity to interview a participant who had a very different experience of learning towards a career in engineering.

4. In parallel with, and after completing the interviews I planned to conduct some initial literature surveys, to explore how the literature related to the main themes in my autoethnography. This in combination with an initial analysis of the interview transcripts was expected to point towards key themes that could be explored. At this point decisions would need to be taken on the methodological framework for the analysis and general approach to be taken in the second part of the PhD.

Note: As discussed at the beginning of this chapter, most of the preceding chapter was written prior to, and in parallel with the drafting of the autoethnography of learning that follows in Chapter 3. For this reason the initial analysis of the autoethnography of learning, and the next stages of my methodology are discussed in Chapter 4.

Chapter 3: An autoethnography of learning

Note: For reasons discussed in the previous chapter, including the fact that interviews were conducted with participants who read this chapter, everything that follows this comment has been left unchanged from the final draft read by participants in early 2015.

Background and style of this chapter

Background

The initial motivation for this PhD thesis developed from reflections on my journey from distance learning student to distance learning course director, and the feeling that I could contribute something to the academic literature from this experience. As discussed in previous chapters the idea took some twists and turns before coming back to this original motivation and although this was originally intended to be about distance learning it became clear as I started to write that the story was much broader than that. It became a story of lifelong learning that would not be complete without going back to my earliest memories of formal learning, and forward to more recent learning which continued up to and during this PhD.

Unlike the majority of my colleagues in the engineering faculty who have followed a traditional path from full time student to academia, I left school with qualifications that were well below that required for higher education and initially worked in roles that could be categorised as vocational. It would be natural for someone reviewing my academic performance at this point to presume that “he’s just not academically inclined”, but academic qualifications gained after leaving school would now seem to cast doubt on such an assertion. I worked in industry for the majority of my adult life and the vast majority of my Higher Education study was conducted through either part time attendance, or distance learning. I think that this gives me a different perspective to most of my colleagues in engineering academia, and it is this perspective that I hope will be useful in exploring how and why people learn.

I have conducted this PhD research while working full time in a conventional university as course director for distance learning degree courses in chemical engineering, and also as an associate dean promoting distance and flexible learning in the engineering faculty. What follows is an autoethnographic account of the story of learning that led me to this point, the motivations that led me to study after leaving compulsory secondary education and reflects on those experiences from my current perspective as an educator.

Reflection on my past motivations to learn

> ‘The key to understanding others is to first understand yourself’

The above quote is from an unknown source and might be considered conventional wisdom, but Meltzoff and Brooks have shown that personal experience provides ‘a framework for understanding like experiences in others’, and make the even broader claim that ‘self-experience provides a mechanism of change in social understanding’ (2008, p. 1264). One of the reasons for conducting and recording this reflective exercise as part of my PhD thesis, is that I see a reflection in some of my students in terms of motivation, and not necessarily in a positive way. Reflection on my student experience (after reading educational literature), has made me aware that I used surface approaches due to lack of time (working full time and taking on too many credits to get it finished quicker), learning for reasons other than personal interest (such as career advancement), and conflicting motivations (focussing on grades rather than deep learning).

Style of this chapter

This chapter has a narrative, autoethnographic style and within the debate discussed earlier between Ellis and Anderson (Anderson, 2006) the majority is positioned towards the Ellis side. The reasoning for this approach is neatly summed up by Ellis’s response to Anderson (Pace, 2012) that too much analysis transforms ‘the story into another language, the language of generalization and analysis, and thus you lose the very qualities that make a story a story’. I have deliberately avoided analysing the narrative too much in order to let the story flow, with the intention that I will return to more formal analysis in later chapters, but I have marked where I felt different types of motivation first become apparent as motivation is key to the story.

What follows is therefore a narrative of my life in relation to learning, with minimal references, and analysis is kept only to that which naturally occurred as I was writing the story and thinking about these events. Although it is normal practice to complete the literature survey and review prior to completing the main body of research, I deliberately deferred this in order to minimise the influence of the academic analysis on the autobiographical section. It was important to me not to try to pre-empt connections to the literature, and instead to start this process by reflecting on how I felt about, and how I responded to, different types of learning, and what motivated me to learn at different stages in my life. References to the literature naturally become more frequent towards the end of this chapter as I reach the point in my learning experience where I was starting to become exposed to educational theory.

Note: In this thesis I have used single quotation marks for quotes from the literature and occasionally for emphasis, and double quotation marks for speech and my own thoughts. Occasionally I have used double quotation marks within quotes from the literature to preserve the emphasis given in the original text.

School days

Primary education and a defining year

In terms of learning experiences my memory of the early years of my primary school education is limited, but I do remember the phrase:

> *Kenneth is a dreamer…*

This was the start of the first sentence on an early report card. I can't remember the rest of it but 'dreamer' certainly wasn't being used as a compliment. These four words have stuck in the back of my mind ever since and come back from time to time. As I recollected this I thought "was this such a bad thing, I mean I was maybe seven or eight years old, give me a break!" To be fair to the teacher she probably felt I wasn't paying enough attention, but I still can't figure out what she hoped to achieve by criticising a child for having an imagination.

The first critical event that I can remember was in my transition from primary 5 to primary 6 and I recall it because I think it may have played a part in shaping my attitude to education in the coming years.

It's the last week of primary 5 and we are all gathered in the main hall, or at least we were all gathered in the main hall: "There are only 14 of us left and I don't know all of these children; they are mostly from different classes. All the others have had their names called and have left in classes of at least 20, so why are there only 14 of us left? That assistant head lady is the only teacher left. Please don't tell me she is going to be our teacher – she is scary!"

It was later explained to us that this group had been selected from the higher performing students and would be taken by the assistant head of the school. Looking back it appears that this was some sort of experiment to see if a small group with the attention of the assistant head, who may not have had the time for a bigger class, could be developed in line with their ability.

The reason that I think this is an important part of my story, considering what was to happen in high school, is that it is a marker that around the age 10-11 years old I was considered to be in around the top 10% of students in that year. I could not have been more wrong about the assistant head who turned out to be the best teacher I ever had, and I remember the next year as the happiest time I spent in primary or secondary school. She did not seem to have had a problem with my being a ‘dreamer’ and she focussed this into creative writing. I remember her encouraging me to write short stories and poems and giving me giving me great feedback on most of the things I handed in. On reflection this teacher stood out against all others I experienced during my school years, and seemed to be a model primary school teacher combining trust and encouragement, while still maintaining a position of authority. She retained the ability to be “scary” when it was required.

I am fairly sure that the impact of this teaching style was not lost on the rest of the class and I remember a girl who excelled in the standard parts of the curriculum and in particular maths, being allowed to move ahead and eventually being moved up a year due to her rapid progress. The children seemed to develop a different attitude to this teacher than I had seen with any other primary, or secondary teacher. This is best described by the conversation between my classmates on a morning at the end of term, when our teacher was bringing us all out to her home for a barbeque.

The carrier bag in my hand is the focus of my attention as I reach the playground. I remember my mother’s words as she forces the bag into my hand: “you can’t go to someone’s house without taking something”. I think “I am going to get ‘pelters’ for this, bringing the teacher a present – if I don’t bring any attention to the bag maybe no-one will notice and I can slip it to her without anyone looking”…

“What’s in the bag?”

“Nothing”

“I can see right through it, it’s a box of chocolates. Is that for the teacher, did you bring the teacher a present, teacher’s pet”

As the other children gather round support comes from an unlikely source, probably the coolest, toughest kid, and best football player in the class.

“I think your were right to bring a present, we all should have, she’s been really good to us, and bringing us out to her house and everything.”

The rest of the children agree, and attention turns to something more important, like whether someone remembered to bring a football…

It’s hard to explain the impact of this memory, but in that, fairly working class area it was common for children who did well or seemed to be the ‘teacher’s pet’ to face a bit of a backlash, so this display of loyalty was unlike anything I had seen for any other teacher during my childhood education.

The saying ‘all good things come to an end’ was quite appropriate as shortly after the barbeque to mark the end of term there was an arson attack which burnt down the entire school. As she explained:

“I am going to be very busy as we have to rebuild the school and won’t have time to be your teacher anymore. The class will stay together but will be taken over by…”

I felt the sinking feeling as I heard the name. “No, not her, she hates me” as my mind went back to the incident.

There had been an incident earlier that year where I had forgotten my shorts for gym class. The assistant head didn’t make an issue of this as it had been the first time I had happened and said that I could stay in the class and finish the story I had been writing. She had gone off somewhere and I became aware of a couple of other teachers who seemed to be talking about me.

“He is always forgetting his shorts so he can avoid doing gym”

I thought "why is she saying that, this is the first time it's happened, why would she lie?"

Before I knew it was being dragged along to the gym hall and made to participate with my school clothes on. I seem to remember feeling a little humiliated by this, but I wasn't there long. On her way back to the classroom the assistant head saw me in the gym hall and asked me what I was doing there. She was furious with the other teacher. Within minutes I was back in the classroom working on my story trying not to hear the raised voices in the argument that was clearly about me.

Ever since then, every time that other teacher looked at me I had a feeling that she was remembering the dressing down she had been given because of me, and now she was going to be my teacher every single day for the next year.

Looking back at this I have an impression that this pair didn't get on, and that my new teacher knew about my good relationship with the former and that this singled me out for special negative attention. Regardless of how much of this was real, and how much was the exaggerated nervous imagination of a child, what was real was that I *believed* that she hated me. I do have a clear and definite memory of trying to make myself vomit one morning to avoid having to go to school. On another occasion, I remember being late for her class and it's an indication of how I thought she would react that I thought it was a safer bet to stand outside in the middle of winter for over an hour and unsuccessfully try to slip in unnoticed after the first break. This is the first point in my life where I remember thinking "I hate school", and by the time I reached high school this was the prevailing opinion.

Trundling along in High School

How do I describe my high school? It was a big community school which had a public entrance and a main school entrance at either end, with lots of facilities like swimming pool, sports halls etc. It was newly built and well kitted out, but I have no reference point to say how good a school it was academically, in comparison to others in the area. If I cast my mind back I can see it in front of me as I step off the main path.

“Up the steps to the main entrance. It’s this covered area at the front I don’t like walking through. There are always older kids hanging around here, we call it the ‘smokers bit’, its where most fights are arranged. Teachers and janitors never come through here, the cark park is at the other side.

Well at least I’m inside. Still a bit of a mess at the back end of the dinner area. That’s where the strike was last week. What idiot came up with the idea that high school students could go on strike? Still, it was quite funny, the janitors didn’t know what to do when everyone just gathered there and refused to go to classes after lunch! What could they do? It got a bit out of hand though. The same mob that hang out at the front of the school were behind it and when they started throwing chairs around most of us knew that it was time to slip quietly away.

Better get to tutor group, don’t want to be late for saying ‘here’ then spending 15 minutes looking at the wall before going to the first class. Maths first, there’s another waste of time. I wonder what the jokers will be up to today. So far we have had the tables put out of the window on the roof, swapping the twins into different classes and turning the teacher’s desk back to front. Every day is April fool’s day in that class!”

These memories make me think of a school that although brand new and full of great facilities, there was very little discipline, or at least the discipline varied hugely from class to class. The head was a "Dr", and he was probably the first Dr I had come across who wasn’t a medical doctor and I don’t think I really understood why he was called “Dr”. I gather that he didn’t believe in corporal punishment. It seemed ironic to me at the time that disciplinary measures in primary school where the ‘belt’ was still in use were harder than in high school. In primary 1 I was punished with a ruler across the hand and I was pretty much going to try and avoid that in future. In later primary school I remember seeing some older boys coming out of the head masters office crying and clutching their hands. I vaguely remember being less afraid of the pain than of the humiliation of crying in front of everyone and I didn't want to have to go there.

High school was very different. I didn't really know the "Dr", he seemed to spend a lot of time in his office, and he seemed odd to us pupils, somehow different from us and from most of the other teachers. Looking back I remember him as some sort of "liberal academic type", with fuzzy hair and glasses. I remember thinking that he was posh, or at least posher than us which I suppose wouldn't be all that hard! There was a bit of a joke going about that if you were "caught about to throw a brick at a school window, make sure you break the window". The story was that "Dr" would offer you a cup of coffee and chat to you, which we all thought was hilarious. The idea was that if you were going to get taken into a headmaster's office you wanted to make sure it was the head, not the deputy head, who was a different personality entirely. The deputy head was a tough, central Scotland character. I was caught throwing snowballs at a window with a bunch of other kids, and was taken in to him once. There was no corporal punishment so we knew he couldn't hit us, although we weren't completely sure that he wouldn't either. He was very calm, I don't know what it was but I didn't want to go back in there again. Better break the window next time and make sure we got in front of the "Dr".

There were no defining moments like I described in late primary school and my academic interest was already diminished, although I was still doing ok in the first few years. The 5 years I spent there seemed to trundle along with me effectively doing just enough to get by. I remember having a strong interest in history, particularly Scottish history, that continues to this day, but I don't remember anyone encouraging this, or describing any options related to this that might lead to further study or a career. I also started to develop a strong interest in contemporary music composition and performance that perhaps had developed along the same lines as the creative writing encouraged by my primary 6 teacher. Again I don't remember this being encouraged, and in some cases it seemed actively discouraged.

On reflection one thing that seemed to be missing in high school was an individual to guide, encourage and to spot areas of aptitude that could be developed. Perhaps this should have been our tutor teacher, but he seemed to see his role as taking attendance at 8.45 in the morning and then leaving us to chat until 9am when classes started. There were also guidance teachers but as with my tutor teacher, while I don't remember anything bad about them, I also don't remember them having any influence on me.

Mathematics is pointless!

Mathematics was a special case for two main reasons, the first and most obvious was that the teacher had completely lost control of the class. I am not sure why he lost control, he wasn't disliked but no one had any fear of him either. I always thought of him as a nice guy. I remember having conversations with him about music and he went to the trouble of taping what he thought was the best of his Jimi Hendrix collection for me! He could have been a good teacher in a different school, with students from a different background. It seemed as though the class sensed some sort of weakness, and certain elements ran amok. I wasn't the worst, but I wasn't innocent in it either and if I met him now I would feel the need to apologise.

As I thought about this class I remembered that sometimes the noise was so loud that teachers from neighbouring classrooms had to come in as it was disturbing their own class. I also remembered that on days when our teacher was off and another teacher took the class there was no trouble and work would get done, so it seems that other teachers were able to control the same group of students. It struck me that "the school must have been aware of these issues, but didn't do anything about it. Is there anything they could have done, can you fire a teacher for not have control of a class? Perhaps there were disciplinary procedures or discussions going on in the background, but I had that same teacher for at least 2 years prior to 4th year exams, and even the most dedicated student would have struggled to learn effectively in that class!"

The other problem I had was that once you have passed beyond arithmetic, mathematics becomes quite abstract, and is probably the only subject at that level of schooling that appears to have no purpose in its own right. I understand now that maths is a tool, that is needed for other subjects, like science or finance, but I don't remember that connection or context being made at the time. I found it very difficult to accept the effort required to learn difficult topics that I could see no use for and it has since become clear to me that I need context or a purpose for learning, or I simply switch off.

As I read the above I realised that there may be a contradiction here as I thought "I'm quite happy dealing with abstract concepts in literature or philosophy, in fact I usually enjoy this, so why do I rebel against them in maths?" Is this linked to my experience of maths in high school, is it something to do with the way that I learn, or just what interests me? Perhaps I need to rephrase this as, "*if I don't have a personal interest* then I need a context or purpose for learning."

Interestingly we had a stand in maths teacher for one week, who controlled the class and taught a lesson in Geometry. I don't remember the teacher's name, or anything else related to the class or that day, but I have never forgotten that I can work out the length of any side of a right angled triangle if I know the length of one side, and one of the other angles. The conversation between teacher and students went along the lines of:

> *"There is a tree in my garden that I need to cut down but I am worried that it might hit the house if it falls in that direction, how do I find out the height?"*
>
> > *"Get a ladder and a measuring tape?"*

> *"It's too tall for a ladder and it's too thin at the top to hold a ladder, or for me to climb."*
>
> > *Silence and blank looks, followed by a lesson in geometry, and then back to the example*
>
> *"The ground is flat and the tree is straight so I know that the tree is a right angle from the ground. If I walk away from the tree with a measuring tape I now know one side of a right angled triangle. If I then look up at the top of the tree from that point and measure the angle of my line of sight with a protractor then I have all the information I need to roughly calculate the height of the tree and more importantly, how far it will fall."*

If this teacher had just told me that I could work out the length of any side of a right angled triangle if I know the length of one side and one of the other angles, I would have forgotten it by the end of the day because I would not have been able to see any purpose in this knowledge. I haven't always remembered Sine, Cosine and Tangent, when to use them or the equations involved, but this is just reference material that can be looked up in a book. I would consider this to be an example of good teaching using a simple example of a real application, and a teacher taking the time to make it. The evidence that proves this, is the fact that 25 years later I can still recall both the concept and the example.

Music – a distraction or a missed opportunity?

Another factor that must be mentioned from this period is music and the impact that this started to have on me and my ambitions on leaving school. I had an interest in music from late primary school and had started learning guitar around this point. Initially a few chords from my father and then mostly from books. I tried to get guitar lessons in school but was told that they were full. I am not sure how they had managed to fill the classes before I had even been informed that they existed and I was a little aggrieved about this. However this had happened, it seemed that I was somehow ‘outside the system’ and it took a couple of years of perseverance before I was able to get formal lessons. By this time I had missed the boat in terms of a formal musical education, but this perhaps wasn’t a huge issue as a classical music education wasn’t as critical for the folk or contemporary music I was most interested in.

In the latter years of high school I had started to flirt with the idea of going to music college as there were a couple of Further Education colleges offering HNC/HND level courses in contemporary music. I was very interested in this, and had visited one of the colleges on a music department supervised trip. I can’t remember clearly why this didn’t work out, but I do remember that as my mother had just recently gone back to work, their joint earnings had just moved into the bracket where I was not eligible for a bursary. I remember thinking that it was strange that the state applied this policy given that my parents were against the idea of me going to music college so would not have contributed to it. Looking back on that time with hindsight, I can see that I potentially could have taken a part time job to support myself, but I would have had to live away from home due to the college location. I was already working part time in a supermarket so I was aware of the rates of pay available and it was difficult to see how I could have earned enough to support myself.

Eventually the combination of teachers and parents being against the idea, finances, and leaving my friends to live somewhere where I wouldn’t know anyone, combined against my desire to go to Music College. This could have been an excuse and it may just have been a risk I wasn’t prepared to take. There was no real risk that I would end up destitute, as I knew I would always be welcomed back home, but there was a definite fear of failure: “*What if I go out on a limb and I don’t even get accepted? What if I go there and then find out I am not good enough? What if I lose touch with my friends and don’t make any new ones?” What if I can’t make enough money to support myself?*

I think that the primary reason for not pursuing this was that with so many people advising against it, to do it anyway and then fail would have been crushing. At that time, music, or something related to it, was the only thing that I wanted to do but ultimately I took the easy option and rather than try and fail, I gradually gave up on this idea.

If I knew then….

Just reflecting on this period doesn't serve a purpose on its own, but writing about it started to help me form an image of myself as a learner and some clues about how and why I learn. Before I move on from this period, I wanted to pause and think a little about what might have been, if some of the events, or actors involved had played out differently. Not through regret, as on balance I have a good life and a successful career, but through what could be learned. While I see my life experience as being what makes me who I am, I would not necessarily wish another child to have the experience I was to have in the coming years.

I started to consider how someone with the knowledge that I have now about the workplace and education could, or should, have advised my high school self. I imagined a short conversation with an idealised guidance counsellor, or perhaps myself travelled back in time, and my early teenage self. The guidance counsellor in the below conversation is fictional, but my responses are probably fairly close to how I would have reacted at the time.

"Most of your subject teachers say that you are capable, but don't apply yourself"

"I'm not really interested in most of that stuff"

"What are you interested in – can you tell me about your hobbies, what you do in your spare time etc, is there anything you are interested in at school?"

> *"Well, I like music, I play guitar, sing a bit, write songs and stuff. I read a lot about history, mostly Scottish history but some other stuff, like North American Indians - I suppose I did enjoy a lot of O-Grade history when we were doing the Russian revolution and the First World War but I found the history of farming methods really boring. I play football, but everyone does that, and I'm not really that good."*

"That sounds interesting, anything else?"

> *"Well, I mess around with my new computer a bit, I write programs, mostly copying games out of program books but I've made up some of my own simple programs."*

"Do you have an idea of what you would like to do as a career?"

> *"I'd like to do something to do with music but everyone keeps telling me that it's a fantasy."*

"It's good to keep your options open at this stage but I can see a number of things that could allow you to pursue your interest in a career in music and keep your options open at the same time."

> *"Such as"*

"Well, for example you have an interest in history and an interest in music, you might find it interesting to combine these and explore the history of music. Of course you will need to maintain a good level of English as well, but you could potentially study Music History, or you could consider journalism as you obviously have some creative writing ability.

> *"But what kind of job would you get out of doing history?"*

"Well, the obvious one is a historian, but there are probably not a lot of jobs in that specific area, but there are lots of related careers such as librarians, publishing, writing and even politics. But you would need to get good grades in History and English to keep that option open"

> *"Ok, but I think I would still rather do something that was closer to music"*

"Well ok, then take your interest in computers and programming, and combine that with music. I also noticed that you seem to do well in the craft and design class. There are lots of music related technology jobs out there and you could use this to help with your own music, and if that doesn't work out you would still be involved in music through the technology side of things. You'll need maths and physics for this. Some of those things you are studying in maths at the moment that don't seem to have any purpose will be needed when you get further into programming and technology. And Physics gives you all the background knowledge that you need to understand how things like electric guitars and amplifiers work and how to make them."

> *"I didn't know that was what Physics was about. I had been thinking about making my own electric guitar but I didn't think that Physics had anything to do with that."*

"How about keeping your options open by taking a two pronged approach and then you can double your chances of finding something that you like doing when you finish school. If you concentrate on maths and physics and keep up the interest in programming then you will learn a lot of things that can help with your music but can be used in other music related careers. If you also do well in English and History that can help with your writing and can also open up opportunities for other careers."

I realise that this is a fantasy scenario, but looking back at this critical period between around 13-16 years old, I really needed someone in the education system to help give me a motivation for learning. Perhaps someone asking what interested me, what motivated me, and what I did in my spare time, could have brought out a number of viable career options that would potentially motivate study?

I distinctly remember having great trouble when choosing O-grade subjects at around age 13, in making the connection between the subjects on offer, and potential careers and at that age I had no idea that there was a potential career connection between music and physics, or maths and programming. I don’t remember anyone at high school ever sitting down and asking me what I was interested in or explaining ‘why’ I was doing these subjects and how it might benefit me or relate to potential careers.

Yes, there were guidance teachers but they seemed to be working from a script, where you are good at maths and physics so you will be an engineer and so on, without actually trying to find out what motivated the student. In retrospect, I recognise looking back that my desire to work in the music industry may have been unrealistic, in the same way that many children want to be football players or film stars, but I think that a skilled and knowledgeable guidance teacher could have made a big difference by simply connecting my interests and motivations to potential study and career routes.

Early motivations for learning

Before moving on from this point I thought it would be useful to summarise my motivations for learning in school, because these motivations were very different to my motivations as an adult. As a child I don’t think I was very aware of my motivations for learning. I went to school because I had to. I enjoyed some subjects and not others, but my preferences didn’t change the curriculum, how subjects were taught or who my teacher was! As an adult I was very conscious of my reasons for learning, and this is why I think the analysis of my learning motivations from this point on has much more validity than my motivations while at school. I had written about my motivations for learning as an adult before I wrote the above sections about my childhood, and the former was very clear to me and flowed very easily on to the page. I found it much harder to analyse my motivations for learning as a child because this was so bound up within the differences between the lack of independence and responsibilities as a child, and vice versa as an adult. My education at primary school and the majority of high school was compulsory.

My motivations for learning at school really came under two broad categories, most of which was what *I had to do* in order to keep teachers and parents “off my back!”

> Motivation 1: “Because I had to”
>
> Motivation 2: “Because I wanted to”

The smaller portion were those topics that I did because I enjoyed them, and most of this was explored in my own time. When I started to write about this and list the things that I did as a child I started to have one of those autoethnographic epiphany moments (Ellis et al., 2010) that went something like this:

I started to write:

> *Some examples that I remember included reading about Scottish history, briefly and mostly unsuccessfully trying to learn Scottish Gaelic from a library book, learning about computers and how to program, again from library books, learning an instrument (guitar), music composition….*

I thought “hold on a minute, for such an underperforming student I spent a huge amount of time in the library, I assimilated a lot of knowledge and learned a number of skills purely motivated by my own interest.

A personal computer

There was another significant development that happened outside of high school but had a very significant impact on both my future education and career. Around the point that I was entering high school personal computers were starting to become available to children of average and lower income households. My earliest memories of these were those belonging to neighbours and friends but eventually my parents relented and bought me a Sinclair Spectrum+ for my birthday. As I recall this was well beyond the monetary amount that would normally have been available for my birthday present but it was made clear that they were spending extra on this because of its educational value. Like most parents at that time they knew little about computers so it was quite forward thinking of them to spend more money than they could probably have afforded because they saw something important in “this computer thing”.

Looking back I think this was an important time in relation to how children interacted with computers. Computers were nowhere near as easy to use and reliable as they are now and children using them were out of necessity much closer to the hardware and software. Even just to play a computer game a user needed to understand at least a few command line terms such as ‘load’ and ‘run’. The cheaper computers such as my Spectrum did not have any form of hard or floppy drive and the user needed to use their own cassette player, which had to be connected with audio cables in order to load any software into the computer. As a child I wondered about the screeching noises coming from these cassettes while I sat for 5 minutes waiting on a game to load so I read a book and found out that the programs were made up of binary 1’s and 0’s, and this was represented on the audio tape as two different pitches. Friends copied each other’s games by connecting cassette players together, and found out that we had to vary things like recording volume and turn off the noise reduction to make it work. This was a very simple form of engineering problem solving and through experimenting with different settings I realised that if the volume was too high or too low, the computer couldn’t interpret which sounds were 1’s and which were 0’s and the program would fail. I found out that the cheap cassettes that I got from the market worked better than the expensive ones, and later found out that this was due to the limited frequency response on the cheap cassette suiting the very narrow band of frequencies required to represent a 1 and 0.

In order to be able to get free games I would copy the code out of books and magazines, which would lead me to wondering what all these programming words meant, so I would get another book to learn about that. I wanted to know how the computer worked inside and I got another book to learn about

RAM, ROM, Microprocessors and how these components interacted with each other. The upshot of all of this was that I have retained a deep understanding of computers in terms of how they work and what kinds of things can be done with them. This may have had a greater single impact on my success in a number of jobs than much of what I learned formally, from being the only person in the garage who could work the new diagnostic computer, through multiple projects as a technician and engineer and an intuitive ability to adapt to computer driven technology and software with ease, and often without any training required.

Reflecting on what I learned out of personal interest

Until writing this chapter I had never really thought about the number of things that I had learned that were not a part of the school curriculum. At this point I thought it would be a useful exercise to try and list some of the skills and knowledge that I learned to a reasonably deep level, during and just after leaving high school that were not related to what I was studying in school. The table below gives a summary of some of the things that I learned 'outside' of school.

Subject	Scope	Source	Influence from school
Musical instrument performance	(Guitar to performance level and some other instruments to a lesser extent)	First few chords from my father, most of the rest from library and purchased books.	Some lessons and formal education in later years of high school after I had brought myself to a reasonable level through books and practice.
Ability to read and write music	Understood the majority of the theory and remember most of this still, but did not become fluent as formal music notation wasn't needed in the musical forms I was involved with.	Mostly from library books	As above

Zoology, and in particular Ornithology	Had a very comprehensive knowledge (for my age) of animal classifications, habits and particularly birds. At one point, took part in a national survey for the RSPB.	Books	Very little. Took Biology O grade (and briefly higher) based on this interest but I remember a lot of what I read from books and little of what I learned at school.
American 'Indians'	Had a reasonably comprehensive understanding of the various theories behind arrival and ethnic background of native Americans, important historical characters, tribes, cultural practices etc.	Books, a key trigger being 'Bury by heart at Wounded Knee by Dee Wallace.	Nothing that I remember
History, in particularly Scottish History.			History O Grade
Computers, Programming and IT	Understanding of the operation of a computer and the major components at system level. Ability to write basic programs.	Almost exclusively from library books.	None.
Electronics	Understanding of basic circuit theory.	Learned the basics from a book that I purchased shortly after leaving school.	Don't remember anything from school about this – but then I didn't choose physics.
Language	Made an attempt to learn Scottish Gaelic from a library book. Learned some phrases but pronunciation was difficult from a book and gave up.	Probably prompted by my interest in Scottish History and a library book I found on the subject.	Not taught at my school

Fiction	Heavy reader of fictional children's novels in primary school and into early high school started to read adult fiction, semi-historical novels and developing an interest in classic literature before this tailed off in later high school.	Library, gifts and purchases.	Some influence on what I was reading from English classes, the most important being To kill a mockingbird by Harper Lee.

Table 3.1: Learning 'outside' of school

Putting this into a table brought home how much I had learned during, and shortly after my high school years that was not related to school. There was also evidence of a desire for learning, and in particular reading, given that I was willing to walk the 3-4 miles round-trip to get books from the public library. I am not suggesting that anything above is particularly special, or at a higher level than many other students of that age, but many people I have spoken to presume that students who do not do well at high school, but come back to degree level study as mature students are, "late developers". When I started my own degree as a mature student I remember feeling sometimes that I was perhaps not as clever, or in a lower category than students who had been capable of doing this "first time around" as a teenager. I now started to consider that perhaps this was nothing to do with being capable, or being the right time, perhaps there were other factors at work. Educationally, I was clearly on track in primary 6, I was clearly off track by the end of 4th year, but in between I was still actively interested in learning.

> *Was I a victim of a bad school, system or just unlucky with the teachers I got?*
>
> *Was this nothing to do with the school and just as simple as being my own fault for not applying myself?*

I see the two questions above as the opposite ends of the scale between blame the student or blame the education system, and neither are fully correct because I know I had some bad teachers, but I also know that I often did the minimum, or was even sometimes belligerent towards formal learning. After a period of further reflection on this period in my life I came up with some more focussed questions:

How influenced was I by local social attitudes that being smart was not cool?

> I thought back to some of the friends I had in the critical periods and I think that many of the people I surrounded myself with were not very academic. There was definitely a rebellious and anti-academic culture amongst many of the people I was friends with, but I did also have friends at that time who would later go on to Highers and university.

Was this something to do with a rebellious tendency of being prepared to learn the things that I wanted to learn, but reject what others were forcing on me?

> My earlier reflection seemed to indicate that while I remember hating school and rebelling against the curriculum, I was spending my own time learning about subjects that I was interested in.

Is there something in my learning style that doesn't suit standardised forms of teaching?

Or conversely,

Is/was there something wrong with the formal schooling system that didn't/doesn't take account of different learning styles?

> As I was considering the above I remembered that as I was doing my distance learning degree I often wondered whether the reason that I was performing as a distance learning student and not as a conventional one, was that this style of learning suited me better. I know that I can have a short attention span, and sometimes when in a talk or a lecture I can 'drift' and suddenly realise that I have no idea what has been said for the last few minutes. The advantage of

learning from a book is that I can go back and re-read something – in classroom learning you can't rewind what the lecturer has said!

I seemed to learn willingly when I was interested in the subject, but I don't remember a teacher in high school ever asking me what I was interested in. If a history teacher for example had offered me the chance to research a subject that I was interested in, I would probably have responded much more enthusiastically. I wasn't interested in Scottish farming methods in the 17th century, but there are plenty of other aspects of history that I would have willingly read about in my own time. This level of individual attention might be unrealistic in a state school curriculum where there are large classes, but it's worth considering that some students might be demotivated by being forced into studying things in which they can see neither relevance nor personal interest.

Leaving school with no direction

As a high school student I had the ability, but very little motivation or direction and as I hit the O grade exams in 4th year I found myself capable enough to achieve bare passes in all of my subjects, with practically no revision. There was one shock when I found out shortly before the exams that I had been put forward for the CSE (a lower qualification that the standard O grade) in English. I complained about this to the teacher as I was convinced it was a mistake, and even if it wasn't I should at least have been consulted. Looking back on this I thought *"what the hell was going on back then that I was not doing well in English". "I mean English?! Writing, literature etc. My head was always in books, I enjoyed writing, with the possible exception of history there couldn't be a subject in the curriculum that it would have been easier to get me engaged in!"*

Although I passed all of the 4th year exams with minimal effort I was realistic enough to know that I would not get away with this in Highers. My teachers confirmed this as they had all with the exception of mathematics recommended me to take Highers in their subjects, but only if I was prepared to “put the work in”. I had become quite rebellious and decided that I was not prepared to do the work required for Highers when I didn’t even know what I would use them for. Instead I would “get my own back on school” by staying on in 5th year but only doing what I wanted to do! I took one higher in Biology which I dropped out of within a few months and spent most of the rest of my time doing modules in the Music department, or ‘hanging out’ with friends.

I have to admit that I did enjoy that year which was almost like a year out, even though it wasn’t supposed to be, but it came to an end and although I made some moves to join a music course, when that that didn’t pan out I was forced back to the reality of entering the workplace. I had found myself at the end of 5th year with one extra O grade on top of the 5 I already had scraped through at the end of 4th year, no thoughts of future study, and a career plan that involved applying for any jobs that I was qualified for and taking the first one that I was offered.

As a final thought from this High School period, it struck me that I seemed to remember concepts that were *not* related to school more clearly than I could remember those that were. This made me think again about the concepts of deep and surface learning that I learned more recently, and note that I appear to have had a deeper learning in subjects that I learned out of personal interest or those in the curriculum where I could see relevance.

The big bad world

The workplace, and new motivations for learning

I found a job relatively easily but also realised fairly quickly that it was a bit of a ‘dead end’. It was a small factory making ultrasonic scanners for medical use and although my job wasn’t very technical I got my first exposure to engineering in the real world. As it was a small operation I got a really good overview of how all the different departments from design, production, test, sales, and administration interacted with each other. I liked working there but a realisation gradually dawned on me that job security and future earnings were potentially linked to having some kind of tradable skill or qualification and I left after one year for a four year apprenticeship in the motor industry.

It struck me that before this point, what I learned or didn't learn had a limited impact in the here and now, and as long as I did the minimum and passed the basic subjects at O grade level my parents would be satisfied and my teachers who had a number of students to worry about would not be too concerned. Obviously there was a longer term impact, but for some reason I wasn't thinking of this, and when I did think of it I did not have a clue what I wanted to do anyway. Once I was in the workplace, learning or not learning had a very clear and immediate impact. Learning could impact my salary, what kind of house I would live in, clothes I could wear, whether I could go out with friends at the weekend. Even more critical was not learning, as it could have the impact of not having a salary at all. I initially thought of this as 'career and financial' motivations but separated them into:

Motivation 3: Career motivations

Motivation 4: Financial motivations

The reason I separated these is that although I often thought of these as the same thing, because I was in a career to make money, there have been times that I have been motivated by the career itself, for example just wanting to 'do a good job' or have the respect of my colleagues.

In the latter years of high school I had no future career in mind and felt no motivation to study, so when it started to become more difficult (4^{th}/5^{th} year) I was not prepared to put the required effort into subjects I had limited interest in. However, now that I was working in industry I realised that in order to increase my earning potential, job security and to be able to have an interesting and rewarding job in the future I would need to obtain skills and education, and this led me to a traditional 4 year apprenticeship in the motor vehicle industry. Although I probably did not consider it at the time, this was probably the first time that I had experienced a motivation for education that was not driven by ‘having to do it’ or ‘wanting to do it’, and I had now found motivation based on potential financial reward and job security. A clear memory from this period was the fear of being unemployed, and of somehow getting to a point where it would be too late to do anything about it. I was developing a strategy for job security and I saw training or learning as a means to this end.

The motor industry

The next period and my job as a motor mechanic shaped my adult life in so many ways that I could probably write a thesis on this alone! The previous sentence nearly included the phrase “in both positive and negative ways” but when I thought about it I realised that even though much of it seemed negative at the time, many of the negative aspects have also shaped me in positive ways. On the other hand, although I can see things that came from that experience that had later positive impacts, I could also question whether I would have seen it this way while I was having to live through it. The only thing that is certain is that it did impact me, and having just written and reflected on the relatively sensitive primary school pupil, the contrast against the more hardened individual that I had to become to get me through my apprenticeship, is quite sharp.

When I consider the working environment of the garage, it’s akin to how I imagine industrialised workplaces from many decades previous and the best way to give a taste of the environment is through a series of examples:

The garage was a very old high ceilinged building, with huge doors that were obviously designed to enable buses and vans to enter, and were mostly left open as cars were constantly coming in and out. In winter it was only a few degrees warmer than outside. The floor was concrete so was very cold to lie on and the metal tools that had been there all night were unbearably cold to touch, it wasn’t possible to wear gloves because of the lack of dexterity. I remember the dread of picking the cold tools up first thing in the morning. I also remember cars coming in covered with snow, which would then start to *melt and drip on you from above until it got to the point that you were lying in a puddle of water. There was no sick pay so if you became ill you had to choose between no pay or going into that environment with a cold or flu. My hands were always dirty, as the oil and grease seemed to stain them. I remember going on holiday for two weeks and it took that length of time to scrub them clean. This of course led to dermatitis and I remember a fellow apprentice whose fingers had doubled in size. He was still trying to work like that because he couldn't afford the drop down to statutory sick pay. Most of the older guys had something wrong with them that could be connected to the work environment.*

It was widely known inside and outside of the motor trade that apprentices were 'initiated' through what was known as 'greasing'. Although we never thought of it this way, in another environment it could be considered sexual abuse or assault. The apprentice would be grabbed by a group of mechanics, stripped, and a mixture of grease, metal filings and anything else that could make it more unpleasant would be applied to the apprentice's genitals. I think that the practice was starting to die out by the time I started my apprenticeship, but the threat of it was always present. The only apprentice I witnessed this happening to was probably picked on because he was the least likely to be able to defend himself or cope with the humiliation, and he ultimately left before finishing his apprenticeship. I was threatened with it a number of times and I think that I avoided the experience because I was slightly older and stronger, but mostly because I made it clear that while I realised I couldn't fight off five or six men that, "If you come near me with that stuff I will take one or two of you down with me". This is just one example, but it gives an impression of what was sometimes a brutal environment and young men had to either grow up fast or get out.

Health and safety was only nominally adhered to, and I saw a number of accidents that could have been prevented if the safety equipment had been freely available. In one example that could have been prevented with safety glasses, an apprentice cut his eye and had to be taken to hospital. When he *had left the workshop manager punched his clock card out so that he wouldn't be paid while he was at the hospital, and when he returned he was sent back to finish the dusty brake job with an eye patch on, inevitably resulting in the dressing being contaminated with asbestos dust. I recall falling off a ramp myself from 6 foot off the ground because it was common practice to send the apprentice up with the car ramp while the journeyman worked below, in order to try and meet job times. When I compare this work scenario with my next job, in the electronics industry, I would not have been allowed to work at this height without a permit and a safety harness.*

There was no exhaust extraction so inhalation of exhaust fumes was an everyday occurrence and it wouldn't be uncommon for the exhaust fumes of another car to be only a few feet away from your face when you were on the floor working on your own job. There was a certain irony in the constant reminders while at college to connect the exhaust extractors, and to wear protective gloves, masks and goggles, when none of these things were routinely available in the workplace. I remember contacting the local Health and Safety Executive about safety violations, but they didn't seem very interested and didn't get back to me.

It was made very clear by management that unions were not allowed and that anyone who joined a union would be fired. I was told by my journeyman that a few years before the mechanics had all walked out because management had sent the apprentices up on the roof to fix it without any safety equipment or harnesses. A written warning was issued to all who participated on the same day. There was another story being put about of another garage within the same organisation where the tradespeople joined the union en-masse and the owner simply shut the garage on a different pretext. Although this suppression of union activity was clearly illegal the fact that there was no union meant that there was no-one to report it to.

There was no way to improve things from within, and there didn't seem to be very much sympathy on the outside. Most people seemed to think that mechanics were very well paid, because of the high fees the garage charged, *but these were in reality about 10x the mechanics hourly rate. There also seemed to be a perception from the public that Mechanics were untrustworthy so it is not likely that there would have been much public support even if it was possible to arrange a campaign or strike. When I was an apprentice I compared this to the public perception of nurses who received significantly higher pay, had a shorter training period, were held in much higher regard by the public and unlike mechanics didn't have to buy their own equipment and work-wear.*

Education as a way to escape

The reason that I felt it was important to give an impression of the atmosphere in the garage is that it is directly connected to my motivations for learning and in particular my motivation to escape that environment. I think that this experience gave me a minor insight into how people in less privileged societies may sometimes view education, as a way to escape to a better life. So I referred to this as:

Motivation 5: 'Escape'

I looked around me in the garage and noticed that there was hardly anyone over 40 working there, and the ill health of the men who were approaching that age was evidence enough of why. For some reason I was determined to finish my apprenticeship and spent another two years in the garage after this, but much of those two years was spent planning my escape route and researching different options. When I tell people about my experience in the garage they often say, "Why didn't you just leave?", but like many oppressive environments you are held back by a feeling of worthlessness that is nurtured there. I can remember the foreman telling people things like, "you have it too easy here", "no one else would have you" and to people that left to go somewhere else, "you'll be back when they find out how useless you are".

Surprisingly, people did come back and this seemed to reinforce the idea being sold by management that "this is as good as it gets". As I have worked in far better jobs since and now know better I speculate that this phenomenon was either that they were going to other garages (that were just as bad), or that there was some kind of unhealthy addiction or lack of confidence.

Network Marketing

As I was thinking about how to escape the motor industry a friend approached me about a “business opportunity”. I would have rejected this as a scam if it had come from someone I didn’t know, but this was someone slightly older who I trusted and respected so I got on board and invested what amounted to about a week’s wages at the time to buy the ‘starter pack’ and registration. The money spent on the starter pack to the parent company was only the beginning and over the next year or so I paid a significantly higher sum to the network organisation for motivational books, tapes, equipment etc. This was not enough to put me into any kind of debt, but if I had added up the constant drip feed of a £10 here and £40 there it would have been a significant sum.

Whether this was a scam or not is up for debate and probably depends on your point of view. The parent company was a global organisation in existence for decades and had probably expected that their agents would make most of their money from direct sales. Some clever people had analysed the agent commission structure and realised that it was much more profitable to sell a small amount, and earn commission from a large network of agents below them who also sold a small amount. The network needed a constant supply of new recruits, in turn recruiting others to make the business viable, and to maintain the income generation for those at the top of the network so the focus was always on growing the network rather than sales. It was not that the promised income was not achievable, technically it was and the numbers did add up, but in order to do so it was necessary to build a network organisation below you which involved convincing others to join and build their own sales network. The latter point is the key and this is easier said than done, which meant that the network organisation relied heavily on motivational techniques.

I could write a lot about this experience that might be relevant to psychology or business, but the reason that I mention it here is because of how it affected me in relation to motivation and learning. If I considered this venture from a business perspective and subtract the time and monetary costs that I invested from the income generated, then it was an unmitigated disaster. However, 20 years later this is not quite so clear cut and I wondered:

> "How much of the path that I followed after this point can be linked to this experience?"
>
> "How much of what I learned here have I used since without realising it?"

I thought about some of the things I learned during this period. I gained a minor insight into running a small business, but I also gained some people skills and learned some sales techniques along the way. I met and listened to talks by some very successful people and observed how the business orientated and very motivated people in the organisation acted and interacted. These were things that I would not have had any exposure to in the motor trade.

I was encouraged to read at least one book a month from a prescribed reading list which probably sounds a little cultish, but in reality these were all books that were on general sale in bookshops rather than specific to the organisation, and most fell within the self-help or motivational categories. The book I remember most clearly was first published in the nineteen fifties by Professor David Schwartz (1987) and was largely focussed on motivation, building confidence, positive thinking etc. It was the antithesis of the negativity and the "this is as good as it gets" attitude I had experienced in the motor industry.

Another book that I remember clearly was by Robert Fulghum (1988) who espoused a theory that everything a person needed to know in life was learned in kindergarten. This theory was clearly over simplistic but it was really trying to sell a semi-humorous credo of ‘play fair’, ‘don’t take things that aren’t yours’, ‘don’t hit people’ etc and the idea that a lot can be learned by adults from the basic rules and common sense that children are taught at an early age. It wasn’t the intended message of the book that had the most impact on me though, it was the author’s back story and the fact that he had been amongst other things a ditch digger, ranch hand, bartender, and salesperson, before studying theology and becoming a religious minister, and later teacher, newspaper columnist, writer and novelist.

Looking back on this period now, I can see that a fairly intense period of reading and learning about people who changed and improved their lives one way or another must have opened a window to alternative possibilities for my life and career. I also learned a lot about motivation, including why the motivational strategies employed by this organisation failed to motivate me. Their entire motivational focus was on encouraging people to ‘dream’ and focus on material possessions such as luxury cars, boats and houses, and exclusive holidays that were currently out of their reach. None of these things had any great appeal for me, and my motivation was still simply to escape the garage to a better job, or to earn enough money to give up work and allow me time to focus on the things that interested me.

Within a relatively short period of time I had realised that this network marketing scheme was not for me. I wasn’t good at selling people things I didn’t fully believe in and I also had concerns about some of the techniques that were being used. I realised in a relatively short period of time that this was not going to get me where I wanted to go, but its only by reflecting on this period in the context of the 20 years that followed that I can see how much I got out of this, and how it may have been one of the key triggers that set me on the career and educational path that I eventually followed.

Learning for relevance and applicability

There was also an experience of learning in the garage that shouldn't be overshadowed completely by the negative aspects. While working in the motor industry and following day release classes at a local technical college I started to encounter theoretical ideas that I could directly apply in a practical sense. This was a traditional four year apprenticeship (prior to the 'modern' apprenticeship) and the first three years were centred on the relationship between an apprenticeship and a "journeyman". The journeyman was the term for someone who had successfully completed their apprenticeship and was considered experienced enough to take on and train an apprentice themselves. The idea of an apprentice working directly with a journeyman for a number of years, alongside college day release, had the advantages of teaching theory at the same time as experiencing practice. This type of training also meant that I was almost always learning something that had direct relevance to my current job and it was much easier to focus on learning something when you knew you were likely to make use of it.

Motivation 6: Learning for relevance and applicability

The quality of the learning experience was however, heavily reliant on the journeyman, some of which used apprentices as a way to increase time based bonus. I was lucky in this respect and my journeyman spent time teaching me, and I believe that this practical education sometimes gave me an advantage later as an engineer, over engineers who had received a more formal education prior to practising.

I thought about what I could remember about motor vehicle technology considering that outside of doing it as a job nearly twenty years ago I have little interest in cars. As I considered this further I realised that this was not a remembrance of facts and figures but a more of an understanding or a visualisation. I thought about *how* this knowledge entered my head, tried to remember what I know about motor vehicle technology and to record this below:

As soon as I started to consider this topic the phrase "internal combustion engine" came into my mind. When I started to think about what I knew about this I visualised the engine, and then some of the internal engine components such as the crankshaft, camshaft, valves etc, and immediately thought of there being a "cycle". What I was thinking of was the "4 stroke cycle" but that phrase didn't pop into my head until moments later. I visualised the piston moving upwards and thought of the word "compression", and then I thought "no, the fuel needs to be drawn into the cylinder first as the piston moves down, that's induction, then the piston goes up and compresses the fuel and air mixture, then the spark ignites the fuel driving down the piston and that's called ignition, and then the piston goes up again to exhaust the waste gases." All of the above came to me in seconds, and within a few more seconds thoughts rapidly came into my head of valves opening, electricity being distributed to the spark plugs via the distributor and within about 10 seconds I had a complete visualisation of how the fuel delivery, electrical and mechanical systems combined to make the engine work, and had started to think of how that turning force turned the gearbox, turning the drive shafts, turning the hubs and wheels, and this started to spread into a myriad of related concepts and systems and images of these.

I was surprised at the way that this vast array of knowledge spread into my consciousness so quickly and I had never before thought about how natural this knowledge still was to me. I realised that I could still remember how all of the electrical and mechanical systems in a motor vehicle worked and how they interacted with each other. As I considered this further I realised that this was not a remembrance of facts and figures but a more of an understanding or a visualisation. I could "see" the engine and how it worked internally and how this connected to the other components to drive the car. This knowledge was natural to me, like knowing that a stream flows downhill, and I considered that if I had not forgotten this by now I probably never would. This made me think of a phrase from the literature about threshold concepts and how once a threshold concept has been learned it is difficult to unlearn (Meyer and Land, 2003).

It seemed that many of the concepts I learned in the motor trade were acquired threshold concepts for me, but why they had become so was not completely clear. “Was it because of repetition?” I didn’t think so as internal engine work wasn’t very common. “Was it because it was relevant?” This was more likely as I would have known while being taught about this that I may have to put the knowledge into practice and rebuild and engine within days. Perhaps it was the practical aspect, *learning by doing,* and possibly reinforced by the fact that later I had to teach other apprentices these concepts.

My only experience of full time higher education (as a student)

After completing my 4 year apprenticeship I gradually started to consider where I could go from there. I had taken some interest in electronics and was working through a textbook on the subject, and the combination of this knowledge and my understanding of computers had currency in the motor trade, at a time (mid 1990’s) when electronic control of vehicle systems was of growing importance but computers and electronics were still unfamiliar to most mechanics. I considered progression within the motor industry, such as management, or working towards the Master Mechanic qualification, but there were limited opportunities for progression or increased earnings. It was a poorly paid industry, with poor conditions and a very negative environment and I really didn’t see the potential rewards as being worth the cost and effort of completing further qualifications.

After nearly 7 years in the motor industry I took what seemed like a radical step at the time and left my job to join an industry sponsored full time Higher National Certificate course in Mechatronics. The reason it felt so radical was that my already limited income was slashed by more than 60%, and by this time I had bought a house which I would probably have lost if I couldn’t find a job at the end of it. This was a milestone moment which could have gone very differently as I was initially rejected after the interview. I thought this course was a good match for me so I made a follow up call to ask them what

I could do before between now and next year's intake to improve my chances and this show of commitment was enough to grant me an additional unsponsored place that they had been holding.

This course was part of a technician training programme sponsored by the Semiconductor industry and included a summer placement that was effectively a job interview with one of the companies involved. Reflecting on my motivation during this period brings forward another motivational factor, fear of failure.

Motivation 7: Fear of Failure

I have already given a taste of the attitudes within the motor industry and I was terrified of the idea of having to return there as a failure. There obviously was also the fear of becoming unemployed, but as I had a fairly high confidence that the garage would take me back, the real fear was of having to go back "there"!

The other primary motivational driver during the HNC programme was relevance as the course was very specifically designed for the career that I was about to enter. Although much of the subject matter was interesting, when it was not interesting it was at least reassuring that it was going to be relevant to the job and I wasn't just "wasting my time". The summer placement also helped with relevance and applicability, because I was working on shift with engineering technicians and seeing in practice the things that I was learning about.

Fairness in assessment?

Whenever I think of teaching and learning during the HNC, my thoughts always drift to one of my fellow students. He was well liked, but most of the rest of the class recognised that he was either not capable of the level of study, or wasn't prepared to apply himself enough to get through at this level. Although, quite rightly in my mind, no-one took it out on him, there was a feeling that because the course was sponsored by industry that the college would just push him through.

This came to a head for me when I was asked to resubmit a project report for what seemed like some fairly insignificant issues. I later met with the lecturer in his office and the conversation went along the lines of:

> *"His report has been put together with glue and pictures cut out of a components catalogue, it's like something from nursery school and you have passed him. I've done a serious report and you want me to resubmit"*
>
> *"I think you know that there is a difference between what you are capable of submitting and what he is able for. You want to be submitting work at a standard that reflects what you are capable of"*
>
> *"Right, so I have to do more work than him, and to a better standard but I get exactly the same mark, a pass. Surely everyone should be held to the same standards if we are all getting the same certificate"?*

Ultimately, as you would expect, I lost the argument and had to resubmit, but I was aggrieved by this and felt that it detracted from the value of the qualification, but was mainly annoyed because I was being asked to do more work for the same reward and I felt that the same standards should be applied to all students.

Another issue related to the same student came up later that year. I had been off on Monday, and in Tuesday morning, accompanied by a few smiles from the rest of the group, someone said, "Guess who you've been paired with for the final project". While I was off on the Monday, everyone had rushed to ensure that they were paired with anyone but him. This was good natured teasing and I shared the laugh, but soon marched off to the lecturer's office again;

> “You know what’s going to happen here, I will be doing all the work and he will saunter in half way through the day. I’ve nothing against him personally, but you know he is not going to be able to contribute to this”
>
> “Look, the projects are in groups of two, someone needs to work with him”
>
> “No way, this is a bridge too far. This is the most important part of the course, and I’ll either have to do double the work just to pass, or end up failing because he won’t pull his weight. We have to present this project to our potential employers. Remember the presentation he did for communications, it was a good laugh and everything but I need to appear professional when I am presenting to a potential future employer.”

Eventually I prevailed and was put in a group of 3 on a project that was too big for the 2 people that were currently assigned to it, and the other student was given a smaller project on his own. I felt a bit sorry for him working on his own, but the final project was too important. I always think of this experience whenever my current students complain about group working. I hear my colleagues, and sometimes myself, saying things to students like, “it evens out”, and “you have to learn to work with others”, but it’s not that easy when it is you that is being affected. I find this to be a big problem when designing group project work, which is considered to be of great importance in engineering, and coming up with marking regimes that encourage group work but also reward those who contribute the most. It’s true in industry that you end up in groups with people who don’t pull their weight, but in industry these people are eventually fired. The main difference though is that in “real life” group work you don’t subsequently get a mark out of a hundred that you then have to carry with you in every job interview for the rest of your life.

The best job I ever had?

At the end of the HNC I ultimately found myself working within the semiconductor industry as an Engineering Technician. I often describe this as the best job I ever had. This was probably skewed by the recent comparison with the garage, but even with hindsight I can see that this company got a lot of things right in the way they motivated employees. I was working on challenging tasks, sometimes on my own, sometimes in a small friendly team. There was encouragement and reward, a respectful working environment without being so weighed down by political correctness that it became sterile, and while those who wanted to progress were encouraged, others who were happy to just ‘get the job done’ were not pressured into moving on.

One of the best initiatives was what they called the ‘Technicians Technical Ladder’. This initiative encouraged motivated technicians to write reports and present projects to an annual panel of engineers and managers. If the panel approved you received one credit or moved up a rung on the ladder. Once you had three credits you would be transferred to an engineering grade and offered the option of either moving into a Monday to Friday engineering role, or remaining a shift technician but on an engineering pay grade. The technical ladder effectively removed the grade ceiling for technicians, with the company in turn benefiting from projects that were outside the normal scope of a technician’s job. I would identify the technical ladder programme as a key factor in motivating me to study for a degree in engineering. It turned what could have been “just a job”, into a career, and encouraged me to go beyond my daily allocated tasks and find projects and improvement opportunities that I could use towards the goal of reaching the next rung on the technical ladder.

While in this company I again found motivation to learn driven by career aspirations but in a much more positive way than before. I was now reasonably well paid and relatively secure. I didn’t “have to” do this, I didn’t *really* need the money, but I enjoyed the work, was starting to have confidence in my abilities and was starting to develop career ambitions that were not solely related to income. I decided that I wanted to become a professional engineer and I knew that I would need a degree for this. I looked at a number of options, including part time and even full time study, but the least risk and most flexible option was a part time distance learning degree programme. One factor in particular that attracted me to distance learning was that I had a feeling I wasn't going to be in the same location for much longer, and I needed a study programme that was portable.

I was with this company for less than three years but I had already completed two of the three credits required by the technical ladder. Although the site I worked on was very successful, global economic factors were raising questions about its future viability. I was offered a job overseas, and the company I was moving to had given guarantees that they would take over the fees for the degree programme that I was about to start. I relocated, and my decision was vindicated when my former company started to announce redundancies less than a year later. I didn't have nearly as many good things to say about my new company, as the previous one, but it was still a good job, well paid and in comparison to my experience in the garage it was paradise.

Across the sea and a distance learning degree

A new kind of learning

My new job wasn't nearly as challenging and rewarding as my previous one, and in a way that may have been a good thing as I was able to concentrate my extra energy into the degree. To begin with this was a traditional distance learning course based mainly on printed course materials and textbooks, with assignments being posted in the other direction, but the beginnings of online learning were also starting to appear through online forums and basic web pages. The internet did not yet have the bandwidth for video, and this type of media arrived in the post as VHS tapes, and sometimes CD-ROM's.

Studying this way was tough…

I stare at the textbook in front of me and wish I could go back to bed. It's Thursday afternoon but I've just worked 4 nightshifts, 6.45pm till 7.15am each night. Traffic was a nightmare this morning. This is a bizarre existence, I come out after a nightshift and go straight into rush hour traffic heading into the city. I get home after work and I don't know if I want a bottle of beer or breakfast cereal. It was after 8 before I got home this morning and I'm only driving 5 miles! I look at the clock, it's just after 2pm and I have been staring at this same page for an hour. 4 hours sleep is not enough, but I need to get up early after the last nightshift to 'swing around' into days and get into a dayshift sleeping pattern.

At least I've a month of dayshifts in front of me, that will help me catch up with the study. I can't think straight during the month of nights. Colin will want to go to the pub tonight. Maybe I should just go it might help me sleep and get me out of nightshift mode. I need to get my mind back to the subject at hand but I can't get my head around this concept. Radio Frequency electronics is not a subject for a nightshift week. I need to see if I can find a different way of looking at this, it's a pain not having the internet here. Maybe I should go to the library but too many distractions there. I could email the tutor, or try the forum, but it could be days before anyone gets back to me and I'll be back on shift with the assignments due just after that. Maybe I should switch to another subject, what else to I need to look at, Neural Networks, no thanks, better just go to the library and get online, should I eat before I go, I wonder what's on the TV…..

While there were challenges, some aspects of this type of learning seemed to suit me. I think my tendency to 'drift' sometimes went against me in classroom/lecture based teaching, whereas if I did that with distance learning I could just reread the page. Maybe that's part of the reason why I seemed to learn more from reading books in high school than I did from the classroom?

I remembered a work colleague who started the same course a year before me but didn't get past the end of the first year. He said that he just couldn't get motivated to study on a Tuesday afternoon in the house. Maybe it was not having a classroom schedule to keep him on track, or a difficulty adapting to this different style of learning (he already had a Higher National Diploma so he was capable of the level), or maybe it just wasn't important enough for him.

This made me think of my current situation and how the success and failure of my own distance learning students does not seem to correlate with the level of their entry qualifications. I see students who already have degrees in other disciplines who don't reach the end of the first year, and others who have barely scraped past the entry requirements but finish with first class honours. According to my colleagues who look after full time admissions they do see a correlation but then they are dealing with a more homogenous group, who are nearly all the same age, with an almost identical set of qualifications.

The distance learning course materials I received were of good quality. One relatively unusual aspect was that the Electronics module also came with a very large box, referred to as a 'home kit', which contained electronic components and test equipment. This was quite innovative, and brought with it a practical aspect that while very important for engineering study is unusual in distance learning, and arguably impossible in online learning. However, when I consider this from my present day viewpoint as a course director the concept is fraught with logistical difficulties such as shipping and production costs, liability if someone misuses the equipment and hurts themselves, support if the equipment doesn't work and so on. I stopped for a moment and considered how difficult it would be for a course like this to compete financially even then, but even more so with today's proliferation of free online courses and spiralling shipping costs.

Mathematics again

I previously discussed my difficulties with the abstract teaching of maths in high school, but while this bad start had not helped me in a career in engineering it had a varying but relatively small impact up until now. In the motor vehicle industry maths came up occasionally in college but at a low level, and on the job, other than arithmetic it didn't come up at all. At Higher National level the required mathematics was slightly more demanding but I was able to do enough to get by, but again there was little need for it on the related job as a technician.

When I received the first set of course materials, for 'analogue and digital electronics' there was an introductory booklet labelled 'read this first'. It was all about maths and the importance of this to studying electronics. The booklet included a maths exam which the student was advised to attempt as a closed book self-assessment before starting the course. I took the test and couldn't answer very many of the questions but I added up my score and compared it against the bandings given. I can't remember my exact result, but it was in the lowest band which carried a very strong warning that the student should defer the course, and take a level 1 maths class. I don't remember the exact wording but in my head it sounded like *"Do not under any circumstances take this class, you don't know the first thing about engineering maths, seriously don't take this class YOU WILL FAIL"!!!!*

I of course ignored this warning and instead bought the recommended Engineering maths textbook and started the electronics course in parallel with teaching myself engineering maths. I soon realised that even the engineering maths textbook, which was supposed to be revision for the electronics course, was beyond me and I had to seek out other resources at a lower level to supplement this. So, at the very beginning of this degree, when I was supposed to be revising engineering maths, I was actually learning much of it for the first time, and in order to do that I had to revise high school maths, most of which I had completely forgotten, while at the same time trying to learn electronics which used mathematical constructs to explain the concepts. It wasn't an ideal start and should probably have ended in disaster.

Imaginary numbers?

There was one unintended positive side effect of this approach. By going against the published advice of the university and learning the maths alongside the electronics I had direct relevance for the abstract mathematical concepts that I was faced with in the textbook. One of the best examples of this is when I came across complex numbers part way through the electronics course.

I had been studying from the maths textbook earlier that day and was now in the pub having a quiet pint with a friend. After a lull in the conversation;

"How's the study going?"

"I think I have had enough, they want me to believe in Imaginary numbers now!"

My friend laughs, "imaginary numbers?"

"Yeh, it's these complex numbers. I've just started the chapter but after reading that bit about a complex number having an imaginary part I am really starting to question this. I mean what is the point of some of this crap?"

"Well, rather you than me mate!"

What I didn't realise at the time was that I had reached a critical point, in both my relationship with learning, maths in particular, and also whether I would even continue with the degree. In my much later study of education I would learn that what I had faced here had been well documented as a threshold concept (Meyer and Land, 2003), a concept that while almost universally troublesome to students, if grasped, could allow a student to cross a 'threshold' and open a door to a greater understanding.

In a fortunate coincidence the day after my unhappy encounter with complex numbers, the next topic in the electronics text, was alternating current (AC) circuits which required an understanding of complex numbers and how to manipulate them. When I actually returned to study this concept in earnest I had very little trouble with it and the concept remains fairly well understood to this day (even though I have had very little use for it in practice since). I think that the reason for this was that firstly I was being given a practical example of where I could use complex numbers, and most importantly the visualisation described below allowed me to 'see' what was happening in a practical scenario at the same time as learning how the maths could be used to represent this.

Before this point all of my learning and experience of electronics had been with direct current (DC) where conventional numbers work fine, but alternating currents (AC) have both magnitude and phase angle. The figure below shows an example of a rotating current generator of the type I would have been studying in electronics. As I learned about how electricity was generated, I realised that there was a 'real' part (the alternating voltage) that would correspond to the blue spot on the side view of the wheel and the voltage output in the sine wave to the right, that could be represented by a real number. But in circuit theory it's also necessary to know the phase angle represented by the front view of pulley wheel that can't be seen when looking at the pulley from the side, or the measured voltage output, and is thus the 'imaginary' part.

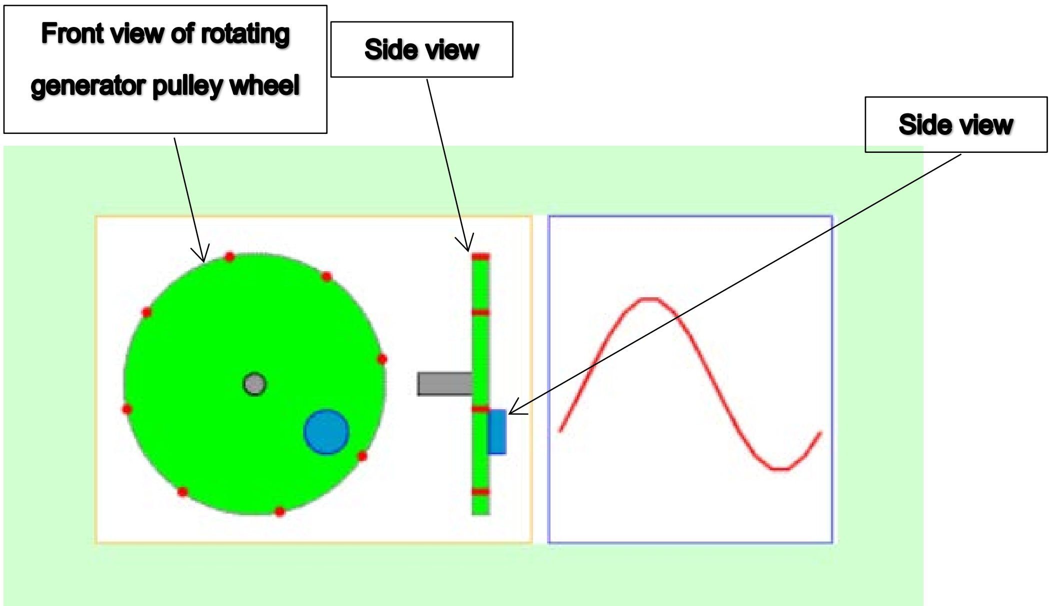

Figure 3-1: Rotating current generator and voltage output (Lesurf, n.d.)

I believe that if I had been asked to accept the concept of complex numbers without being able to visualise a practical reason why I needed a 2 dimensional number with an 'imaginary' part, I would probably have stubbornly rejected it. This also drives home the fact to me, that to be motivated to learn, I need to be able to visualise a purpose for the concepts I am learning. For me it was luck that I encountered a practical reason for complex numbers at the same time as learning the mathematical concept. The reason that I include this diagram is that it is this visualisation and the need to represent magnitude and phase in electronics that I remember about complex numbers, not the pure mathematical theory behind it.

So did the math's turn out to be useful?

One of the things that has struck me most about my study of engineering is the contrast between how fundamental mathematics is to engineering education, while in contrast it has seemed almost irrelevant in my career as an engineer. I thought about this a lot while I was studying engineering, and I still think about it now, so took a break from writing this section and dug out a few of the electronics texts from my undergraduate study.

The first thing that I noticed was that the mathematics had once again become unfamiliar, mainly because in the years working as an engineer that followed this study I had not needed to use maths. As an engineer I had used spreadsheets and modelling software to solve engineering problems that required manipulation of data. In many cases the entire process of measuring, calculating and analysing data was automated, and as an engineer my decision was often based on a visual output from this analysis such as a point on a graph.

The second thing that I noticed was that many of the concepts that I had studied varied along a line between partially relevant and completely irrelevant to the practical tasks I would undertake as an engineer. I wondered how much time I had spent studying concepts and even whole subjects that held neither personal interest nor practical application in my career? If the time I had spent on this in order to gain a qualification, had actually been spent on in depth learning of aspects that could have been directly applied in my job, would my learning have been deeper, and would I have been a better, more effective engineer? I also wondered whether, and to what extent some of the things that I thought were irrelevant perhaps had a relevance that I was not aware of?

Throughout my career in engineering I heard people say things like “you probably only use about 20% of what you learn in your degree”, or “you soon forget all of that maths stuff because you don’t use it in industry”. When I later entered academia I found engineering lecturers almost religiously defending the need for not only the current levels of engineering mathematics, but arguing for more and bemoaning the mathematical ability of current students. What surprised me most was when an academic admitted to me that they didn’t really use classical mathematics in their research. I thought “if it’s not used in industry, and it’s not used in research then what *is* it used for?”

One argument offered was that by just using computers to solve problems you wouldn't understand *how* the solution was achieved, but the same academics use computers every day without understanding how to write the programs they use so this seems like a contradictory argument. Is it possible that the only reason that there is so much advanced mathematics in engineering education, is because of a self-fulfilling prophecy of academics continuing to teach others in the same way that they were taught?

Credit overload and an obsessive motivation?

Against the published advice of the university I had decided to go straight into 90 credits of level 2 classes in my first year of distance learning degree study, using my Higher National Certificate to get credit for level 1. This was an equivalent load to 75% of year 2 in a full time engineering degree. As I had bypassed year 1, I also had to self-teach myself engineering maths and other fundamentals alongside my degree study so I was probably doing close to full time study while also working a minimum of 44 hours per week. In the following year I moved up to 120 credits of honours level study, and although I managed to negotiate a month of unpaid leave to help with the workload, I was also planning for another international relocation with the move scheduled about a week after my last exam.

The credit overload was not reflected in my first year marks and many of my assignments were graded at 90% and higher. This caused a friend to say something along the lines of "you will end up with a first class honours if you continue at this rate". Although my only aspiration had been to pass the degree, I can now see that this moment and good results at the end of the first year triggered a motivation that was based on a 'goal' that had nothing to do with either the subject matter of the degree, or career/financial rewards. When I consider that my career goals at the time did not require anything above the minimum classification, I now reflect that there was a new motivational factor at work here.

Motivation 8: Grades or the goal itself

I have competing feelings about this. In retrospect I think that my electronics tutor may have been a generous marker, and probably gave away too many hints about the assignments, but I wonder whether I would have been so motivated if I had not received these early high marks, as they gave me confidence that I was capable of this level of study. On the other hand, I became a little obsessed with the grade, rather than the learning, and I was caught out a little in the exam when I did not have time to perfect everything as I had done in the assignments.

I wonder now what was behind this motivation. Prior to this degree I wasn't even aware of the honours classifications and within a few months of the conversation described above I was determined that it had to be a first class degree and nothing less would do. Some of this appears to have been a direct result of doing well in the first assignments and a natural desire to maintain this standard, developing into a competition with myself to see what I could achieve. There may also have been a subconscious need to prove myself to others.

In the environment I was now working there was a stereotypical 'them and us' rivalry and inferiority/superiority complex existing between technicians and engineers. Generally speaking technicians had practical skills and qualifications that were below degree level, and engineers had degree level qualifications and tended to focus on more theoretical and technical management issues. There are some parallels here with doctors and nurses, army officer and private solder, manager and subordinate and like these other working relationships part of this may be a throwback to the class system. I would not have been immune to this and I suspect that part of my need to do well in this degree may have been to prove that I was 'as good as them'.

Motivation 9: Proving my worth to others

Coming back to the excessive credit loading that I had taken on, while what I achieved could be a model for time management and motivation, it was probably not so for mental health and quality learning experience. While indicative of the level of motivation that I now had for formal study, in retrospect the excessive load probably led to what I would later know as surface approaches (Webb, 1997). The excessive load which I took on of my own accord is also indicative of an impatience and the fact that I am often working towards the end goal of the qualification, rather than the learning experience itself.

I also remember being under a great degree of stress because of this workload and I see the same signs in some of my part time students. The stress of a final year and the impending results is enough on its own but coupled with the challenges of balancing time for study with a demanding employer, as well as family and personal lives, the stress levels can be explosive. As a course director I find myself explaining this to teaching staff who are bearing the brunt of these student's outbursts or unreasonable complaints, and trying to pacify the students themselves. This is a good example of where empathy has helped me as an educator of distance learning students.

Having achieved an upper second class honours degree I dropped the study levels back for a year to a single 15 credit module as I started to work towards topping the Bachelor of Science (BSc) up to an MEng (Master of Engineering). Why did I decide to continue to MEng? I didn't need it for the job I was going into, but I was again thinking beyond this and how a BSc without a specialisation would be perceived by future employers. I also had set my sights on Chartered Engineer (CEng) and I needed an MEng for this. There was one other motivational factor. Between the ungraded transferred credit that I had used counting against me, and being a little unfortunate with the grading system, I had very narrowly missed out on the first class honours that I had set my sights on. The MEng gave me the opportunity to "fix" that, and although I cut back to a more reasonable 60 credits per year, I poured everything into the next two years and in particular the final project, to ensure that I achieved the desired distinction. By the time I got there, all other motivational factors had been eclipsed by this single minded goal.

Strategies for learning or strategies for getting through?

The discussion above reminded me of how I studied during the early days of my degree and how the huge load required me to have a strategy for nearly everything I did. I remembered that I “studied for the assignments”, speed reading the course materials highlighting passages of text, and only really learning when I came to the assignment for that section, which I would spend a huge amount of time on, trying to maximise the percentage marks. As there were thirteen assignments in my electronics module, and another four in the computing module, this was probably less of an issue than it might first appear, as the assignments covered most of the course content. However, as part of my strategy, I had analysed the University’s compensation scheme, and worked out that as long as I maintained an average above a certain value, I could avoid doing two of the electronics assignments and one of the computing assignments with a negligible impact to my grade. Time was limited, and I had to strategize to get through, but given my skimming then cramming for assignments strategy, I suspect that in the case of the computing module, that this meant that a quarter of that module may have been skimmed!

The dreaded examination

When I came to the exams in the first year, I did well but not nearly as well as in the assignments. I would admit that this may in part be due to my skimming approach, but despite this and because I had put so much into the assignments, by the time the exam had come I had reviewed the entire course, studied hard and had learned a huge amount. The thing that struck me in the aftermath of the first exam I had completed since I was 16 years old was how unnatural a process this was. To have spent perhaps 600 hours learning about something and to then be assessed on my knowledge of that subject in a 3 hour memory test. In my case it felt particularly harsh as after completing 13 assignments with an average of over 90% I was high into the

‘1’ grade for the assignment, but with 69% I missed out on a ‘2’ band in the exam by 1 mark and was then awarded a 3 overall for the class. The policy was that the final award would be the lower of the two rather than an average and I remember being angry and demotivated by this, feeling that I may as well have not bothered in the assignments.

The other unnatural aspect was how unlike reality this was. Engineering is a vocational subject and if I needed to apply a concept in the workplace I wouldn’t try and memorise an equation on the off chance that I might need it later. I would try to understand and remember the concept, make a note of the equation and supporting information and then refer to it in the future as needed.

Master of time management and strategy?

Looking back on all of this this, even if I remembered nothing of the content, I at very least became a master of strategy and time management and I would have to admit that this has served me well in my future career. In fact, when I am advising distance learning students I often stress that they should sell the fact that completion of a part time degree while working is evidence of excellent time management skills.

In my distance learning degree I spent a huge amount of time strategizing about how maximise my grades. I deliberately choose modules without exams because I knew I was much better at project work where I could take my time, refer to notes and textbooks and think the problem through, than when I needed to rely on speed and memory. I tended to skim the course notes then use assignments, which I spent a lot of time on, to guide my learning and this resulted in very high assignment marks and slightly lower exam marks. The exam marks often dependant on how close the exam was to my revision strategy and the questions that I had worked on beforehand so some portion of this was inevitably down to luck.

The above might give an impression of someone who was only able to plug numbers into a question and had not developed an ability to think and apply problem solving methods, but in my working life as a technician and later an engineer this was not the case. I disliked having to follow procedure and tended to find novel solutions to problems by applying first principles and transferring solutions from disparate contexts. As I wrote the above I started to consider why I acted this way in education but not in practice. I remembered how I had become motivated by grades. In part this was positive and may have helped me make it through the degree, but it's fair to say that I was probably more motivated by getting a first class degree than I was by anything that I was learning. When considered in a certain context it could be argued that my approach was correct. If I wanted to simply learn about electronics I would have bought a book. I was doing a degree not just to learn but to obtain an item that would have vocational currency so the primary goal was *not* learning, which by this stage I had realised I might not even use, but the degree classification. In this context it makes perfect sense to utilise the strategy that gains the highest mark; “it’s all very well for teachers to talk about the learning not the grade being the most important thing, but its me who has to carry the degree classification around my neck for the rest of my life!”

There is another motivation that comes to mind when I think of this period, one which has been mostly positive in my life, and in my head is known as; “I’ve started so I may as well finish”. Once I have expended effort towards something, I can’t bear to see that time wasted. There is of course a negative side to this too, in that sometimes I “don’t know when to quit” and spend more time trying to finish something just because I have started than the final outcome is worth. I think that this attitude started during my apprenticeship, where I put up with so much in the early years that I just became more determined to finish. I had a similar attitude to my degree where I knew I was initially out of my depth, but I put so much into it that even though I was nearer the start than the finish, I still couldn’t bring myself to make the effort I had already expended count for nothing.

Motivation 10: Finishing

From Industry to PhD

Graduation and a career as a professional engineer

By the end of my distance learning university education I had achieved a Diploma in IT, a Bachelor of Science (BSc) with upper second class honours and a Master of Engineering (MEng) degree with distinction. The 'with distinction' part here is interesting; what motivated someone who had no interest at high school level, and was completely unprepared for degree level study, to achieve the highest possible classification, while only able to focus part time and with minimal tutor support? I have answered a lot of this in the previous text but it still puzzles me a little. How much of this was just me, and how much was external influences? Could I have achieved more (academically) if I had more positive influences at an earlier stage, or had access to different styles of teaching and learning?

Sometime in-between graduating with my BSc and completing the MEng, I was offered a job as an engineer with the same company. I had a sometimes fractious relationship with this company as a technician, but this improved as an engineer, partly because my job was more challenging and also because, in my opinion, the company did not place as much value in their technicians as they did in their engineering staff. I enjoyed this job and was able to apply some of what I had learned over the years, but I often felt that I owed more of my engineering problem solving abilities to my apprenticeship than I did to the degree.

It was these practical abilities, and a tendency to want to learn about a technical issue by observing rather than crunching data or theorising that gave me most of my success as a professional engineer. I became heavily influenced by a set of ideas that were often referred to as 'Lean Manufacturing', or just 'Lean'. My company had made a corporate decision to follow this philosophy and it had become the buzzword within the organisation. This was a good fit for me as I felt that lean was just a new way of describing something that I had always done but it raised my profile in the company because the type of simple but effective projects, often based on observation and incremental improvements that I was doing anyway, now had a name, they were 'lean'.

A particularly successful project had a primary effect of fixing a costly recurring problem in the manufacturing process, and a secondary effect of allowing us to reduce consumption of a very expensive and volatile chemical. Conservative estimates would have put the annual saving for the company at around £20 million dollars although the real saving could have been much higher, depending on how many interruptions to production that there would have been if the project had not been implemented. The circuit that I had designed and built was very simple and cheap to build from off the shelf parts, but what was innovative was the way that I had implemented it using spare machine outputs that were not intended for this purpose. First observing the issue, applying first principles to think through how I could detect the issue before it happened, applying incremental improvements and then integrated it into existing systems gave this all the hallmarks of a lean project. The low cost high impact solution was implemented in sister factories around the world, and resulted in my first experience of presenting in a technical conference, I had to design and deliver training courses and was exposed to the protection of Intellectual Property (IP) process through discussions with a company lawyer over whether formal protection for the invention was required.

I considered how much of this project came from my degree education and concluded that it would have been unlikely that I would have been able to solve this problem without the knowledge gained in my engineering degree. However, it was the knowledge of concepts rather than the ability to prove anything mathematically that allowed me to do this. I knew from my degree that passing a sound wave through a pipe with a liquid in it would produce different frequencies than a pipe with a gas in it, and used this knowledge to source an ultrasonic sensor from a supplier. The circuit I designed required knowledge of electronic principles but at no point in the project did I write down any mathematical proofs. When it came to writing proposals, reports, training material, specifications and presentations about this project I clearly benefited from the technical writing needed in degree projects, but at no point did I need to describe anything mathematically.

Lean had become an effective banner for me in this and many other projects, but the importance of this philosophy for me was its simplicity. Lean in its essence could be taught to any employee at any level in the company, with about an hour of training, but there was an interesting development about how this was presented within the company. Lean, became Lean Six Sigma, where the addition referred to statistical analysis techniques. The training courses became longer to allow for the added complexity and various Lean Six Sigma qualifications were introduced. Some people started to go on external lean and Lean Six Sigma courses and even Masters degrees devoted to the subject. I remember saying to one of my colleagues:

"has no-one noticed the irony that in the first class on lean there was a video about how the air force maintenance teams reduced their costs and transformed their organisation with a 1 hour class for all staff, and since then we are now running day and week long classes on this?"

There seemed to be an inability in this engineering led organisation to accept the simplicity and qualitative nature of this process and need to unnecessarily complicate it and make a training industry out of it. I wondered about how much this was related to the educational background of those making the decisions and a need to be able to describe everything mathematically. I wondered about how this related to education and how something simple can be made complicated by those who are teaching it, possibly to satisfy their own ego, justify or advance their status, or because of some other need to over analyse or increase the complexity of a subject.

With the load I had taken on during my degree, the gathering of qualifications had become a slight addiction, and I also qualified as a Chartered Engineer (CEng), and a Project Management Professional (PMP) before the end of my time with this company. The PMP qualification, which is an international non university affiliated qualification, issued by the U.S.A based Project Management Institute (PMI), has an interesting feature which I have often thought is very relevant to lifelong learning; it is *not* automatically a lifelong qualification.

The PMP qualification needs to be ‘maintained’ and the certificate has a very clearly indicated date of award and date of expiry. At the end of each 3 year certification cycle, I am required to submit evidence of activity in the area. This is likely to comprise of project management related education (learning or teaching) and practice. While I would consider my university qualifications or my registration as a Chartered Engineer to be of higher value, and at a higher level, none of these have required me to revisit the knowledge or understanding that I acquired in order to achieve the qualification. I don’t really do a lot of formal project management, but having gained the qualification I have been motivated to retain it and in order to do so I have given a few lectures, read a few books and written a project management simulation. Some of these things I would have done anyway, but the recertification cycle gives me extra motivation to look for opportunities to maintain my qualification. I contrast this to degree education and in particular the modular system, where intensive study is followed by an exam, which is often followed by “phew, I passed, I can forget about that now!”

Before moving on from this period of my life, characterised by intensive (mostly distance learning) study, alongside an increasingly demanding career and a lot of international travel, I did one final course. I paid for it myself, almost as a nod to the career I *didn’t* follow, and completed a 30 credit undergraduate module in ‘The Technology of Music’.

From Industry to Academia

All through my post school education but in particular after I started distance learning, I was consciously observing and thinking about the way that I was being taught and how I learned. I had started to consider what I thought made a “good teacher or a bad teacher”, which of my tutors I felt were in it for the “right reasons” and which I felt were “just taking the money”. I thought of education, like healthcare, as a field where people should have a “duty of care” and wondered what it would be like to have a career that directly affected society and people’s lives. All of my previous employers had been private companies and I generally felt that the impact of whether I did a good or bad job was mainly for the benefit or detriment of wealthy business owners or faceless shareholders.

I had read a lot about studying while I was doing my degree and part of my strategy was to learn how to learn. I had read that people had different learning styles, recognised some of these aspects in myself and had thought a lot about the good and bad aspects of my learning experience. Partly in order to move back home to Scotland, and partly because of this developing interest in education, I started to look at jobs in this area. When I saw a vacancy for a person to run a suite of engineering distance learning courses in a conventional university, I was surprised to find that my experience seemed to be a good match to the job spec. One of the key requirements of the post was for a Chartered Engineer with industry experience, but I also had personal experience of distance learning, a good understanding of computers and technology, and my experience with music had exposed me to many of the techniques and technology required to record and present audio and video based course materials.

The job started out as one of mostly management and logistical development, but I very quickly became more involved in the strategic and academic direction of the courses. When I arrived these courses were not really what I would have considered true distance learning, and were based on six weeks of intensive on campus teaching spread out over the year. This model had worked well while the course was meeting the specific needs of local industry, as the companies paid the fees and gave their employees time off for the on campus teaching blocks. By the time I arrived the number of students sponsored in this way had dwindled, and less than half of the registered students were able to attend classes. It was clear that the model needed to change.

The students who attended the campus classes received high quality teaching in very small groups, but students who could not attend such as the few overseas students received nothing in place of this. I felt quite strongly that all of the students we accepted on the same course should have access to the same standard of teaching, even if that meant that the standard might drop for those who were used to attending in person. There was also the fact that continuing to run on campus classes for about five students was financially unsustainable.

I started to move the course towards a fully, and mostly online distance learning format. This period brought a lot of challenges and resistance, from staff who didn’t want to change the way they taught, to the few remaining students who were able to get time off work to come to the campus classes. But whatever else is said, it was certainly successful and the student numbers tripled. The online approach also allowed the reach of the course to spread and enabled students from all over the world to participate.

The shoe on the other foot?

After 20 years engaged in various forms of learning since leaving school, I had found myself for the first time with the shoe on the other foot. Although I had taught apprentices and run training courses in industry, for the first time I was formally employed as an educator and seeing things from the other side of the fence. It was an unusual role to begin with as I was the course director but not an academic, and at that point I wasn’t doing any teaching. In many ways I operated as a kind of broker between the distance learning students, and staff who sometimes had difficulty or an unwillingness to understand distance learning and the particular issues these students faced. The fact that I had been an adult learner for 20 years, compared with only a few as an educator, meant that I tended to retain a student perspective, although I was also developing an empathy with my academic colleagues and the issues and challenges that they faced.

This new perspective was most apparent in my attitude to formal examinations. As I have said previously, I felt as a student that formal examinations disadvantaged me. I didn't do well in exams. I felt that they were an unnatural scenario that didn't bear any relation to practice in the "real world" and that assignments and projects were a fairer way to gauge someone's understanding. My student perspective was influenced by the fact that I was studying alone and submitting my own work, and so presumed others were doing the same. In academia I found myself repeatedly dealing with plagiarism, and without exams I had no way of knowing who was really doing the work. This introduced a conflict. I wanted to bring my student perspective into course design, but my perspective as an educator was telling me that exams were still a "necessary evil".

Although I felt that exams were necessary it was not the exam itself that I felt was important, just the verification that it was the student doing the work. I had many discussions about this with my new academic colleagues and gave them my perspective. I told them about a digital communications exam where the students were allowed to bring in a fully annotated course reference text. The reference text did not explain concepts but held all of the needed equations, communications standards etc, and so instead of testing memory, the exam tested the students ability to use the reference material, understand concepts and use this to work out solutions to problems – just like an engineer would! The exam was not any easier than other exams because by allowing the reference material the course team had obviously felt justified in asking more complex and less predictable questions. The reference material would have been little help to anyone who had not learned the subject matter in advance, but it helped avoid the traditional staring blankly at the exam paper for ten minutes for want of a trigger word or equation.

Postgraduate Certificate in Advanced Academic Studies

After a couple of years working at the university I took up an opportunity to do a class in teaching and learning online in the hope that I would find resources and methods that would help to improve my distance learning courses. In the first part of this module I learned little that was new, but the second part was a project and required a short literature survey. The literature that I sourced on distance and online learning was the beginning of the connection between my experience and educational theory which would later motivate me to start this PhD. I was drawn into debates about distance and online learning and related these discussions to what I had seen in practice, both as a student and as an educator.

I was particularly drawn to Kenneth Fee (2009, p. 100), commenting on how often e-learning is designed to satisfy the 'whims of those who will not actually be experiencing the learning'. My own experience confirmed this to be true, but I also thought “how often is it designed for other reasons such as saving money, making money or in an attempt by a teacher to reduce their workload rather than because it improves learning”. When I read MacDonald’s (2008) suggestion that not all students like learning exclusively online, this reminded me about how as a student I often found it easier to learn from printed course materials, than from videos and online activities. I thought of a colleague who with the best of intentions had taken the time to develop his online class and introduce interactive quizzes, videos etc. He subsequently received a barrage of complaints because the students wanted course materials that they could “print out” for various reasons including the fact that many needed be able to study when travelling and in locations without internet access. I think the students may have been partly at fault for not giving the new format a chance, but there was also a strong element of mixing up what those ‘experiencing the learning’ wanted, with what he thought they wanted.

As I thought about the use of learning technology it became clear to me why I preferred the term *distance learning,* to the arguably more current *online* *learning* or *e-learning*. I felt that distance learning should make the best use of any available resources that can be provided regardless of whether these are online, printed, or physical like the excellent ‘home kit’ I used in my electronics degree course. I wasn’t against online learning, but I found myself agreeing with criticisms that it was often just being used as a new way to access content (Sharda, 2010), and should instead consider the right technology both for the learning environment, subject matter and target market. I felt that if the learning content was text and static pictures then spreading this text across many HTML pages might look pretty, but it isn’t going to aid the student with learning, and in this situation the ‘right technology’ may still be a printed book or PDF.

As I thought about when online learning could bring a benefit, I remembered a very basic program that I had when I was studying electronics. This wasn’t supplied as part of any course and I can’t even remember where I got it but it used very basic graphics to visually explain numerous electronics related concepts. Whenever I couldn’t understand something from the text or mathematical description I would turn to this program and through visual examples of the flow of ions or electrons in a material, the concept would all of a sudden make sense. I considered how different students learned in different ways and I thought “a great online course for engineering would be one that could combine these, using links to offer visual explanations, in parallel with conventional explanations and mathematical proofs but this would take a huge amount of time to develop”.

I was beginning to link my experience with the newly discovered educational literature, but I was also finding that the boundaries my experience crossed would introduce conflicts. When I was exposed to ideas in educational literature about the use of social media in learning I contrasted this with what I had previously read in relation to effective time management. Much of the literature in this area advises against multitasking, and suggests where possible the removal of distractions. I thought about my own experience as a distance learning student and how I would often prefer printed course materials because I could use these to get myself away from the TV, the internet and anything that might be more interesting than the subject at hand. I thought “what could be more distracting than social media and a host of links, adverts and interactions with friends when you are trying to concentrate on something?”

I found all of this quite this interesting and I was beginning to develop a critical interest in educational literature. This meshed very well with both my experience as a student and later educator, with other fields that I had studied to varying degrees such as project and time management as well as my general observations of human beings in both education and life in general. When I learned I could use this module as credit towards a Postgraduate Certificate in Advanced Academic Studies, I registered on this course. In some ways this was typical of how I often convinced myself to take on courses, telling myself that “I’ve already done part of it, so I may as well continue and get a qualification out of it”. That doesn’t mean that I had no interest in the subject, but a major factor for registering for this qualification was that I was potently aware that I was now working in Academia, quite possibly for the long haul, and I felt I needed a related qualification.

Epiphanies

Although my reasons for taking on the full PG Certificate were partly strategic, I found the rest of this course which focussed on teaching, learning, assessment and course design to be even more interesting than the online teaching module. It was the literature in particular that I found interesting and I was exposed for the first time to concepts like deep and surface learning, threshold concepts and signature pedagogies. When I think about this period it relates very well to a quote I found when I first started to research autoethnography; ‘autoethnography is related to autobiography and autobiographers often write about “epiphanies” ’ (Ellis et al., 2010). My epiphany or series of epiphanies came as I started to explore the body of educational literature and realised that I recognised aspects of myself as a learner, both negative and positive. Reflexive ethnographies ‘document ways a researcher changes as a result of doing fieldwork' (Ellis et al., 2010), and it could be said that in a sense the researcher changes due to the impact of reality on their understanding of theory. I was conversely being affected by the theory, *after* experiencing the practice, as I had been an adult learner for decades and worked in education for years, before receiving any formal education about education. When I think about this now I notice that this also reflects my career as an engineer – where most of my understanding of Engineering was practical first before later learning theory, whereas most (conventional full time) engineering students understand the theory first before going into practice. It's very clear to me that having a practical knowledge of engineering before studying the theory, helped to motivate me to learn as there was a 'practical purpose' to learning this way and in the same way my experience as a distance learning student and educator helped motivate me to learn, but also gave me reference points with which to empathise, agree, disagree, discuss and debate.

I think that here were two significant reasons why the impact of these educational theories had a particular impact on me. Firstly, as discussed above, the perspective of the learner was still very fresh in my mind and as I hadn't started teaching, I tended to relate to this more as a learner than as a teacher. The other reason was that as I looked around the room I suspected that unlike me, most if not all of these people had been successful enough in high school to go straight to university and successful enough in university to become academics and teaching fellows. It made me wonder things like:

> *"What makes them different from me? Are they just naturally smarter, did they develop earlier, were they just surer about what they wanted to do in life? Are these 'ideal learners' who are somehow a better fit to the conventional education system or did they just work harder?"*

When the class covered 'signature pedagogies' (Shulman, 2005a) I thought again about mathematics and how pervasive this is in engineering education. I wondered if using maths to explain engineering concepts was simply a 'signature pedagogy' that exists because each generation teaches the next in the same way that they were taught. I thought how my background differed from my colleagues and how I had been focussed on practice for a long time before encountering theory in the way that it is taught at degree level. I also considered that as a distance learner I did not learn engineering in the same way as my colleagues, and while I was learning I was already working so I could see on a daily basis whether my learning had any on the job relevance. I thought “It’s probably reasonable to suggest that I am less influenced by signature pedagogies than my colleagues. Could this give me an insight or perspective that they do not have?”

Threshold concepts

Of the theories that I was being exposed to in this class the one that probably impacted me most was that of ‘threshold concepts’ (Meyer and Land, 2003). I learned that ‘core concepts that once understood, transform perception of a given subject’ (Meyer and Land, 2003) are related to what Perkins (2006) describes as troublesome knowledge and concepts that are almost universally difficult for students in various disciplines. A Threshold Concept could be considered one that although troublesome and perhaps alien to a student, if fully grasped, could allow a student to cross a ‘threshold’ and open a door to a greater understanding of the subject.

As I read more about threshold concepts I had a series of epiphanies about my own learning. I read the following passage from a paper on threshold concepts:

> ‘Moles as a concept is too alien for most to cope with and so many students give up trying to understand the real concepts... and end up rote learning the equations and applying them...this means that they can't cope with anything out of the standard question’. (Carstensen and Bernhard, 2007)

This was so familiar and remembered this as a point where I struggled in chemistry. Carstensen and Bernhard said that for many students the idea of billions of atoms being present in one Mole is difficult to grasp but as a student my own difficulty was not in relation to the scale, but in the concept that a 1 Mole of a substance had to be related to the number of molecules in pure carbon through Avogadro’s constant. This was a very different concept to that of mass which I had previously encountered and the idea that one Mole of one substance was a different weight/mass to another, was troublesome for me at the time. I reflected that I was very like the students in the above quote and I never became fully comfortable with the concept.

In contrast Carstensen and Bernhard (2008) identified threshold concepts in engineering that I would never have thought existed. They discussed ‘local reasoning’ and ‘sequential reasoning’, where in the former students think that a change in the circuit affects only that node and the latter where students think the change would only affect currents and voltages after that point in the circuit. This was a warning that I am not immune to taking threshold concepts for granted and I could see that if I was teaching basic circuit theory I could easily fail to identify these concepts as being troublesome to students. I later found this issue confirmed in the literature by Davies (2006) who asserted that threshold concepts are ‘taken for granted by practitioners in a subject and therefore rarely made explicit’.

Deep and surface learning

The differences between deep and surface learning approaches was another area where I could see many parallels with my own experience. I read Ramsden (1984) claiming that a lack of interest or a failure to perceive relevance is associated with a surface approach I and recognised this particularly in the latter years of high school maths. As ideas like Algebra came along and required a greater degree of effort for understanding, I was not prepared to make that effort as no one had bothered to explain the relevance. When I later mentioned this to some friends with more conventional engineering educations, they did not see the need for relevance when learning maths and seemed happy to work through these concepts without ever questioning why! This led me to believe that there are at least two types of students when it comes to mathematics. The first group and the most catered for are those who are happy to study maths for maths sake, and the second group who need to be motivated by an ultimate purpose. I wondered whether the common practice of teaching maths as a standalone subject misses this second group.

I also reflected that my education as a distance learning student, and for career reasons my drive to complete this degree in a very short timeframe, while also working full time, may have caused me to use surface approaches. Many students following part time or distance learning courses while working are likely to be in a similar position.

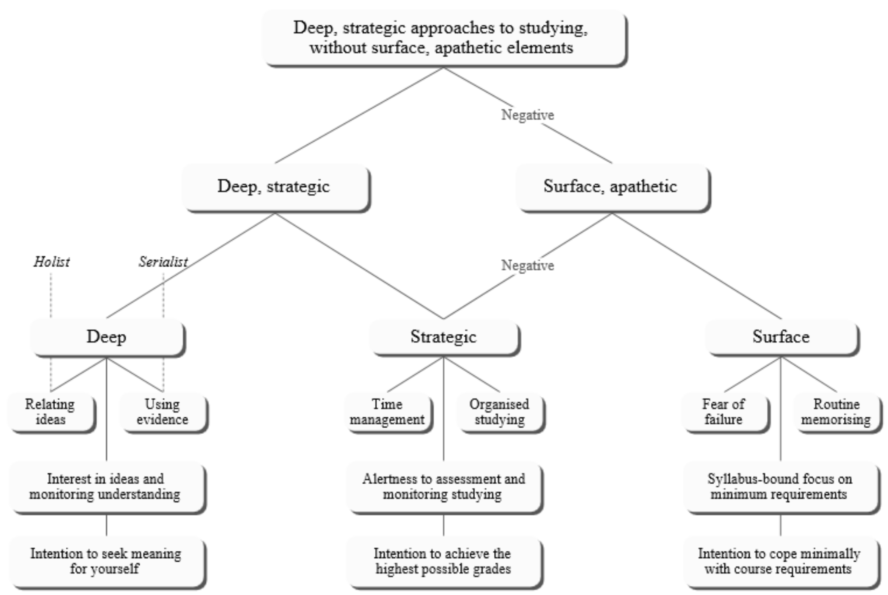

Figure 3-2: Components of the ASSIST inventory contributing to effective studying (Entwistle, 2000)

The diagram above was one that I first came across during this study period, but it became more relevant to me after writing the earlier sections of this chapter. In particular I realised that my formal learning was almost always strategic but I can also see that my approach varied between these approaches at different times and in different situations. I do not entirely agree with Entwistle (2000) that 'fear of failure' is directly connected to a surface approach. For me, fear of failure was a motivating factor and I don't think that it was in any way connected to the learning approach that I took. For me strategy will always be a part of formal learning because most people are doing a degree for career or financial reasons, but I can also see that many of the examples I have given in this chapter where relevance or personal interest helped me to learn, were a good match to Entwistle's definition of deep learning.

When I thought about surface approaches I wondered whether there scenarios where a surface approach can be beneficial or necessary. As an engineer in industry it's often necessary to have a very broad, 'black box' understanding of some concepts and skimming to obtain this understanding in a limited time might be appropriate. I realised that scanning is something that I have become very good at and recently noticed that when reading something informational I have often finished long before another person reading the same thing. I wonder if this 'skill' of scanning something rapidly and pulling out the necessary information is something that I developed while using surface approaches to study and thus could be considered a positive benefit of surface learning?

Constructing images

A particular paper that caught my attention in this class was by Tamsin Haggis (2003) and suggested that academics *construct images of themselves* in their students. Haggis was challenging many of the concepts discussed above and questioning whether academics developing these theories were trying to teach an 'ideal learner' (2003, p. 98) created in their own image. She wanted academics to rethink some of these ideas for a new generation of students who were entering a mass education system and were from very different backgrounds to the majority of academics who would be teaching them.

Haggis (2003) argued that much of the literature concerning concepts such as deep and surface approaches makes a presumption that students in mass higher education have the same aims as the academics, and want, or can be made to want, to relate meaningfully with the subject. Although Haggis (2003) was referring to conventional educational methods, I was aware from experience as a learner and as an educator, that many distance learners are motivated by other factors such as career advancement, rather than a pure desire for learning. Adult students who are working full time and may also have families are also under incredible time pressures and this may also contribute to surface approaches.

Haggis suggestion that academics 'construct images of themselves' made me think about the background of the people who wrote these educational theories and the academics in the class. I speculated that they had followed a traditional route of school, then university, then academia and if this was the case:

> *"How well placed are they to understand the needs of learners who's motivations for learning are very different from theirs?"*

In the context of Haggis I thought about of surface approaches from my student perspective:

> *"Was I wrong to skim? Was it not this that got me through the immense workload? It's all very well for an academic to talk about deep learning but if I am going to be barred from certain jobs because a degree is required then surely I have every right to gain that degree by whichever valid means that I can!"*

When I thought about Haggis and academics 'constructing images of themselves', I contrasted my student voice above with the attitude of some of my academic colleagues. Many of them have a very noble attitude to learning and want the students to understand science and engineering in the way that they do. They get frustrated when students press them about past exam questions and feel that they are missing the point, that they should be focussing on learning and understanding rather than just passing the exam. But in a mass higher education system, the reality is that many of the students are not there because of a love of learning, or a passion for science and engineering, they are often there because they want a good job, and some cases because there were no jobs to go to when they left school. To me this was the root of what Haggis was trying to say. That academics need to consider new ways to approach the teaching of students who are not natural learners like them, or naturally passionate about the subject like they are, realising that they can't motivate these students in the same way that they themselves might be motivated.

I thought about something I read once about management and how managers often want A but reward B. An example of this is where they say they want quality, but operate a time based bonus system. If educationalists set up degrees in a modular fashion then students will approach them in a modular way. If they assess using exams that reward students for memory and regurgitation then that is how the students will respond. It wasn't that I was trying to lay the blame for all of this at the foot of teachers, far from it as many aspects from degree structure to student numbers are completely out of the teacher's control. Policy makers, industry, societal attitudes and students themselves all come into play.

I started to ask myself whether I might have something to contribute, having been a student who did not fit well with the conventional education system, but who almost by accident ended up working within that system. The impact that these educational theories had on me in relation to my own experience as a learner, was the seed for this PhD and associated research.

High school failure becomes Associate Dean

Around the point where I was coming to the end of the PG Certificate and starting to consider a PhD, my success in developing the distance learning programmes within my department led to my appointment as an Associate Dean for distance learning in the Faculty of Engineering. Some months after my appointment, someone who had become aware of my early career background asked me, “How does someone go from being a motor mechanic, to an Associate Dean”. I laughed out loud and responded, “I think we would need to go for a drink as that answer that could take a few hours!” It was a light hearted and genuinely interested enquiry, but the irony was not lost on me and the question kept coming back into my mind. If I was to put modesty aside for a moment I would be forced to recognise that I had been reasonably successful both as a professional engineer in industry, and later in academia, and the enabler for entry into both careers was my university education.

In my mind I took the first part of this question back a bit further to “How does a High school failure become an Associate Dean”. I don’t mean this in a self-deprecating way regarding the former or a boastful way regarding the latter, and I wouldn’t personally use ‘failure’ to describe a 17 year old with their whole life ahead of them. However, considering my earlier potential, to leave school with bare passes in a handful of O Grades could not be considered a success. When I then consider becoming a qualified tradesperson, a Master of Engineering degree achieved with distinction, a successful career as an engineer, a range of other qualifications, and an appointment as Associate Dean, there is quite a sharp contrast. Depending on how you define success I have achieved more than many people my age who went straight to university from school. My reflection on the change between these two points and the motivations and methods that enabled it, later became the focus of this PhD.

An important note to finish this chapter on, is that the above is not intended to suggest that I have been failed by society or the education system, or that I have somehow not achieved my potential because I did not go to university straight after leaving school. What I am today is a product of my experiences, and without my practical background prior to becoming a professional engineer, I would not have the advantages that this gave me over those who only had a theoretical education. If I had not completed a distance learning degree as a technician I would not have the ability to empathise with my students in the same position. If I had not struggled with mathematics and its seeming irrelevance in industry I would not been in a position to question this in academia, or empathise with students who also struggle with it. Critically, at least for this thesis, if I had not had the unconventional experience of coming into professional engineering from a practical background, then moving into engineering in academia, and ultimately crossing into the social sciences to complete this PhD, as well as all of the other experiences above, then I would not have this story to tell and this thesis would not exist. The questions I might ask about my learning experience and motivations are more valid in respect to how they might affect others in the future, and this is what I now move on to in subsequent chapters.

Part 2

Chapter 4: From Autoethnography to a Bourdieusian analysis (including methodology part 2)

Introduction to part 2 and this chapter

Part 1 of this thesis was autoethnographical in nature, while the main focus of part 2 is a Bourdieusian analysis of engineering and engineering education. This may appear to the reader to be quite a leap, but between completing the previous chapter, and the decision to explore a Bourdieusian analysis of engineering education, was over a year of interviews, analysis, literature surveys and discussion. This chapter is a link between the autoethnographic part 1, and the narrowed focus and more conventional analysis of part 2. The initial sections of this chapter therefore describe the process that led to the narrowed focus on engineering, and the methodological decision to use a Bourdieusian analysis, before describing the Bourdieusian methodology and how it is applied in the later sections. In part 1 of this thesis I was primarily the subject of the research, in part 2 I am primarily the researcher, and this has necessitated a shift in perspective and approach, and may also be noticeable in a change of writing style.

This chapter mixes methodological elements, data and discussion of the decision making process, and proceeds as follows:

- **Initial reflective analysis**: This section briefly discusses and acknowledges the natural unstructured analysis that occurs consciously and unconsciously through the process of writing autoethnography.
- **Methodology used to analyse the autoethnography** describes the methodological elements I have used in my attempt to add a layer of structured analysis of my autoethnography.
- **Major emergent themes** briefly discusses the four main themes that emerged from the autoethnography, and how the interviews and initial literature reviews influenced this process.

- **Narrowing the focus to engineering education** discusses in more detail how and why the decision was taken to focus on engineering.
- **Bourdieusian methodological elements** describes and argues for the Bourdieusian concepts that are utilised in part 2 of this thesis.
- **A Bourdieusian analysis of engineering education** summarises the argument that will be made and describes the structure of part 2.

Initial reflective analysis

According to Ellis there is a natural analytic process inherent in the writing of an autoethnography, and that when people tells stories in general they 'employ analytic techniques to interpret their worlds' (2004, pp. 195–196). Ellis suggests that stories are inherently theoretical and analytical, and referring back to my discussion on memory in Chapter 2 I would suggest that this is because a memory is not a facsimile, it's a version of events that has already been processed and analysed, compared and contrasted with other knowledge and experiences. So while I made a great effort to avoid pre-ordaining specific themes beyond the constraint that the story was about learning, it was clear that I was consciously and unconsciously analysing the autoethnography as I wrote, as well as absorbing themes proffered by supervisors, reviewers and others.

The first part of this process was both reflexive and reflective, and my first reflexive reflection when I thought about my own *conscious and unconscious analysis*, was the motivations that I had tagged throughout the autoethnography. These were written without reference to literature or any formal study of motivation and was just a simple way of tracking how my motivations changed through the story. I am not sure why I did this, but it must have seemed to me as I wrote that motivation was an important part of my story. I feel in retrospect that that this went a little against my stated intention to not pre-empt the focus of the story, but on the other hand it may have been very difficult to write the story at all without having some kind of theme to structure it around. Taking a reflexive view on this I think it is fair to say that my story was not just about learning, it was in the main about *motivation for learning.*

The fact that motivation was the key theme in my mind while writing the autoethnography is exhibited by the *motivation tags* that I interspersed throughout the autoethnography that can still be seen in Chapter 3. These were:

Motivation 1: Having to
Motivation 2: Wanting to
Motivation 3: Career motivations
Motivation 4: Financial motivations
Motivation 5 ‘Escape’
Motivation 6: Relevance and applicability
Motivation 7: Fear of Failure
Motivation 8: Grades or the goal itself
Motivation 9: Proving my worth to others
Motivation 10: Finishing

In the closing stages of writing the autoethnography chapter I also created the following visualisation of how these motivations overlapped in my mind. The following two diagrams were in fact initially at the end of the autoethnography chapter, but I removed them just before I created the final draft. On reflection, I believe I did this because I thought these would be the first stage of my analysis, which again points to what was perhaps a partially conscious decision that the next stage would be an analysis of my autoethnography based on the theme of *motivation for learning*.

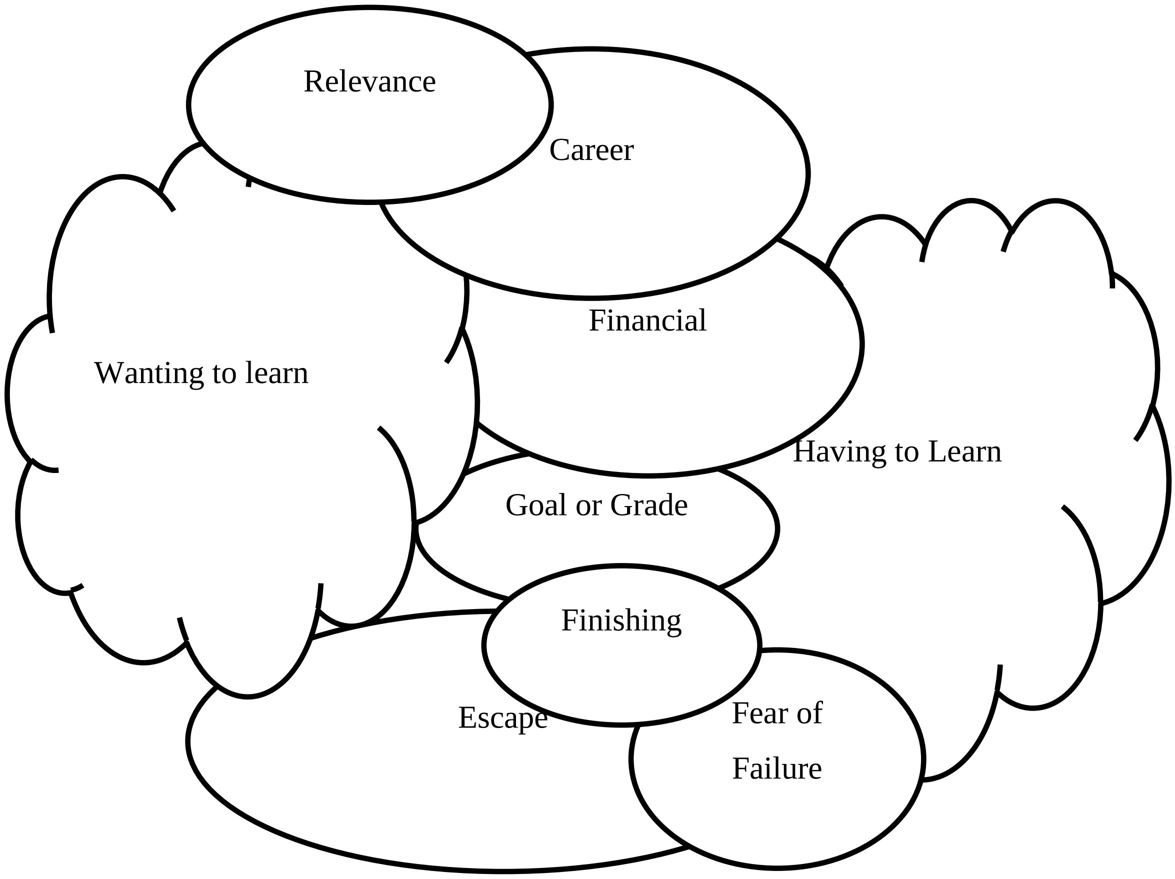

Figure 4-1: Overlapping Motivations

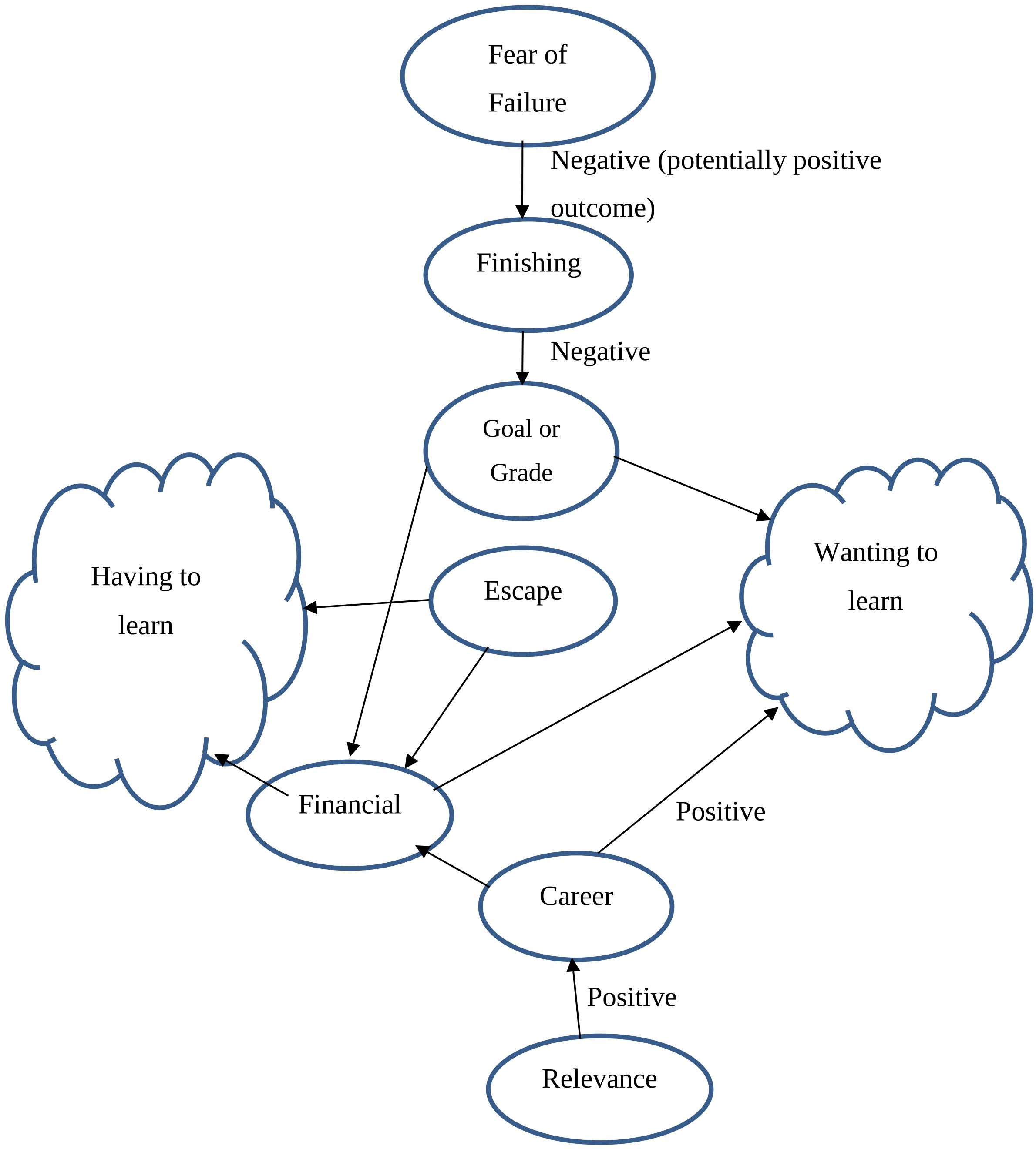

Figure 4-2: Connections between different motivations

The above diagrams which were removed from my first completed draft of the autoethnography of learning, show that *motivation for learning* was a key theme which was clearly in my mind as I was writing the autoethnography. In some ways I felt that this was a kind of root theme as its impact pervades into every part of my story.

Methodology used to analyse the autoethnography

As outlined at the end of Chapter 2, I had planned a serious of initial interviews where the participants would read my autoethnography and discuss their reactions during a recorded discussion with me. The interviews were semi structured in the sense that I had asked the participants to record their thoughts in the margins as they read through the autoethnography chapter, but that there were no restrictions on what they should or could say. The discussions therefore generally followed the timeline and contents of the autoethnography. One of the reasons for the interviews was to capture the perspectives of others, and referring back to the discussion in Chapter 2 and Denzin's statement that a 'story told is never the same as a story heard' (2014, p. 55), it was my conviction that the story that I think I am telling, is inseparable from its impact and the interpretation of others. For this reason I chose to incorporate the analysis of the autoethnography of learning, with my analysis of the interview transcripts.

As discussed at the end of Chapter 2, I planned to have at least four participants read the autoethnography and offer their comments. The theory behind this is discussed in Chapter 2, but there were multiple reasons for asking participants to read the autoethnography and discuss in a semi-structured interview. Although not a primary reason, issues of quality in relation to autoethnography, and in particular the notion of credibility, were also a factor. Although this could be criticised as pandering to an objectivist approach, the reality is that I will need to translate my findings back to the primarily objectivist discipline that I work in. Knowing that the autoethnography has been read and commented on by others who had knowledge or experience of the events discussed, is likely to help to address this for many readers. Another reason was an ethical right of response. In an autoethnography that partly covers my childhood, my parents are not only implicated, but it is also impossible to disguise their identities. Allowing them to respond was an ethical check, and if there had been significant issues highlighted at that point, there may have been a need to alter the autoethnography or the approach. As discussed in Chapter 2 the interviews were also intended to explore multiple perspectives on the events of, and the issues raised in my autoethnography. In the analysis this helped me to see my autoethnography from different perspective, and incorporate that data when analysing the autoethnography.

Each of the below participants read my completed autoethnography of learning, and discussed their reactions with me in a semi structured interview.

1. My Mother
2. My Father
3. Abdul – a recent full time chemical engineering graduate
4. Jason – someone who went to the same high school as me

As discussed in the previous section Ellis has suggested that the act of telling a story is a form of analysis, but later within the same text she states that an autoethnographer may wish to later add another layer of analysis and this can either be 'thematic analysis of content or structural analysis of form' (2004, p. 196). Structural analysis is not appropriate, as I am not trying to analyse why I wrote the story in the way that I did, but rather I am treating the story 'as data and using the analysis to arrive at themes that illuminate the content'. The emphasis then becomes the 'abstract analysis rather than the stories themselves', and here Ellis also makes the connection between this and the inductive approach of grounded theory, which I have previously discussed in Chapter 2 particularly in reference to Pace (2012)

I had no previous experience of analysing qualitative data but in my early reading I found Glaser and Laudel (2013) suggesting that 'two of the most widespread methods of qualitative data analysis' are 'coding and qualitative content analysis'. This paper described coding as a method that retains a link to the text, while qualitative content analysis separates and processes only the relevant information. Immediately this separation did not seem right for autoethnography, where the richness of the text (both autoethnography and interview data) and the small sample size made me feel that there would be a need to continually refer back and take meaning from the sources. This was in line with Glaser and Laudel's conclusion that coding 'outperforms' qualitative content analysis where the data is needed in 'later stages of analysis', and in particular in relation to 'meaning' and 'construction of narratives' (Gläser and Laudel, 2013, p. 2).

I initially questioned the extremely subjective nature of me coding my own autoethnography, but I was reassured that it has already been recognised that '*all coding* is a judgement call' (Sipe and Ghiso, 2004, p. 482 my emphasis) that involves 'our subjectivities, our personalities, our predispositions, our quirks' (p. 483), and that while this subjectivity will open up possibilities, it will also inevitably 'obscure other potential alternatives' (p. 482). I also noted the suggestion that 'coding is only the initial step towards a more rigorous and evocative analysis' and that it is a 'cyclical act' (Saldana, 2009, p. 8). While I was open to the possibility that coding might assist in highlighting themes, I felt that it would be important to return to the autoethnography or interview data to clarify and analyse the meaning of what had been said.

Attendance at a research methods class and reading the recommended text (Braun and Clarke, 2006) brought me from the process of coding, to methods for thematic analysis and framework analysis, and the possibilities offered by software tools such as Nvivo. Braun and Clarke discuss how researchers often write about themes 'emerging' as though this is a passive process, and that this denies the '*active* role of the researcher' in identifying, selecting and reporting patterns and themes of interest (2006, p. 80). Themes do not 'reside' in the data, and if they 'reside' anywhere it is in our heads where we create links from the raw data (p. 80). This is particularly relevant for me as a reflexive autoethnographer, as the selection of themes and many of the links will clearly have been made in my head as I wrote the story. Another important discussion in Braun and Clarke was the question of what determines a theme and the 'question of prevalence' (2006, p. 82). They assert that while the number of instances can be important, instances do not alone make a theme more crucial, and that ‘the ‘keyness’ of a theme’ is related to ‘whether it captures something important in relation to the overall research question’.

The decision to ask the initial participants to simply read the autoethnography and make notes on whatever came to mind was aligned with an inductive approach where I would attempt to link the themes directly to the data (Braun and Clarke, 2006, p. 83). This approach carried the risk that the themes may not align well with the original research question and that this may need to ‘evolve’ (Braun and Clarke, 2006, p. 84), but this was in keeping with autoethnography as both a product and a process (Ellis et al., 2010), with a destination that cannot be ‘hidebound by expectations’ (Muncey, 2010, p. 63).

There was also the question of whether the analysis would be a semantic approach considering only the surface meanings of the data, or a latent analysis involving interpretation of the ‘underlying ideas, assumptions and conceptualizations’ (Braun and Clarke, 2006, p. 84). As my autoethnography is already my interpretation of events, and the intention of the interviews was to seek the impact and interpretation of my story on others, it would not seem appropriate to then try to analyse the interview data beyond what is actually said by the participants. However, in relation to my analysis of my own autoethnography, I needed to apply some latent analysis, particularly where what I said and how it was interpreted by others was not aligned with what I meant. There was also the fact that on rereading and thinking about the content of the autoethnography months after writing, the importance of some aspects grew in my mind, as did my questioning of what I focussed on and what I left out.

Major emergent themes

Although I have already made it clear that that in part 2 I have chosen to focus on engineering education, I think it is important first, to discuss briefly the other key themes that came from the analysis of the autoethnography and subsequent interviews. Ellis suggests that in her view of traditional ethnography the 'worst offence' is 'omitting details that don't fit the analysis, or playing down their importance' (2004, p. 126). If I were to only discuss the theme of engineering education that would in a sense suppress the fact there are other possible themes and to act as though the theme of engineering education just magically appeared ahead of all other possible interpretations.

As discussed earlier the theme of *motivation for learning* was in my mind during and on completion of my autoethnography of learning. It seems very clear to me on reflection that motivation, not ability, was the gate to academic success when I was younger. This was highlighted by my mother's comments in her interview, that I spent my exam study leave fishing and still passed, and my father's comments that I only did the minimum required at school. In my autoethnography I also discuss many things from computer programming and IT architectures, to History and Zoology, that I self-learned voluntarily, while completely disengaged from the school curriculum, and that as a young adult, once I decided that I wanted to do an Engineering degree, I did it in half the recommended duration and still received a distinction. The latter stands in stark contrast to my attitude to doing the minimum work required to scrape passes in O grades, and my refusal to take any Highers at high school.

While writing my autoethnography of learning, the theme of motivation was clearly in the forefront of my mind. While writing about my teenage self I was impacted by the contrast between how demotivated I was in school, and the motivation I had to learn a variety of subjects outside of school, as well as the high levels of perseverance and motivation I found for formal education within a few years of leaving school. I had already begun to explore the literature on motivation prior to the decision to focus on engineering education. I could see links between Maslow's hierarchy of needs (Maslow, 1943), intrinsic and extrinsic motivation (Vallerand et al., 1992), and the motivational tags from my autoethnography (see table below), but in a sense my tags were just my own personal way of stating something that was already known in the academic community. While my autoethnography might be seen as a case study in motivation, and in particular the journey from *A*motivation (Vallerand et al., 1992, p. 1007) to successful extrinsic motivation, it was difficult to see any new theory being developed from this alone.

Level in hierarchy	Maslow need description	My informal analysis	Educational literature
5	Self-Actualization Needs	Wanting to	Intrinsic motivation
4	Self-Esteem or Ego Needs		
3	Love and Belonging Needs	Doesn't relate well to motivation, but possibly more towards intrinsic, and wanting to, or the bridge between.	
2	Need for Safety and Security	Having to	Extrinsic motivation
1	Biological and Physiological needs		

Table 4.1: Relationship between my tags and concepts from the literature

A second theme related to my *trades experience and social class* started to emerge as I considered how much of the literature on autoethnography discusses the voices that get to be heard, and the fact that there was little to nothing representing the voice of a mechanic or other tradesperson. I would not have considered class to be a relevant theme when I began the PhD, but as the participant reactions to my autoethnography prompted both my parents and my school friend Jason to talk about their own experiences I realised that social class, and in particular social capital, were very much factors in their lives, and on reflection in my own. As Jason joked that he didn't know I was interested in computers and that I was right to hide it from him, it started to become clear that there were pressures within our social group *not* to achieve academically, and to “fly under the radar” as Jason put it. It also became clear from the interviews with my parents that when my earlier academic promise didn't materialise into Highers or university, that my

Father's fleeting (and undisclosed at the time) hope that I would go to university, was very quickly dismissed as an unlikely dream rather than an expectation, and my Mother stated that she was just happy that I got a job.

The combination of the interview reactions, and the literature that I was now reading, showed me that class, and in particular social capital, was a very important theme in my autoethnography. Again, while the realisation of the impact of class and social capital might have been an epiphany for me, it was difficult to see where this would bring about new theory. One area which I believed might be worth exploring further, was the combination of these first two major themes, with an exploration of how motivational theory relates to social class. It struck me while reviewing the literature on motivation and social class in parallel, that many aspects of motivation could be linked to social class and social capital and the constraints that this might place on being intrinsically motivated. Although much of the literature on motivation seemed to identify intrinsic as the preferred form of motivation, there seemed to be very little in the literature discussing the extent to which types of motivation are linked to the opportunities for learning, or subsequent employment, for those of various social groups. I considered how some of the things I recalled being interested in learning while at school, would not have been related to what my social group would have considered valid career avenues, and the interviews with Jason reinforced this. The interviews with Abdul, and his relatives continually asking why he was not studying to be a Medical Doctor also showed that this is a factor across social and cultural groups in different ways. Prior to making a decision to concentrate on engineering education, the connection between social class and motivation seemed to have the most potential for further exploration, and remains an area of potential future interest.

Distance and online learning was clearly a theme that was strong in my mind before I started to write the autoethnography, but I later realised that its place in my story was really as an enabler. I could draw very little from either the autoethnography or the interviews that would suggest I could contribute any significant new knowledge or theory from this theme, beyond stressing the importance of this method of study for those who wouldn't otherwise have the opportunity. In that sense this theme also connects to class/social capital, and motivation, and in many ways the first three themes are closely linked.

Finally the relationship between *mathematics and engineering* was highlighted as a key theme. I had realised during the writing of the autoethnography that mathematics was becoming a recurring theme, because of my difficulties with it as a subject at certain stages in my life, the importance of it when studying engineering in an academic context and conversely its lack of relevance in my experience of engineering practice. As this has since developed into the main theme and focus of the remainder of this thesis, I have deferred the detailed discussion around the process of choosing and developing this theme to the next section.

As discussed in the introduction my original, somewhat vague research question was:

> *What can I understand about the nature of learning from studying my own experience as a lifelong learner?*

To recap, the four main themes that I identified from the analysis were:

1. *Motivation for learning*
2. *Class and social capital*
3. *Distance learning*
4. *Engineering and mathematics*

While the 4 major themes could fall within the broad umbrella of the above research question, the narrowed focus already discussed would naturally require the research question to evolve. The reasons for choosing to focus on engineering, and the development from the engineering and mathematics theme to a more specific question around the nature of engineering education, are the focus of the next section.

Narrowing the focus to engineering education

The second half of this thesis is focussed on exploring an apparent *disconnect between engineering education and practice.* This developed from a theme which I had initially referred to as ‘engineering and mathematics’. There were a number of contributing factors that led me towards a focus on this theme, but one of the first steps towards this was when after completing the interviews and receiving the transcripts I completed an NVIVO word frequency analysis. I processed a combined word frequency analysis of the interviews and autoethnography, and a separate word frequency analysis of the autoethnography and each of the interviews. The aim of this was not to prove anything quantitatively, but rather to test whether a different, perhaps more objective analysis, would change how I thought about them or uncover something that I hadn't considered. For the autoethnography not unexpectedly 'learning' was the most common word, and other education related words were common. However, possibly the most interesting correlation was that when words such as 'engineering', 'electronics', 'work', 'job', 'experience' etc were combined, they were similar in number to words related to education. This highlighted the fact that a large part of my autoethnography was clearly about professional learning and my career in engineering, which was also an end point of the story. In terms of a word representing a single academic subject, maths/mathematics was easily the most prominent, and when this was related back to the autoethnography, for context, the context was mostly negative, and connected to my perception of mathematics lacking relevance in practice, in contrast to its pervasion in engineering education. I have included tables showing the most frequent words used in the autoethnography and the interviews in the appendix.

Having completed the word frequency analysis I moved back to a more subjective analysis using NVIVO and coding of themes. I started with the four broad themes that I had settled on at the end of writing the autoethnography and added additional themes if they did not fit readily into the original themes. The table below shows the conclusion of this process, with the sources column referring to the autoethnography and each of the interviews, and the references to the occurrences of the theme. A particular issue with this approach was that the number of sources discussing a particular theme was influenced by subjects that the particular interviewee was comfortable discussing, or had experienced themselves. This meant that for example while themes related to teaching, education and class were discussed by most of the participants, the connection between mathematics and engineering was only focussed on by the single participant with a strong connection to engineering. In a sense, the fact that only one participant had experience of engineering education, and none had any experience of engineering practice, has limited the significance of the interviews as data. However, their significance to quality as discussed in Chapter 2, and their part in the process of analysis, and as an alternative perspective on the autoethnography, remains important.

Nodes

Name	Sources	Reference
Bullying	1	1
Control and fear of failure	1	2
Critical incidents	5	16
Distance or Different learning	4	14
Impact of autoethnography	5	23
Learning preferences	6	22
Mathematics and Engineering	3	28
Memory and perspectives	5	23
Motivation for learning	6	30
Negative feelings about school	5	15
Other	4	18
Relevance and interest	4	25
Responsibility	4	5
Teachers and curriculums	5	34
Trades experience and social clas	5	39
Trying to be anonymous or fit in	2	5

Table 4.2: NVIVO codes (sources include autoethnography and interviews)

Within the interview with the recent chemical engineering graduate Abdul, there was much discussion about this aspect. It became clear that Abdul was very engaged with mathematics at high school, and that when studying physics Higher he found this to be structured as maths with a context. Abdul was clear that he didn't know why he chose to study chemical engineering at university, and that having completed his degree he didn't really want to be an engineer. It struck me that Abdul was very engaged with Mathematics, which made him a natural fit to an engineering degree, but on completion he had little affinity for engineering. In contrast, I was not engaged with mathematics at school at all, and so was not a good fit to an engineering degree, yet I had been content and successful working as a professional engineer.

While some interesting discussions and minor themes emerged, most of the NVivo themes were a fit to the original four themes that I initially identified and discussed previously. As I had made a point of avoiding discussing my own interpretations with the participants beforehand, this shows that either my gut instincts from my own personal analysis was correct, or that I unconsciously created themes that matched my original analysis. Either way there would be no *right* or objective answer coming from this process. That does not mean it was not a useful exercise, and the combination of my personal analysis, word count analysis, interviews and thematic analysis, helped me to reflect on what the autoethnography was about from a number of different angles. However, this process also served to reinforce a main issue of concern, which was that in retrospect, an autoethnography covering thirty years of my life was always likely to produce themes that were too broad for the narrowed focus required in the second part of the PhD, and it was clear that at some point a subjective choice of narrowed focus would need to be made.

Ultimately I needed to make a decision on what the narrowed focus would be in this *part 2* of the PhD. When I returned again to the main reason why I set out to do this research, it was that I believed my story deviated from the norm in 3 ways:

1. I followed a non-standard route into professional engineering (via trades/distance learning instead of conventional full time degree)
2. I followed a non-standard route into engineering academia (from industry instead of academic route)
3. I followed a non-standard route for engineering academia by engaging in social science/education as a discipline, and even more so by using autoethnography as a method

Each of the points above taken on their own would make me a non-standard case, but taken together I felt that this gave me a unique perspective/platform from which I could challenge dominant discourses. I later noted that all three of these points related to engineering. Point 2 had originally read, 'non-standard route into academia', and I later qualified this as *engineering* academia, after it was pointed out to me that in disciplines such as education, it is not uncommon for teaching professionals to later enter academia. I started to wonder why engineering academics with industry experience were so uncommon, and why this issue seemed to be particular to engineering academia.

My autoethnography is evidence of a non-standard, but successful, route into engineering, which was the end-point, or destination of the story. It has also raised a number of questions about, and challenges to, the nature of engineering education and why it seems to be disconnected from practice. The subway line analogy from Chapter 1 (figure 1-1), shows that while the origin and destinations on my journey are the same as the conventional routes to professional engineering and engineering academia, the stops along the way give me a very different perspective.

Although it wasn't my original intention, I effectively wrote two autoethnographies. The unintentional autoethnography was my methodology which I had only intended to write in an autoethnographic style, but as I started to explore the theme of engineering I realised that this was also partly autoethnographic data. This chapter had captured my epistemological journey from engineering to social science, but when I later reflected on this as data, I realised that it also highlighted the epistemological differences between my experiences of the practice of engineering, and the content of engineering education. In what at the time were really just incidental observations, I had noted that many qualitative social science methods and concepts, could be related to certain engineering methods and practices.

I had started to reflect that much of my experience of engineering practice was subjective and qualitative, while engineering education seems to be almost exclusively objective and quantitative. I wondered about how many potential engineering students were being discouraged by the association with mathematics, when in my experience I never used anything more complex than I had learned in high school. I established in Chapter 2 that despite coming from what in social science terminology would be considered a very positivist tradition, that I clearly had a very constructivist mind set and as I was writing the previous chapters I had started to believe that one of my key arguments would be that I had been guided into the wrong career. As I wrote about the later stages of my career, I started to change my view and recognised that I had a reasonably successful career in engineering. It became apparent that taking a creative or qualitative approach was never a problem in my engineering career, only in my engineering education.

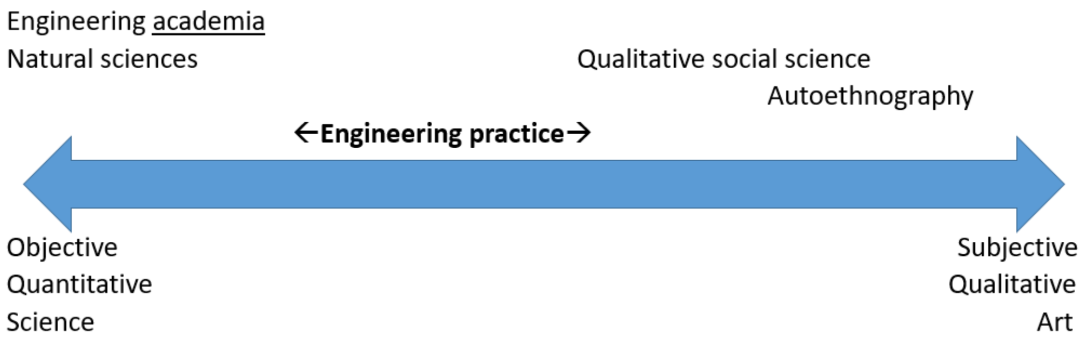

Figure 4-3: My perception of engineering on an epistemological continuum

The latter point summarises my experience that engineering education is in a sense, epistemologically out of step with engineering practice. It is perhaps only because I entered engineering through an alternative route, and learned what engineering practice was about *before* attempting a degree in the subject, that the contrast for me was so stark. My early searches of the academic literature found very few challenges to this, but when I searched amongst industry and institutional literature there was an abundance of criticisms related to the disconnect between engineering education and practice. As I was clearly not the first person to challenge this disconnect, the next iteration of my literature review started to ask *why is it like this?* This led to a literature review that focussed on what engineering is, how it has developed, and how that approach relates to engineering education. It has also necessitated a review of literature published by industry and engineering institutions, because of the fact that these important and influential perspectives are not well represented in academic literature.

I had initially started to link this disconnect between engineering education and practice to some previous reading on signature pedagogies (Shulman, 2005b) and constructing images (Haggis, 2003), that I have discussed in previous chapters. However, as I started to dig deeper into the literature, exploring the meaning of the word engineering and the historical and contemporary contexts, I started to feel that these concepts were insufficient on their own to describe the social factors influencing the relationship between practice and education. It became clear very quickly that engineering is a very difficult profession to define and that while there are a number of contributing factors, there is a clear historical divide in the development of two competing traditions in engineering, one based in practice, and the other in science. Having previously explored social theory while considering the theme of social class, I began to see the divides between engineering science and practice in Bourdieusian terms, and that this might provide a framework for exploring the perceived disconnect. The next section of this chapter describes the Bourdieusian methodological elements that I have used in the subsequent chapters.

Bourdieusian methodological elements

Forms of capital

In the introduction and in the Chapter 3 autoethnography, I recalled the inspiration from concepts such as signature pedagogies (Shulman, 2005b) and constructing images (Haggis, 2003), and their impact in relation to leading me towards this PhD research. These concepts were a useful way to describe the cyclical nature of pedagogy within the boundaries of the higher education system, but said nothing about the internal and external factors that caused it to be that way in the first place. My literature survey had uncovered multiple perspectives and arguments from within education and within industry, some technical, some related to status and social class, and a clear division between scientific and practice based visions of engineering as a profession. A framework was needed that could encompass all of these factors.

My initial post autoethnography analysis had led me to think about my life and the lives of others in terms of how much was my own choice and how much was defined for me by the institutions I attended and the advice I was given. This led me towards some initial literature surveys on class (Atkinson et al., 2012; Skeggs, 1997; Skeggs and Loveday, 2012 etc). I accepted that the concept of class may still be necessary for people to frame their legitimate 'responses to inequality' (2012, p. 488), but for me this concept was insufficient on its own to explain the complexity of modern social structures. I also felt that I related too closely to how the feeling of being looked down on provokes anger in the working class (Skeggs and Loveday, 2012, p. 483). For me the concept of class makes me defensive, and as I moved away from the writing of the autoethnography, towards the analysis, these emotional responses were more likely to hinder than help a balanced analysis. As my literature survey expanded from class into social theory, I read, and agreed with the idea that social, cultural and economic capital 'together shape the kinds of experience it is possible to have' (Atkinson et al., 2012).

The concept of economic capital is widely understood and can be defined as anything that is 'immediately and directly convertible into money' (Bourdieu, 2004, p. 16). The wording of the previous quote is important, because while on a base level economic capital is money, it is also anything that under the right circumstances can be converted to money. This includes the obvious, such as property or art, but also the less obvious such as rights related to land, such as fishing rights, or planning permission. Bourdieu goes further and states that economic capital can also be institutionalised in the form of qualifications, and is related to social capital through connections which might be mobilised (Bourdieu, 2004, p. 16). These, sometimes hidden relationships between forms of capital are an important part of Bourdieu's theories, as exchanges of capital, and the sum and structure of capital (Garrett, 2007, p. 20), can define the opportunities available to agents.

Although economic capital is widely understood at the surface level, there are complexities that lie beneath this when we come to consider what we mean by terms such as *value* and how capital considered only in its economic sense can diminish the lives of many whose contribution does not produce a measurable economic value (Skeggs, 2014; Skeggs and Loveday, 2012). I was aware of the Marxian concept of capital through my interest in history and through dipping into 'The communist manifesto' (Marx and Engels, 2005) as a historic curiosity, but the Marxian lens was only the beginning of questioning the source of this *economic* capital, which is of course seen by Marx as the exploitation of human labour by those who control the means of production. Marx remains important to *this* discussion of Capital, because along with Durkheim and Weber, his ideas were a key influence on Bourdieu (Navarro, 2006, p. 14). Economic capital is also extremely relevant to engineering practice, because the vast majority of professional engineering work takes place in industry, where the accumulation of economic capital is usually the primary motivator, and critical to staying in business.

Social capital may be considered colloquially as *who you know*, or more formally as the 'social obligations' or 'connections' (Bourdieu, 2004, p. 16) that exist between people or through their 'membership in a group' (Bourdieu, 2004, p. 21). These relationships and memberships add together to 'resources that individuals can mobilise' (Zembylas, 2007, pp. 449–450) and thus can be transformed into other forms of capital. These relationships sometimes exist only in a 'practical state', via social networks, gained through geographical, economic and social proximity to others, but can also take an institutionalised form through a family, school or party name (Bourdieu, 2004,

p. 21), or a formal title (2004, p. 16). An important aspect of social capital is that while an individual agent's social capital is defined by the size of their network and the amounts of capital held by the agents in their network, socially connected agents also multiply and reinforce each other's capital (Bourdieu, 2004, p. 21). As it would be in any field, social capital is relevant to both engineering practice, and to engineering academia, but critical to the discussion in subsequent chapters, is the impact of social connections between these two fields.

Cultural capital can be described as 'familiarity with the dominant culture in a society' (Sullivan, 2002) and according to Bourdieu (2004) it can be embodied, objectified or institutionalised. Embodied cultural capital could be a product of what one is born into, not in a genetic sense, but rather through accumulation over time. This could include accents, using 'educated language' (Sullivan, 2002, p. 145) or even a way of thinking. If the 'education system assumes the possession of cultural capital' (2002, p. 145) then higher class students are more likely to succeed. This 'legitimises the dominant position' (2002, p. 146), 'maintaining the status quo' (2002, p. 145) and ensuring 'class reproduction'(Grenfell and James, 2004, p. 510). For example, in reference to Universities in South Africa, Naidoo (2004, p. 460) suggests that the higher education system 'acts as a 'relay' in that it reproduces the principles of social class', using a 'cloak of academic neutrality'. As cultural capital can take time to accumulate, parents sometimes defer to their children through investments in private schools. 'Progress for the children' is thus framed in terms of movement away from 'the culture and values of their parents' (Brewer in Reay, 2001, p. 335).

Objectified cultural capital could include art, books, fine wines, clothing and even the body (Bourdieu, 2004, pp. 17–21; Skeggs, 1997, pp. 82–85). Sometimes people who have gained economic capital try to 'pass as middle class' through going to opera and listening to classical music (Skeggs, 1997, p. 86) or by having the right type of furniture or paintings (1997, p. 86). These things can be purchased, but some remain linked to embodied capital through the ability to appreciate these things - I may now have the economic capital to purchase expensive wines, but would I be able to discuss the subtleties with others who hold the relevant embodied cultural capital? Because cultural objects can be transmitted through legal ownership, they can be used as a disguise for economic capital (Bourdieu, 2004, p. 19), but the owner must also have access to embodied cultural capital, 'either in person or by proxy' (2004, p. 20) to use them for their specific purpose. Agents who have embodied cultural capital in the form of scientific and technical knowledge therefore have significant collective negotiating power over the owners of the means of production, or may find themselves dominated if they are set 'in competition with one another'(2004, p. 20).

Embodied cultural capital is vaguely defined and subject to the 'biological limits' of its human bearer, whose knowledge and abilities can be challenged, or have 'fluctuating value' (Bourdieu, 2004, p. 20). Cultural capital can however be institutionalised, and legally guaranteed through the awarding of, for example, an academic qualification. Cultural capital in this form is no longer 'constantly required to prove itself' (Bourdieu, 2004, p. 21), it is captured at a particular moment and effectively becomes independent of its bearer and the actual cultural capital possessed. This is obviously an important concept in relation to both the higher education system who receive economic capital in return for providing institutionalised cultural capital, and for the engineering profession who use this form of capital to legitimise their profession.

Most of the concepts discussed above link in some way to power. While the links between social and economic capital and power are obvious, perhaps the links to cultural capital that Navarro (2006) is trying to highlight are more subtle. Navarro claims that 'all forms of power require legitimacy' and 'culture is the battleground' (2006, p. 19) on which social differences and hierarchies become entrenched. There are many different theories of power that are beyond the scope of this thesis, but Weber defined power as the probability that an actor 'will be in a position to carry out his own will despite resistance'

(Heiskala, 2001, p. 242). Clearly the forms of capital, and in particular the dominant form of economic capital, contain within them the power to erect structures that can lead to domination, but it is important not to ignore the 'personal power' (Miller, 2010, p. 4) or *agency* of an individual to attempt to transcend these structures.

The forms of capital could be said to overlap in some ways. It's not immediately obvious whether a 'title of nobility' is (Bourdieu, 2004, p. 16) social capital as stated by Bourdieu, or if it is institutionalised cultural capital. Each form of capital can also be transformed into another (Zembylas, 2007, p. 450). Economic capital can purchase private schooling, exclusive memberships and artefacts. This reduces the available economic capital but increases social and cultural capital. It could be suggested for example that politicians use the honours system to exchange cultural capital in the form of peerages, for the social and economic capital that they need to acquire and maintain political power (Boffey, 2015; Mell et al., 2015). This exchange of capital between the dominant groups, suggests the exclusion of those who do not have capital to begin with.

In addition to economic, social and cultural, symbolic capital is often cited explicitly as a fourth form of capital (Mendoza et al., 2012; Navarro, 2006), although others state that all forms of capital are symbolic (Grenfell and James, 2004, p. 510). Where symbolic capital is referred to explicitly, examples of it are usually intangible concepts such as honour, prestige and recognition (Mendoza et al., 2012, p. 559). Symbolic capital is the 'composite' (Burke, 2015, p. 11) form of capital, which gives legitimacy to levels of the other capitals, and through this seeming legitimacy goes unrecognised as capital (Bourdieu, 1990, p. 119). In academia symbolic capital is particularly important in the form of reputation and this sets up a cyclical relationship with economic capital as reputation increases research funding and vice versa (Grenfell and James, 2004; Mendoza et al., 2012). Bourdieu in fact states that economic and symbolic capital are 'inextricably intertwined' (Bourdieu, 1990, p. 119), offering an example of the person who by virtue of public knowledge of his wealth and reputation, may obtain resources 'without laying out a penny'. Bourdieu described three types of capital in academia, academic (control of resources), scientific (reputation and prestige) and intellectual (influence) (in Mendoza et al., 2012, p. 561). As will be discussed in later chapters, the forms of capital that are valued in engineering practice and engineering academia are very different, and this is a key factor for the discussion in Chapter 7.

Fields, habitus and doxa

The various forms of capital provide a more holistic view than simple notions of class, but they do not on their own account for how individuals develop or maintain this capital, or how individuals develop and maintain their world view. For Bourdieu the social world can be conceptualised as a 'multidimensional' (Mendoza et al., 2012, p. 559) array of *fields*. Fields are in effect 'social arena within which networks, relations and struggles over resources take place' (Zembylas, 2007, p. 449). Fields can consist of agents and institutions, both of which are positioned hierarchically in 'dominant and subordinate positions' (Naidoo, 2004, p. 458) within that field, dependent on the type and amount of capital that they can mobilise. To a degree a field can be compared to a high stakes game, except that the rules of the game are not codified and the players may not be conscious of their place in the game (Bourdieu and Wacquant, 1994, pp. 98–99). Viewing this game as a field allows for an analysis of the 'objective relations between positions' and the 'determinations' that the field makes on its occupants (1994, p. 97).

These determinations are part of what forms the *habitus* of agents present within a field. Habitus is the 'embodied history' (Bourdieu, 1990, p. 56) of the agent, effectively the absorbed history of the individual turned into an unconscious nature (Bourdieu, 2010, p. 78). Bourdieu is suggesting that while agents appear to be acting with autonomy, that this autonomy is 'of the past', habitus as history producing history and a resulting 'permanence in change' (Bourdieu, 1990, p. 56). Bourdieu is effectively saying that habitus is the embodiment of an agent's experience, and the historic experience of their social group, and this may pre-dispose them to certain actions, or to believe certain options are not available to them, resulting in a repeated experience within a social group. Individuals located in close proximity within a field will to some extent also have a shared history, and similar goals, and therefore will to an extent share a habitus (Mendoza et al., 2012, p. 560).

Habitus is a vague concept (Garrett, 2007, p. 226), and while it does not define deterministically what an agent will do, there is a tendency for habitus to exclude or avoid certain practices that are unfamiliar (Reay, 2004, p. 433). It could be said therefore that habitus is less about defining what an agent will do, and more about the restrictions on the options available, or the options that an agent is likely to consider. This means that while habitus can be generalised at the level of society, it is more complex and multi-layered at the level of the individual and becomes a 'complex interplay of past and present' (Reay, 2004, p. 434) and will be influenced by both available capital, and the field it is operating within.

Although it is not uncommon to see academic work focussed on either fields *or* habitus (Mendoza et al., 2012; Naidoo, 2004; Reay, 2004), in my interpretation these concepts are inextricably linked. Bourdieu refers to habitus as a 'structuring structure'(Bourdieu, 1990, p. 53) that predisposes the agent towards certain, often unconscious actions, but that habitus only becomes active in relation to a field and can lead to different actions depending on the state of the field (Reay, 2004). Unless one takes a deterministic view of habitus, which does not appear to be Bourdieu's intention (Reay, 2004, p. 432), while the field shapes the habitus, habitus must also shape the field. The forms of capital also have more relevance when related to a field, as they are the 'medium' for relations within a field (Grenfell and James, 2004, p. 510), and forms of capital that are highly valued in one field, may have less value in another. While economic capital is likely to transcend most fields, certain types of social and cultural capital may only be of value in particular fields. For example, the cultural capital demonstrated by an appreciation of fine wines and classical music might have little value in a field where beer and Rock music are the dominant cultural norms. This discussion on how the forms of capital are valued differently in different fields, and how this impacts the habitus of the agents within those fields, is at the core of the discussion in subsequent chapters, and in particular in the conclusions of my Bourdieusian analysis in Chapter 7.

The extent to which I control my own actions (agency) and the extent to which the structures (institutions, social groups etc) around me define this, are a source of much debate in sociology. When I first became aware of this debate in the early stages of this PhD, my own world view would have led me to state that "it's a bit of both". Bourdieu argues that the concept of habitus accounts for both, and transcends the 'dualistic vision' (Bourdieu, 1990, p. 56) of agency or structure, but that the habitus 'predisposes' agents towards certain behaviours (Reay, 2004, p. 433), informed by the capital they have available to them and the 'state of the field' in which they operate (Reay, 2004, p. 432). It's possible for a person to break from these structures to a degree, but that would require the agent to become conscious of the impact of these structures on their own habitus. The problem is that as habitus is 'forgotten history' (Bourdieu, 1990, p. 56), so agents are often unconscious to the source of their action. However, habitus can be conceived of as a continuum, where at one end its dispositions are reproduced by a familiar field, and at the other there may be potential for transformation (Reay, 2004, p. 435) and this is where the question of agency and intervention becomes important (Garrett, 2007, p. 230).

Amongst the main criticisms of Bourdieu is a charge of reinforcing determinism 'under the appearance of relaxing it' (Gartman, Giroux and Jenkins in Bourdieu and Wacquant, 1994, p. 132). Bourdieu's rejection of this charge has been discussed above, but he does appear to be focussed on the structure that habitus enforces, and in my reading he tends to only focus on agency when defending against charges of determinism. I would argue that this is because Bourdieu's work tends to focus on those who are disadvantaged by these structures and those who are not aware of the impact and so cannot easily 'step back and gain distance from dispositions' (1994, p. 136). Field (2005, p. 21) suggests that Bourdieu's ideas of social capital are 'one-dimensional, only acknowledging the social capital of the privileged', and defining the poor by their lack of Capital. Again this is likely to be related to the fact that Bourdieu is focussing on what causes disadvantage and while the poor have forms of capital, these forms of capital may not be valued by the dominant group in society and therefore unlikely to sum to improved economic conditions or wider opportunities.

A parallel in engineering is the cultural capital held in the form of trade knowledge and practical skills. These skills are essential, and may take years to accumulate, but arguably that form of cultural capital is not valued to the same extent as cultural capital in the form of an engineering degree. Although it may not be his intention, Field's comments serve as a reminder that it is not always the amount of capital, but more importantly its form and the field in which it exists that defines power relations, and the decisions about what forms are valued are set by the dominant group. As I am focussed on the world of professional engineers and academics, these are not people who are likely to be considered disadvantaged, and so many of these criticisms do not directly apply, but as previously illustrated there may be some indirect connections. The charge of determinism does also have to be considered, and how change can be effected, as this PhD would have little purpose if it was simply reporting out on an issue that was pre-determined and impossible to change.

A final Bourdieusian concept that will be important to this study is Doxa. On its most basic level, Doxa is simply what I would have heard some people refer to as "common knowledge", but in a Bourdieusian analysis it is the unexamined nature of these beliefs that is of interest or concern. It's not unreasonable to suggest that this common knowledge, can sometimes be just that, but in some cases knowledge can achieve 'legitimacy through misrecognition of arbitrariness' (Bourdieu, 2010, p. 168). This could be considered a 'pre-reflexive' (Grenfell, 2008, p. 120) form of knowledge in the sense that it's requires an agent to take a reflexive stance in order to recognise it. Doxa are unquestioned, shared beliefs that 'underpin the related notion of symbolic power' (Grenfell, 1996, p. 121). As shared beliefs they are a part of the habitus constituted within a field, and mediated by the various forms of capital (Grenfell, 2008, p. 120). The diagram below, taken from 'Outline of a theory of practice' (Bourdieu, 2010) is perhaps the most accessible way to understand Doxa. Bourdieu suggests here that Doxa is revealed when it is 'negatively constituted' against a 'field of opinion'. Here Doxa is revealed to be opinion that is not disputed, or has been accepted as 'an unquestionable orthodoxy that operates as if it were the objective truth' (Chopra, 2003, p. 421).

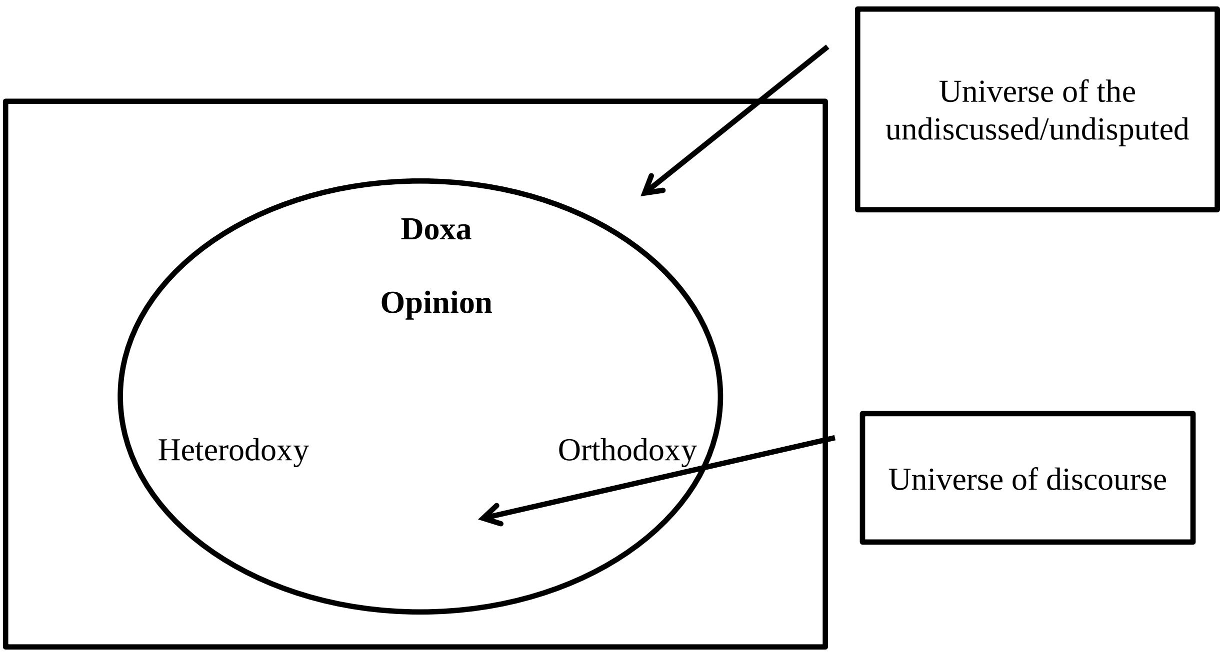

Figure 4-4: Doxa (Bourdieu, 2010, p. 168)

A Bourdieusian framework for engineering

As discussed previously, Bourdieu's work is 'particularly concerned with how social inequality is perpetrated and maintained' (Mendoza et al., 2012, p. 560) and this is a common theme in the work of others using his methods (Naidoo, 2004; Skeggs and Loveday, 2012). While social class and status have some relevance in the issues I am addressing in engineering, the main focus is on the content of the engineering curriculum, and my intention is to show how habitus in particular, leads to a certain interpretation of what is required for a professional engineering education. There is a certain irony in using Bourdieu's tools to explore a 'profession', when Bourdieu clearly had little time for the term which he labelled a 'folk concept', 'uncritically smuggled into scientific language' (Bourdieu and Wacquant, 1994, p. 242). Arguably this is all the more reason to consider engineering as a field (Tulkki, 1999), thus removing the preconceptions of the word and focussing instead on its purpose.

While Reay notes the 'habitual use of habitus in educational research' (2004, p. 431), in contrast, Bourdieu's concepts have not been widely used in *engineering* education research (Devine, 2012a). One of the reasons that I chose to follow this PhD in a school of education rather than within engineering, was that I believed that there was a body of knowledge in the discipline of education that was not being accessed by engineering educators. This led me into another body of knowledge that overlaps into education from sociology which in turn borrows from philosophy, and has accounted for hundreds of hours of reading and learning. I have accessed these theories through my engagement with social science in this PhD, but for most engineering academics their core training is technical (Devine, 2012b), and of the minority who actively engage in education research, fewer still will have had a comprehensive exposure to sociology. This means that the complexity of Bourdieu's concepts as a research method, is likely to make them inaccessible (Devine, 2012a; Navarro, 2006, p. 13) to the majority of engineering educators. There are three major implications from the above discussion. Firstly, it highlights an opportunity to shine a Bourdieusian light on an area which has previously seen very little exposure to it, and may benefit from this approach. Secondly, the ubiquity of the approach in education research, contrasted with its absence in engineering specific education research, highlights the limited overlap between the social science field of education, and engineering education. Thirdly, if the findings of this research are to have any impact in engineering, the findings must be made accessible to those who can effect change within the discipline for engineering.

In this study, the majority of data had already been collected through the autoethnography, and much of the literature survey already complete, before a conscious decision to use a Bourdieusian approach to examine the data was taken. Devine and Reay (Devine, 2012a; Reay, 2004) imply that this is a common misuse of Bourdieu’s theories and that they are rather intended to underpin a research methodology and inform the nature of the investigation. This is of course incompatible with the grounded approach to autoethnography that I have taken, as I purposely avoided considering how I would frame or analyse the data in an attempt to allow the themes to emerge from the story. I would argue conversely that the approach suggested by Devine and Reay could in some cases lead to attempts to *find* data that fits into the Bourdieusian framework where simpler analysis would suffice, and this was incidentally my initial interpretation of one of the studies recommended by Devine (Naidoo, 2004).

Bourdieu’s focus on habitus, and particularly the way in which cultural and symbolic capital can go unrecognised as capital, make the framework ideal for highlighting subtle, hidden and complex issues. My argument for applying a Bourdieusian lens after already collecting and analysing the data and literature, is that the Bourdieusian framework fits like a glove around the issues that my autoethnography has highlighted, and offers a language with which to describe and explore the contributing factors in greater depth. Prior to applying a Bourdieusian framework I had already identified through my autoethnography and subsequent literature review, a separation between engineering practice based in industry, and engineering science, based in academia, and that the curriculum developed in academia, did not seem to reflect practice in industry. The use of field theory allows me to conceptualise engineering academia and practice as fields, and consider their position within fields and in relation to other fields, as well as the power relations between these fields and the capital that enables this. It allows me to consider how habitus might account for some of the positions taken, and to explore how that habitus has been formed and the resulting implications.

For the purposes of this study I have conceptualised *engineering academia* as a field and *engineering practice* as a separate field, in line with the literature surveyed which shows the development of engineering as two traditions. The metaphor of a field is important here because, for example, it is not realistically possible to be an engineering academic from the outside of that field (Zembylas, 2007), and within any field there is a struggle for the various forms of capital (Devine, 2012b). I would argue that the habitus, or the 'window to the world' (Zembylas, 2007, p. 447) of engineering academics is formed within this field, and their shared habitus 'fosters a taken for granted common representation of the world' (Mendoza et al., 2012, p. 560). Particularly so, because as will be discussed in subsequent chapters, most engineering academics spend almost their entire working lives within this field, the same field that they were educated in. It is of course true also to say that *industry* is also a field, but as most practising engineers had their formative experiences of engineering shaped at university they have had their own habitus shaped partly by the field of engineering academia and partly by industry. The concept of fields allows me to consider these fields in concert, how they may be positioned within and in relation to other fields, and how the forms of capital shape the relations within and between these fields.

There is said to be a 'complicity' or 'tension between the 'legitimate' ways of acting or thinking defined by the field' and the 'individual's pre-disposition to conform' (Grenfell, 1996, p. 291), or conversely to disconfirm. Bourdieu admits to only gradually learning about features of his own habitus through the 'gaze of others' (Bourdieu, 2007, p. 89), so there is clearly an extent to which habitus can only be viewed from the outside. I am not a product of the field of engineering academia, because I went straight from high school to industry, and worked there for over twenty years before joining engineering academia. The students I work with are all industry based mature students, so I retain a strong connection to industry and identify closely with the students. Although I completed two engineering degrees, these were both by distance learning, so I was largely isolated from the social and cultural influence of the university. As I was already in practice I was in a position to make an active judgement while following the degree programme, on what I believed to be relevant to my career, contrasted against a conventionally educated engineer who would first understand engineering in the way that it was presented to them at university. My own habitus is therefore largely formed through my transition through practical trades based engineering work, and later professional engineering practice. It has been said that a person in a field of which they are a product is a 'fish in water' (Bourdieu & Wacquant in Reay, 2004, p. 436) and takes the world around it for granted, but when a habitus encounters a field with which it is not familiar 'the resulting disjunctures can generate change and transformation' (Reay, 2004, p. 436). My entry into the field of engineering academia could be considered to be such a *disjuncture* and may present an opportunity to *generate change*, but I will also need to take a reflexive position in relation to my own habitus and how it has been formed.

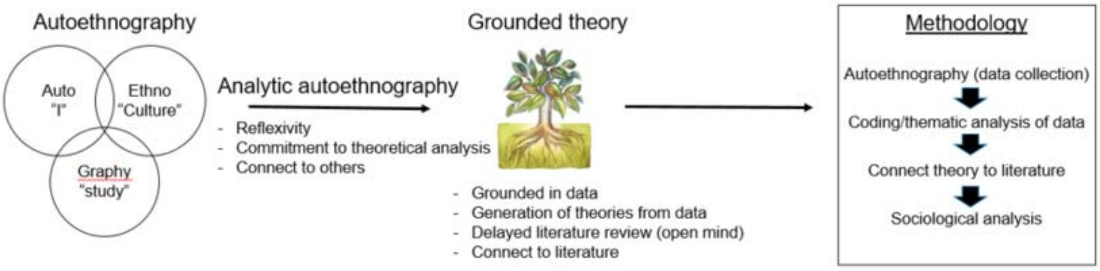

Figure 4-5: Methodology used in this PhD

A Bourdieusian analysis of engineering education

This chapter has in some ways been a link between the autoethnographic elements of part 1, and the sociological analysis of part 2 of this thesis. I have discussed how informal reflection, and more formal analysis of the autoethnographic chapters, and the subsequent interviews, led me to a decision to focus on a perceived disconnect between engineering education and practice. I have also discussed some of the reasons behind my decision to use a Bourdieusian framework for analysis, and outlined some of the key concepts that I will utilise in the subsequent chapters. These chapters are briefly outlined below:

Chapter 5 begins by setting some parameters for what follows by first discussing what engineering actually means. Bourdieu presents the use of language as a potential act of power, often used for this purpose by those in a dominant position (e.g. Bourdieu and Wacquant, 1994, pp. 141–150). As I am challenging the dominant discourse in engineering education it is important to first consider whether (or not) there is a universal agreement on what the word ‘engineering’ means (in English), and if its use, and the development of its meaning, has implications relevant to this study. I first explore the original definition of engineering through the etymology of the word, and contrast this with some modern definitions, finally suggesting a practical or practice based definition. The remainder of this chapter explores whether there is support within the literature for my assertion that there is a disconnect between engineering education and practice, and briefly explores the nature of this disconnect with reference to both academic and industry sources. A secondary purpose of this chapter is to introduce a reader from outside of the discipline of engineering to the terminology and structure of the profession.

According to Bourdieu the social world is ‘accumulated history’ (Bourdieu, 2004), and by extension, this could also be said of how professional fields are structured (Noordegraaf and Schinkelb, 2011, p. 104). It is therefore critical to understanding the fields of engineering and engineering education, to first consider that accumulated history and how it informs the current position of those fields in relation to each other, and this is the focus of Chapter 6. If Habitus is a 'product of history' (Bourdieu in Garrett, 2007, p. 229) , then an understanding of how the history of engineering and engineering education informs the habitus of the members of those fields is also important.

Chapter 7 is a Bourdieusian analysis of contemporary engineering education and practice. Building on the discussion in Chapters 5 and 6, this chapter reconceptualises engineering education and practice as fields, and considers these fields in relation to broader fields such as academia and industry. The valued forms of capital in each of these fields is discussed, how this shapes the fields and the habitus of its agents, and the potential impact on engineering education. Chapter 7 concludes part 2, while Chapter 8 closes out the thesis, with some reflections on the thesis as a whole, and some discussion of possible future research.

Chapter 5: What is engineering: What does it mean and what does it look like?

Introduction to this chapter

A major theme from my autoethnography of learning was my perception that there is a *practical* disconnect between engineering education and practice, which was particularly evident to me from the hegemony of mathematics-based teaching of engineering in the classroom, versus its comparative absence in my experience of engineering practice. It later became apparent to me through writing my autoethnographic methodology chapter, that I had also become subconsciously aware of what I now refer to as an *epistemological* disconnect between engineering education and practice. While the practical disconnect was explicitly evident to me through the contrasting knowledge and skills valued in education and practice, the epistemological disconnect was a more subtle, and gradual realisation of the subjective nature of engineering. However, while autoethnography has helped to shine a light on these issues, it does not give me a justification for generalising 'from an n of one' (Anderson, 2006, p. 386), or in other words, from my experience alone.

This chapter begins the sociological analysis of professional engineering education by first considering, beyond my own perception and in reference to published literature, what it means to be a professional engineer. I approach this by first asking what the word engineering means in terms of the way it is understood in language, and in particular through definitions used by various social groups. Taking a Bourdieusian approach I will argue that these words and definitions are socially constructed and can skew perceptions about what engineers do. In particular I will argue that definitions of engineering that privilege the application of science and mathematics, do not accurately represent the realities of engineering work. Instead I offer a definition that is aligned with the original meaning of the word engineering, the meaning of the equivalent word used in other European languages, and can be applied to all branches of professional engineering. In the second part of this chapter I go on to build an image of the reality of engineering practice through industry, institutional and academic literature. This is intended to provide the reader with a picture of professional engineering practice, that can be contrasted with the dominant mathematical science based view of engineering prevalent in academia. It will also support my argument that there is a disconnect between professional engineering education, and the realities of professional practice.

What does the word engineering mean?

Bourdieu and Language

Bourdieu uses the concept of Doxa to describe how the 'world of tradition' can be experienced by its adherents 'as a natural world and taken for granted' (Bourdieu, 2010, p. 164). The established 'order is perceived not as arbitrary, i.e. as one possible among others, but as a self-evident and natural order which goes without saying and therefore goes unquestioned' (2010, p. 166). In this thesis I am questioning the established doxic beliefs that are prevalent in engineering education, so one purpose of this section is to consider some of the factors from the past that have resulted in the establishment of the doxa of engineering education. Considering the origins of the word *engineering*, the various definitions in use today, and the way that this word has developed differently in other European languages, I argue in the first section of this chapter that the established definitions *are only* one possible tradition, and should therefore *not* go unquestioned.

A father of modern linguistics, Ferdinand de Saussure considered a word, or a name, to be a linguistic sign (La Saussure, 1986, pp. 65–68). According to Saussure a 'linguistic sign is not a link between a thing and a name, but between a concept and a sound pattern'(1986, p. 66). Importantly he distinguishes between a sound, which is a physical thing, and a sound pattern, or signal, which is what is interpreted by our senses, and can be internalised (i.e. we can recite words as sound patterns in our heads without making any external sound). The concept is the abstract part, the thing that is signified by the signal, in the mind of the receiver. Saussure considered the link between the signal and the signifier to be arbitrary, in the sense that House and Maison, both refer to the same concept in different languages. This is true for Saussure who was concerned only with linguistics, but presumes that culturally these words do signify exactly the same concepts in the respective English and French speaking cultures. Taking that a step further, within the English speaking world even *house* and *home* have different connotations, and depending on socio-economic groups or personal experience, house and home can conjure a completely different image. This is important because, as will become clear in the discussion that follows, the word engineering has a different etymology to the equivalent word in other European languages, and some of the published definitions diverge significantly from the original root from which the word engineering has evolved. As much of what follows in part 2 relates to habitus and doxa, then what different social groups actually mean when they say the word engineering, is an important starting point in understanding how a social groups habitus is constructed.

Bourdieu was both influenced by, and critical of Saussure (Schinkel and Tacq, 2004, p. 65), mainly because, (in Schinkel and Tacq's words), language should not be viewed as only a 'formal object of contemplation, but as something which has an impact on reality'. Bourdieu attaches great importance to language as an instrument of power, which can often be used as a means of control by a dominant group (Bourdieu and Wacquant, 1994, pp. 141–150). Connecting this to doxa, words and definitions can be presented as 'self-evident' (Bourdieu, 2010, p. 166), as though they are describing the way that something *is,* as opposed to describing a doxic belief that has achieved dominance, sometimes arbitrarily, or because it was the way it was in the past. In the subsequent sections, I argue that the various definitions of engineering are not *self-evident* but are in fact instruments where, through language, a particular vision of engineering is expressed.

If, as Bourdieu suggests, words can influence reality, then what is understood by a word, or a definition can have far reaching consequences. If the signifier, the concept that is generated in the mind by the signal word engineering, connects the profession to engines and dirty work, it may for example put off women from joining the profession (Beder, 1999). If a published definition privileges science and mathematics then it may influence or limit the choice of engineering as a profession to those who 'did well in high school math and science courses' (Matusovich et al., 2010, p. 290). None of this would be a problem if the signifier generated by the word engineering, or the published definitions are accurate and reflect reality, but as I go on to show in the second half of this chapter this is not the case for many practising professional engineers.

It is important to recognise that there have been criticisms of Bourdieu from for example Hasan, who sees Bourdieu's forays into linguistics as a 'denigration' of the entire field (1998, p. 78). Others have agreed to an extent (Hanks, 2005), or suggested that Hasan has misunderstood Bourdieu's intentions (Chouliaraki and Fairclough, 1999; Robbins, 1999). Ultimately the complexity of this debate from a linguistics perspective is beyond the scope of this thesis, but Hanks does suggest that there is a 'deep consonance' (2005, p. 78) between practice theory and anthropological linguistics, particularly in areas including 'standardization, domination, legitimation and their opposites' (2005, p. 79). Hanks argues for a second reading of Bourdieu that overlooks the vagueness and lack of 'specificity' (2005, pp. 69, 78) in relation to the academic field of linguistics, and focusses on the way that Bourdieu reasons about the connection between language and the concepts of fields and habitus. This is aligned with my own focus in this chapter, not to digress into an overly deep discussion on linguistics, but to recognise a relationship between language and power, and to note that this will have an impact on the habitus and the field.

This discussion on language is also an important predecessor to the next chapter and the historical development of engineering as, according to

Pocock, history is ‘formed by the interactions of parole and langue’ (1987, p. 20). Langue is both language and the rules of language as understood by a social group, but also ‘has an individual dimension, for individuals speak’ and internalise language (Tröhler, 2009, p. 13). Parole is the use of langue, as spoken and written in everyday life, so parole also has both a social and an individual dimension, and is in a ‘complex relation of mutual interdependence’ with lange (Tröhler, 2009, p. 13). Pocock is suggesting that history can only be understood by us today through parole, but that for anything from history to be ‘said or written or printed, there must be a language to say it in’ (Pocock, 1987, p. 20). That language, including the social rules of the time that it was written will determine to an extent what *can* be said, while parole determines what *is* said in it. Like Bourdieu, Pocock is arguing that words: ‘what can be said’ and ‘what is said’ (Pocock, 1987, p. 20), have an impact on reality. As Bourdieu has stated that habitus is a product of history, then it can be argued that there is a circular relationship between history, language and the realities of the present, and all together must have an influence on a habitus.

In this chapter I will show that the word engineering can mean something completely different depending on the social group using it, the language it is being used in, or an adjectival qualification. For example, in the next section I will discuss how in English the words engineering and engine appear connected. Parole can modify (Tröhler, 2009, p. 12) this English word, amongst the social group of professional engineers and allow it to take on a different meaning, but the earlier connotations may remain in the public perception. That public perception is important to the profession, as it affects their standing in society, their perception of how they are perceived, and their habitus. As will be discussed throughout the remainder of this thesis, if the field perceives that the practical aspects of engineering are of lower esteem, it may result in an over emphasis of science and mathematics, eventually culminating in a self-perpetuated doxic belief, rooted within the habitus of its members.

The evolution from the word definitions of engineering

One of the first things I did after deciding to focus on engineering as the main theme for part 2 of this thesis, was to consider reflexively what it means to be an engineer, and what engineering means. Prior to the reading that led to the previous and subsequent sections, the first thing I did was to reach out to my bookshelf to consult a dictionary. My thinking was that this might provide an external view of engineering, a view that is presented to the general public. That dictionary told me that an engineer is ‘a person who designs, makes or works with machinery’, (Higgleton et al., 1992) and a quick browse through some other dictionaries made similar connections to engines, machinery and structures (Cambridge English Dictionary, 2016; Higgleton et al., 1992; Oxford Dictionary, 2016). These definitions would exclude many modern engineering disciplines, so are clearly not helpful, and research has indicated that the public perception of engineering is rooted in an industrial revolution type image related to ‘construction and mechanics’ (Marshall et al., 2007, p. 3). The profession is very aware of this public perception (Marshall et al., 2007), and this may influence how the profession would seek to define and distance itself from those without a university education. A status-driven need to distance engineering from its origins in practical trades, and to instead emphasise its connections to science (Beder, 1999, p. 14), is a recurring theme both in the historic development discussed in Chapter 6, and contemporary issues discussed in Chapter 7. Note that there are some issues with using the word profession to describe engineering and I will address this in the following section, but my use of the term here is a broad classification of degree qualified practising engineers, primarily, but not exclusively, focussed on industry, and connected to an institution.

While Bourdieu describes the dictionary as ‘the exemplary result of this labour of codification and normalisation’ (Bourdieu, 1991, p. 48), the main issue I had with these definitions was that they were inaccurate, or at very least unrepresentative of the profession as a whole. Bourdieu also suggests that the dictionary is language as Saussure understands it, without the ‘constraints’ of ‘the situation’ (Bourdieu, 1991, p. 48). This description of dictionary definitions could also describe the separation of the two main parts of this chapter. This first section considers what the word was, how it evolved, what different social groups believe it does mean or should mean, and the power associated with language. This is a theoretical discussion, not bound by the ‘constraints’ of ‘the situation’. The second part of this chapter considers only the ‘situation’, and the reality of what engineers do in practice.

Marshall *et.al.* makes multiple references to confusion (2007, pp. 3, 14, 31 etc) amongst members of the public in relation to what engineering is, and what engineers do. Marshal *et al* refer to what they call a ‘misleading’ or ‘interchangeable’ (Marshall et al., 2007, p. 37) use of the word engineering, to describe anything that involves maintenance or repair. This, I suggest, could be partly attributed to the etymology of the word *engineer* and its association with the word *engine*. The root of the word engineer originally came to English via French and Latin, primarily from the latin word *ingeniare*, which means to devise and is related to the word ingenuity (National Research Council Staff, 1986, p. 72; University of Houston, 2016). In modern French this word became ingénieur and is very similar in other European languages (Feinberg, 1967; MacLeod, 1992), but the word for engine in modern French and other European Languages became ‘machine’, ‘moteur’ or similar. This sets up a confused relationship between the words engine, and engineer that is specific to the English language, affects public perception of what engineers do, and thus has implications for status and professional recognition. The French ingénieur rather than English ‘engine’-eer, is arguably closer to what it originally meant to be an engineer, and some have proposed adoption of this term for professional engineers in the UK (MacLeod, 1992; Routledge, 2016). Discarding the more dramatic impressions of the word ‘ingenious’, it simply means ‘skill, originality, inventive cleverness’ (Higgleton et al., 1992), which by extension is also the original definition of engineering. I would suggest that this original meaning might better convey the aims of engineering, than some modern definitions that privilege only science and mathematics. I will return to this when I conclude this section with a proposal for a practice based definition of engineering.

Professional organisations and government agencies could be expected to be a source of a more up-to-date definition, but with different motivations and disciplinary bases, they tend to come up with different conclusions (National Research Council Staff, 1986, p. 1). There is also an element of marketing-speak, as the professional body seeks to highlight its importance to society through statements such as ‘solutions to sustain and protect human society’s existence’ (IMechE, 2016) and ‘the benefit of mankind’ (AIChE, 2003). There are two initial issues with institutional definitions. The first is the marketing element already discussed, possibly influenced by the pursuit of recognition as a profession. The second is the focus on discipline specific knowledge, that can be seen by example in the specification of chemistry in the definition offered by chemical engineering institutions (AIChE, 2003). If Engineering is a single profession, I would suggest that there needs to be a definition that is competent in describing the profession as a whole, which puts aside social and economic aspirations, connections to various specific academic and scientific disciplines, and focusses on what it actually means to be an engineer.

The most common feature of definitions published by institutions and professional organisations, is the reference to *mathematical and scientific principles* (AIChE, 2003; Chan and Fishbein, 2009; Engineers Canada, 2015; IMechE, 2016), but in all of these vision statements and definitions there is an important qualifier. For the American Institute of Chemical Engineers (AIChE) this qualifier is ‘applied with judgment’ (AIChE, 2003, p. 1). The Institute of Mechanical Engineers (IMechE) talk about ‘taking science and using it to produce things’ and ‘translating theoretical research into practical solutions and applications’. For Chan and Fishbein it is the ‘application of scientific principles to solve problems’. As far back as 1830 the emerging profession of the engineer was described as being responsible for organising the ‘connections between theory and practice’, and using the outputs of scientific theory for practical purposes (Auguste Comte in Cours de philosophie positive, National Research Council Staff, 1986, p. 73). There is a clear inference here that professional engineering is about the *application of* mathematics and science, and that these are tools to solve problems and create things that have a practical purpose.

Others seek to clarify that professional engineering is not just a branch of science (Lutchen, 2010; Petroski, 2010) or mathematics (Sen, 2013, p. 3), and that it has its own body of knowledge (Petroski, 2010). Sen argues that science 'aims to build theories that are true', while engineering 'tries to make things work' (2013, p. 9). Put another way, scientists are seeking to understand various phenomena, often for the sake of understanding, and in doing so produce new scientific knowledge. In contrast engineers delve into that body of mathematical and scientific knowledge when they need it to solve a problem, but science and mathematics are a means to an end, not the end itself. The scientist chooses to study phenomena of 'interest', while the engineer 'must solve problems as they arise', with a solution that satisfies 'conflicting requirements' (Smith, 2016). A scientist, a chemist, for example, studies an aspect of chemistry, whilst a chemical engineer may often forego a chemistry-based solution in favour of the optimum or most desirable solution, regardless of whether that is electronic, mechanical, social or economic in nature. The argument here is that science and engineering are different. Engineering uses the outputs of scientific research but, as will be seen in the second half of this chapter, it is not constrained by them, and also makes use of the outputs from other academic disciplines as well as its own body of knowledge.

Interestingly the Royal Academy of Engineering (2014) definition states that engineering is about 'transforming ideas and materials into global infrastructure, products and services that in turn increase the wealth and health of our economy and society'. It is notable that the UK's foremost multidisciplinary engineering body does not even mention science or mathematics in their definition. The focus of this statement is 'transforming ideas and materials' into something of practical use and I can relate this statement to both my personal experience of engineering, and to the origin word ingenuity. This statement will also hold when considered against the images of engineering practice discussed in the second half of this chapter. However, this is also a very grand statement, intended to highlight the importance of engineering to society, but in particular in relation to economic capital. This points forward to the discussion in Chapter 7, and the reality that engineering practice is primarily located within the field of commercial industry, where economic capital and profit is the key motivator.

Constraints on defining engineering

Before I go on to offer a practice based definition of engineering, I must first briefly consider some of the constraints. The first constraint in defining engineering is that it is not a unified profession, and it has been stated that 'to be really meaningful, the word 'engineering' almost always needs adjectival qualification' (Johnston and King, 2008, p. 90). Settling on a definition that will fit an electronics engineer who uses computers to design circuits that are not visible to the human eye, to a mechanical engineer involved in the construction of aeroplanes, or a biomedical engineer improving prosthesis for amputees, requires a definition that is as broad as the profession. I have previously suggested that these differences are related to the tools and methods used by a particular engineering discipline, rather than the broad meaning of the word engineering. Ideally a useful, generic definition of engineering should be no more constrained by a single output of scientific theory such as electronics or mechanics, than by science as a whole. However, as the organisation of both engineering institutions and educational departments reflect these disciplines, it must be recognised that this will also impact how various individuals and groups define what engineering is.

There is also the issue of who is 'entitled', or who has the 'proper credentials' to call themselves an engineer and sometimes this appears to hold more importance in the minds of engineers than the ability to do the job (National Research Council Staff, 1986, p. 71). In the UK the title *engineer* is often used by mechanics, fitters, central heating installers etc (Marshall et al., 2007) and anyone involved in ‘fixing things’ (2007, p. 36). This is sometimes a source of frustration for many degree qualified engineers (Clelland et al., 2012), who based on their own habitus, would understandably believe that a university degree is the proper credential. As will be discussed in Chapter 6, historically this was not the case, so the issue of credentials or cultural capital and their relationship to class and status, which will be examined in more detail in Chapter 7, plays an important role in how professional engineering and its relationship to engineering education is defined.

It’s important to note, as will be discussed in later chapters, degree qualified engineers in the UK have neither a legal, historical nor linguistic argument through which to claim exclusive use of the term engineer, and so by some measures engineering might not be considered a profession at all. Bourdieu in fact disputes the very idea of a profession, and referred to it as a ‘folk concept which has been uncritically smuggled into scientific language’ (in Wacquant, 1989, p. 38). However, Bourdieu primarily objects to the word being used as an ‘object of analysis’, allowing the profession to import its ‘false neutrality’ (1989, pp. 37–38), ‘social unconsciousness’ and arbitrary decisions about ‘who is included and who is not’ (1989, p. 38), into an academic study. Many of these issues are avoided by conceptualising engineering as various fields, with overlapping boundaries, as I will do in Chapter 7, as two professional engineers and members of the same institution, one working in academia and the other working in industry will experience engineering in very different ways, and privilege different forms of capital. However, there is clearly a practical issue in distinguishing between someone who uses the title of engineer based on mainly practical skills, and those who use the title based on a degree level education, and are possibly members of professional bodies. I have therefore decided to restrict this study to the latter group, partly because of the limitations of scope, but also because my autoethnography is largely about a journey from the former to the latter group, and culminates in my involvement in educating the latter group. This study, and my definition of engineering explored in this section, is therefore restricted to what could be termed a *professional engineer*. This is typified by (but not exclusively) those registered as Chartered Engineers (CEng) with an engineering institution. A *professional engineer* would normally be degree qualified in an engineering discipline, and this in turn narrows the scope of *engineering education* in this study to that which results in a university degree. This study also focusses mainly on engineering in the UK, and to an extent in other English speaking countries. However, as the international language of engineering and science is English, the meaning contained in these English words may also have an impact internationally.

Towards a practice based definition of professional engineering

As I have discussed in an earlier section, the origins of the word engineer come from a latin word that means to devise solutions. As I build towards a practice based definition of professional engineering, I would suggest that this is still the root of what it means, or should mean, to be an engineer today. While an engineer needs to be able to solve complex problems (Chan and Fishbein, 2009) and design solutions (IMechE, 2016), I have argued that the particular tools and concepts that an engineer uses are secondary to the problem at hand. If engineers are responsible for ‘transforming ideas and materials into global infrastructure, products and services’ as the RAE definition proposes (Royal Academy of Engineering, 2014), they will clearly need to be capable of using ‘science end products’ (Sen, 2013, p. 2) when appropriate, but will also need to use social science, computers, technology, as well as business and management skills (Nguyen, 1998). The depth to which the knowledge in this broad range of subjects is required for practice is part of the discussion that follows, but clearly a broad knowledge base is required that goes well beyond science and mathematics alone.

If the application of scientific principles alone made someone an engineer, then everyone who has washed dishes with detergent would be an engineer. If application is routine and pre-defined, then a trained operator could perform that function and so there must be a factor that distinguishes an engineer from an operator or technician. MacLeod argues that a competent engineer should be able to operate *on*, *with* and *beyond* the knowledge base, and to operate beyond the knowledge base requires 'intuition, flair and creative ability' (1992, p. 362). This definition of a professional engineer is of someone who can creatively apply the knowledge base, 'in an activity when the process of achievement is not or cannot be defined' (1992, p. 362).

The discussion in this section leads to the following summary progression:

> *Solving problems and designing practical solutions* are at the root of what it means to be an *engineer*. This is both the root meaning of the word (ingenuity) and the reality of practice as discussed in the subsequent sections.
>
> For a modern engineer the complexity of the required solution is often likely to require the *application of mathematical and scientific principles,* but designing practical, real world solutions requires a complete *engineering knowledge base* that also includes aspects of business and social science.
>
> An engineer is distinguished from a scientist because an engineer does not intend to create new scientific knowledge, and is distinguished from an operator or technician by an ability to *creatively* apply existing scientific knowledge in new ways and in different scenarios. A professional engineer will therefore require a greater *depth* of scientific knowledge than an operator or technician, and is likely to require a greater *breadth* of knowledge than a scientist.

In conclusion I would argue that at its core engineering is, and has always been about solving problems and designing solutions. As I will discuss in

Chapter 6, the connection to scientific theory and mathematics explicit in many modern definitions, was not accepted by most early engineers, and as discussed in subsequent sections of this chapter, is clearly not the whole of what it means to be an engineer today. Chapter 6 will outline how science and mathematics became increasingly connected to engineering, from a point in engineering history where this became necessary to solve increasingly complex problems, and also for some other less egalitarian reasons, such as status and recognition. However, I have argued that a more accurate definition of engineering is to *solve problems and design solutions* as this does not predetermine the methods used by the engineer to solve those problems. This distinction is important, because if the designers of engineering education were to ask, *what knowledge and skills do engineers need to solve the types of problems that exist in the world today*, they might come to a different conclusion than definitions discussed earlier in this chapter, that enshrine mathematics and science. A definition of engineering also needs to reconcile 'philosophical and theoretically based definitions…, with the practical realities of the working world' (National Research Council Staff, 1986, p. 71) which is why before considering the historical development of engineering in Chapter 6, and how this has influenced education in Chapter 7, the subsequent sections in this chapter consider what a modern engineer actually *does*.

What does professional engineering practice look like?

What skills does a modern engineer need?

To answer the above question I turn first to industry and institutional sources. There are three reasons for this: Firstly, there does not appear to be a great deal of academic literature that studies the day to day activities of an engineer. Secondly, industry is where the vast majority of engineering work actually takes place, so industry bodies are arguably best placed to identify the skills currently required. Thirdly, since the nineteen seventies to the present day (Berry and Whitworth, 1989; Lamb et al., 2010; Royal Academy of Engineering, 2014) there is a constant stream of literature from engineering institutions and industry bodies presenting the lack of suitable engineering graduates as something of a crisis, and a recent industry survey found that over 50% of industry employers stated that graduates do not meet their ‘reasonable expectations’ (The IET, 2015, p. 4). I approach industry views with some caution, because the skills gaps highlighted by employers relate primarily to their immediate business needs, rather than that of the employee (Markes, 2006), or the wider engineering profession. Despite this caution, industry sources at least speak from experience about the skills that *their* engineering businesses require from engineering graduates, and these views are often supported and published by the professional engineering institutions.

What constitutes the skills required by an engineer varies dramatically depending on the discipline, but the literature reviewed for this chapter suggests that industry is not unduly concerned with discipline specific knowledge. The patterns that emerge appear to indicate the issue is with generic skills that transcend the individual disciplines. Where employers do highlight an issue with skills that are likely to be discipline specific, the term ‘technical skills’ (Markes, 2006, p. 645) infers that employers are not complaining about a lack of theoretical disciplinary knowledge, but the ability of graduates to transfer that knowledge into practice (Markes, 2006, p. 638). This is backed up by a recent Institute of Engineering and Technology (IET) skills survey which reported that 57% of engineering employers said that ‘degrees don’t develop practical skills’ (The IET, 2015, p. 5), although it could be debated whether specific practical skills are the responsibility of the university or the employer.

Despite the dominance of the engineering science paradigm in engineering education, the skills that industry are seeking from graduates seem to fall outside of this scope. The below figure shows the desired attributes of an engineer according to aerospace engineering company Boeing. The list below makes clear that a 'good understanding' of science and mathematics is required. Good is a little ambiguous, although it could be argued that Boeing might have said 'advanced', or something similar, if they wanted to emphasise this. However, the majority of the 'desired attributes' fall outside of the typical core content of an engineering science based engineering degree (mathematics and science) and the larger portion are related to business, humanities, philosophy, social sciences, and perhaps critically the ability to communicate through a variety of mediums.

Box 1.2 Desired Attributes Of An Engineer

- A good understanding of engineering science fundamentals
  - Mathematics (including statistics)
  - Physical and life sciences
  - Information technology (far more than computer literacy)
- A good understanding of design and manufacturing processes
- A multi-disciplinary systems perspective
- A basic understanding of the context in which engineering is practiced
  - Economics (including business practices)
  - History
  - The environment
  - Customer and societal needs
- Good communication skills
  - Written, oral, graphic, and listening
- High ethical standards
- An ability to think both critically and creatively—independently and cooperatively
- Flexibility, i.e., the ability and self-confidence to adapt to rapid or major change
- Curiosity and a desire to learn for life
- A profound understanding of the importance of teamwork.

—The Boeing Company

Figure 5-1: Desired attributes of an engineer from Boeing (Crawley et al., 2014, p. 6)

In the figure below showing a gap analysis of engineering employers' perceptions of graduate attributes (Nair et al., 2009), the top three were social and communication skills and only three (4, 5 and 8) have even an implicit connection to a science based curriculum. Markes also highlighted the perceived lack of ‘social, communication and interpersonal skills’, ‘poor business awareness’ and ‘poor management skills’ amongst engineering graduates (2006, p. 645). It is likely that the science and mathematical content is not being highlighted, because it meets employers requirements, but my suggestion is rather that it may be over taught, or over emphasised at the expense of other, as necessary subjects. This was the finding of another study, where Fletcher et al, found that recently graduated engineers ‘felt that their technical knowledge surpassed the requirement for employment, while transferable skills and management-related subjects were generally lacking’ (2017, p. 20).

		Mean		
Rank	Attributes	Importance (I)	Satisfaction (S)	Gap (I – S)
1	Oral communication skills	4.57	3.92	0.65
2	Interpersonal skills with colleagues and clients	4.56	3.99	0.57
3	Written communication skills	4.38	3.83	0.55
4	Capacity to analyse and solve problems	4.58	4.04	0.54
5	Ability to develop new or innovative ideas, directions, opportunities or improvements	4.17	3.72	0.45
6	Time management skills	4.07	3.62	0.45
7	Capacity for co-operation and teamwork	4.60	4.16	0.44
8	Ability to apply knowledge in the workplace	4.33	3.91	0.42
9	Ability to cope with work pressure and stress	4.03	3.63	0.40
10	Capacity to learn new skills	4.60	4.22	0.38

Figure 5-2: Gap analysis of engineering employers’ perception of Monash University graduate attributes (Nair et al., 2009, p. 136)

In the previously mentioned IET survey (The IET, 2015) the question that gained the most agreement (66%), was that employers believed that the ‘education system will struggle to keep up with the skills required for technological change’. This is in line with the concern reported by Markes (2006, p. 648) that ‘employers want graduates who can help them deal with change’, although the latter statement is subtly different as it has the more realistic aim of producing graduates who can deal with change, rather than expecting the education system to deliver graduates fully up to date and conversant with the latest advances in technology.

The preceding discussion is not intended to provide a comprehensive list of the skills required for a person to practice as an engineer, but rather to offer evidence from published literature that what industry wants an engineer to be able to do, does not appear to be a very close match to the now dominant *engineering science* paradigm of engineering education. The aspect of engineering education recounted in my autoethnography that was the most explicit and frustrating aspect of this disconnect, is the role of mathematics. In my experience mathematics was something that had to be learned in order to pass exams, but was mostly unnecessary for my understanding of engineering concepts, or for implementation of those concepts in practice. The next section focusses on the contrast between the absolute importance placed on classical forms of mathematics by educators, versus the way mathematics is used in practice. I will argue that an excessive focus on mathematics in engineering academia, is probably the most explicit example of the disconnect between engineering education and engineering practice.

Mathematics in engineering practice

Mathematics is a core component of engineering degrees, and is also integrated into the teaching of engineering classes as a way to prove and demonstrate scientific phenomena. The 'absolute importance of high levels of mathematical competence' is the established view of engineering academics and is part of the 'dominant engineering science paradigm of engineering education' (Johnston and King, 2008, p. 76). In contrast, my autoethnography highlighted the fact that while I had learned mathematics to an advanced level in order to be successful in my engineering degree, within a relatively short period after graduating I had almost completely lost these skills through lack of use. The next chapter also shows that early engineers were not particularly mathematically inclined, some had outright hostility to the subject, and its primacy within the engineering curriculum is a relatively modern phenomenon. This subsection explores this seeming contradiction between the minimal use of mathematics in engineering practice versus its pervasion in engineering education.

Johnston and King (2008, p. 76) highlight the stark differences between the views of academics and practitioners. Many practitioners ‘asserted that their university mathematics was a “waste of time” and ‘have never used the advanced techniques they were taught’, while academics took almost the opposite view:

> *Many academics, not surprisingly, given the dominant engineering science paradigm of engineering education, stressed the absolute importance of high levels of mathematical competence, some with the implicit meaning that this competence is necessary for students to succeed in their particular advanced course.* (2008, p. 76)

While researching mathematical aspects of professional practice Kent and Noss made a decision to focus on engineering because they wanted to study a ‘mathematically-rich professional practice where a broad range of mathematics is explicitly used’ (2002a, p. 39/1), so they were surprised when their survey of civil engineering practitioners returned comments such as:

> *Once you’ve left university you don’t use the maths you learnt there, ‘squared’ or ‘cubed’ is the most complex thing you do.*
>
> *For the vast majority of the engineers in this firm, an awful lot of the mathematics they were taught, I won’t say learnt, doesn’t surface again.*
>
> *There is a whole lot of maths in what we do that we don’t need to think about really, because other people have done it for us*
>
> (Kent and Noss, 2002a, p. 39/1)

Kent and Noss appear to have begun their study with a presumption that mathematics was an important part of engineering practice, perhaps because as mathematics academics, they would have been familiar with the extent of mathematics in engineering education through service teaching. Regardless of how this preconception was developed, it was clearly shattered by their research into engineering practice which found that practice was generally defined by ‘feel’, (2002a, p. 39/4), approximations (2002a, pp. 39/1-39/2) the ‘overwhelming presence’ of engineering software, and a ‘few percent’ of engineers who specialise in mathematical/analytical problems, many of whom were external and academic consultants (2002a, pp. 39/1-39/2). This study, shows that as far back as 2002, computers were already doing the vast majority of mathematical calculations in engineering practice, and calls were being made for engineering education to reconsider how it interfaces classical mathematics with engineering understanding. The fact that these researchers were so surprised to find almost no explicit use of mathematics in general engineering practice, is a pointer towards the discussion in Chapter 7 and the unquestioned doxic belief within the field of academia that engineering is fundamentally a mathematical profession

Over a decade earlier, another group of mathematics researchers (Berry and Whitworth, 1989) describe a similar experience. Although they were teaching Mathematics at below A-level standard, they found that this was at a higher level than that which the engineers would actually use. The engineers they consulted with added that ‘if they ever did, they would look for computer support or help from a mathematician’ (1989, p. 28). Berry and Whitworth felt that level of mathematics that students were being required to obtain for their engineering degree was ‘completely unnecessary’ (1989, p. 28), and out of step with the way that engineers use mathematics in practice. Yet another mathematics researcher, Julie Gainsburg (2007, p. 481) highlights the ‘mismatch between the mathematics-oriented version of engineering design promulgated by schools and textbooks and design as practised in the field’. She also cites others who ‘challenge the primacy of mathematical theory in the everyday practice of individual engineers’(Gainsburg, 2007, p. 481). It’s notable that this issue was raised by Berry and Whitworth in the nineteen eighties, repeated by Gainsburg twenty years later, and continues to be highlighted today (Koziński and Evans, 2017), with some going as far as to refer to 'the mind-numbing math-science death march that casts aside thousands of capable young people who might otherwise have made effective engineers' (Usher and Sheppard, 2017, p. 67). The question of how such a long standing, and known disconnect is maintained is the focus of Chapter 7.

From my autoethnography, the historical analysis chapter, and the industry, institutional and academic sources above, there is a body of evidence supporting the argument that while classical mathematical methods are prevalent in engineering education, this is not reflected in practice. If this is the case, what are the arguments *for* an advanced level of mathematics in engineering education? Typical arguments include 'training in rational thinking' (Flegg et al., 2012, p. 717), but this argument seems to ignore the fact that rational thinking is practised by many academic disciplines and professions that are not particularly mathematical in nature. Flegg also argues that mathematics provides 'tools for undertaking analysis' and this is of course true, but again there are other ways to conduct analysis, and even where a complex mathematical analysis is required, as discussed previously, this is normally done in practice by computers or mathematicians. Devlin (2001, pp. 21–22) agrees that software engineers 'don't use their college mathematics', but argues that the main benefit is from the 'experience of rigorous reasoning with purely abstract objects and structures'. Devlin also cites evidence that students who do a 'rigorous course in algebra or geometry' (Devlin, 2001, p. 22) in high school, fare better at university, but doesn't provide any evidence for the causal link that he makes, or any indication that other contributory factors were excluded, not least the students whose future university courses contained advanced mathematics.

What is notable about the studies which do challenge the role of mathematics in engineering education, is that the authors are almost all academics from mathematics departments, *not* engineering academics. Although there are calls for higher levels of mathematics from academics, there is surprisingly little, if any, academic research that makes an argued case for *why* explicit classical mathematics remains so important to engineering education. As discussed previously, this may represent a doxic belief formed in the habitus of engineering academics, and this is considered in more detail in Chapter 7. This section has presented classical mathematics as something that is prevalent in engineering education, but not in engineering practice. In contrast the next section focusses on the subjective and qualitative aspects of engineering practice,that are not well reflected in engineering education.

The subjective, qualitative nature of engineering practice

Pedersen (2015) offers a fairly complex argument around the differences between science and engineering design, that is probably inaccessible to most outside of the fields of science and engineering. However, in general terms he describes the process of scientific research, and how scientists abstract, idealise and deconstruct the objects of study, so that ultimately ‘scientific statements are claims about model objects and not directly about the world as it exists independently’ (2015, p. 195). Engineers can use these scientific models, but ‘the model object is not the reality’ (2015, p. 195), and while the approximations are useful, many ‘advanced mathematical and physical theories are only valid in highly abstract and isolated systems’ (2015, p. 179). Where engineers work with objects, whether they be pumps, buildings or electronic devices, they are defined in terms of their function, operational principles, production, economic, and societal significance, and ‘it is impossible to define such artificial objects completely in naturalistic terms’ (2015, p. 181).

The above discussion highlights the fact that engineers, unlike scientists, need to make things work in the real world, and that the real world contains things that do not fit with abstract scientific models. The Kantian ‘distinction between the world in itself and the world as it appears to us' (Pedersen, 2015, p. 196) is also important to engineering. Even if an idealised object is a close enough approximation of the object in reality to be useful, it does not always follow that scientific statements about that object will be valid for the way in which the object represents itself to an *end user*. The history of engineering and technology is littered with objects and inventions that *worked* in the design stage, but were not accepted or understood by the consumer, or design failures such as the insufficiently sticky glue that found itself in huge demand for the now ubiquitous post-it note (Dodgson, 2008). In product design an engineer may have to consider not only whether something is affordable, which might be worked out quantitatively, but also much more qualitative concepts such as value, perceived need and usefulness. Even an engineer, completely isolated from the public, will have to make qualitative judgements in situations where models don't exist, or based on how management or technicians will perceive something, and so qualitative, subjective concepts play a large part in engineering practice.

In an observational study of practising structural engineers, Gainsburg (2007) concluded that veteran engineers had what she called a 'sceptical reverence' for mathematics. While they understood that the laws of mathematics governed everything that they were doing, it was also 'inadequate' (p. 498) and often subservient to many other considerations. Gainsburg concluded that 'engineering judgment, rather than mathematics, is hegemonic over the practice of structural engineering' (2007, p. 497). Vick (2002, p. 102) defined *engineering judgment* as 'a sense of what is important' that comprises 'a diagnostic character in problem definition, an inductive character in combination of evidence, and an interpretive character in providing meaning and context to predictive conclusions' (p. 83). According to Gainsburg the term 'engineering judgement is ubiquitous' in the literature, but is 'essentially unexplored as a research topic' (2007, p. 486). Petroski offers the following definition:

The first and most indispensable design tool is judgment. It is engineering and design judgment that not only gets projects started in the right direction but also keeps a critical eye on their progress and execution. Engineering judgment, by whatever name it may be called, is what from the very beginning of a conceptual design identifies the key elements that go to make up an analytical or experimental model for exploration and development. It is judgment that separates the significant from the insignificant details, and it is judgment that catches analysis from going astray. Engineering judgment is the quality factor among those countless quantities that have come to dominate design in our postcomputer age. (Petroski, 1994, p. 121)

Gainsburg (2007) attempted to categorise the incidents that she observed that could be considered ‘engineering judgement’:

- Determining what is a good or precise enough calculation or estimation
- Making assumptions or simplifications to be the bases of mathematical models
- Overriding mathematically "proven" results
- Determining appropriate uses of technology tools
- Assigning qualitative factors (e.g., soil type) and applicable conditions for selecting formulas
- Overriding official building codes
- Discretizing (grouping elements to reduce the number of types to be designed (Gainsburg, 2007, p. 486)

The term engineering judgement and the discussion above describes a very subjective, qualitative approach to engineering, and my experience of engineering outlined in Chapter 3 is in line with Gainsburg’s research and conclusion, that engineering judgement rather than mathematics, is hegemonic in engineering practice. Judgement, can be related to experience, and it could be argued that experience is something that is very difficult to teach in an academic setting, developing instead out of years of practice. However, it raises an epistemological question around how engineering students are being trained to understand engineering problems, versus the way in which these problems are understood by practising engineers, and this is explored in more detail in Gainsburg's later research (2015). It should be noted, that an engineer's knowledge of mathematics will inform engineering judgement, but subjective, experience based judgement, that sometimes overrides mathematical calculations, is very different epistemologically from the way that engineering mathematics is taught in academia.

Gainsburg also cites a number of studies that highlight 'the social and negotiated nature of engineering work' (Gainsburg, 2007, p. 481) and it is clear that the *human factor* is an important aspect of engineering work, whether it be customers, suppliers, users or employees, with the latter being critical when it comes to prevention of major safety incidents (Mogford, 2016). Lucas *et al* (2014, p. 7) captured numerous definitions and descriptions of engineering and presented them 'as two word clouds' representing 'some of the frequently recurring words associated with engineering'. The first simply makes the most frequent words larger 'while the second seeks to highlight the underlying concepts of the words and show these in similar mode'.

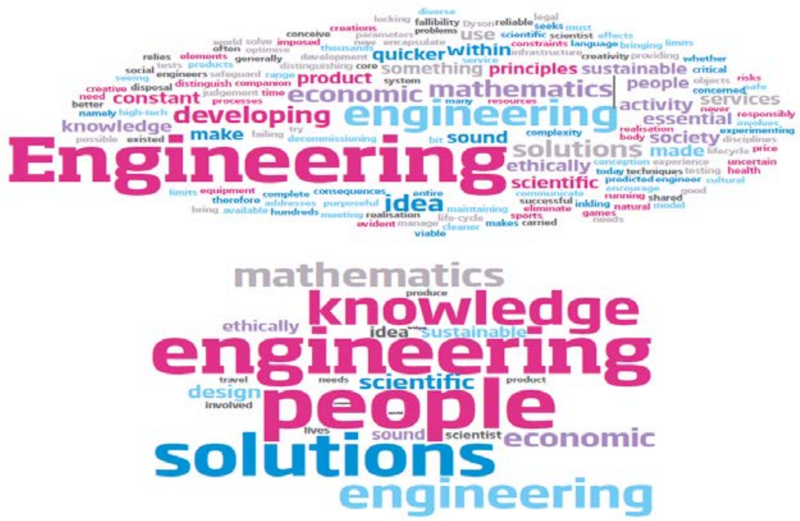

Figure 5-3: Words most associated with engineering (Lucas et al., 2014, p. 8)

Lucas *et al* were ‘struck by the way that the word ‘people’ emerges in the second word cloud, suggesting that many of the more fragmented concepts of the first relate to human activity’ (2014, p. 8) and go on to offer two quotes:

> *Engineering in the real world also involves many social skills… These include the ability to understand and realize community goals; to persuade relevant authorities of the benefits of investing money in engineering projects; to mobilize, organize, and coordinate human, financial and physical resources; to communicate* (John Webster in Lucas et al., 2014, p. 8).

> *Something I learned from five years of studying the experiences of undergraduate engineering students is that engineering education has a funny, maybe even neglectful relationship to… people* (Reed Stevens in Lucas et al., 2014, p. 8).

Beder states that there is an ‘increasing need’ and ‘moral imperative’ for engineers to apply ‘technological solutions that are appropriate to their social context’ (1999, p. 12) ‘and to give consideration to the long-term impacts of their work’. Beder makes the point that modern engineers not only need to be able to design sustainable systems, but they also need to understand the social and political reasons why cleaner, more sustainable technologies that already exist, have not been adopted by the consumer, and incorporate these factors into design. Like engineering judgement, the idea of engineering as a social and negotiated profession, shows that engineering is in many ways an inherently qualitative and subjective profession, which for most engineers follows an inherently quantitative and objective education.

The discussion presented in this chapter does not by any means provide an exhaustive description of engineering practice, but should serve to provide evidence that many of those who have studied practising engineers, and practising engineers themselves, present an image of engineering that is at odds with the focus of an engineering degree. It is notable that most of the previously discussed challenges to the primacy of mathematics and engineering science, as well as research highlighting the subjective, social and qualitative nature of engineering, tend to come from sources outside of engineering academia. The argument that I will present in Chapter 7, framed within a Bourdieusian analysis, is that sociological factors, rather than educational or engineering needs, are maintaining the dominance of engineering science in education, and the disconnect between engineering education and practice. Prior to this, Chapter 6 explores the historic factors that have influenced the development of engineering and engineering education, and ultimately the formation of fields and habitus related to the profession.

Chapter 6: History informing habitus: The historical development of engineering and engineering education

Introduction and aims of this chapter

In the previous chapter, I discussed how the ‘world of tradition’ can be experienced by its adherents not as arbitrary, but as a self-evident and natural order (Bourdieu, 2010, p. 166). I demonstrated that rather than one possible tradition, there are multiple definitions of the word engineer, and that these vary depending on the social or professional field. I also argued that established definitions that have been influenced by language and for social reasons, can and should be questioned. Similarly, doxic beliefs about what it means to be an engineer, and the habitus of professional engineers and engineering academics, are rooted in the ‘accumulated history’ (Bourdieu, 2004, p. 15) of the agents within the relevant fields. In a Bourdieusian analysis, the concept of habitus is at the core of why people do what they do, and according to Bourdieu habitus is accumulated history, which goes on to produce more history (Bourdieu, 1990, p. 56). This highlights the potentially cyclical nature of habitus, that is only broken by either a reflexive step, or an intervention (Garrett, 2007, p. 230).

Bourdieu has suggested that history is a ‘sociology of the past’ and sociology ‘a social history of the present’ (in Charle, 2012, p. 67) and so I would argue that before going on to explore the sociology of the present in Chapter 7, I must first consider how the social history of the past contributes to this. This chapter therefore considers the historical development of engineering and engineering education, as the background to many of the practical and social problems facing engineering today. Ultimately the fields that will be analysed in Chapter 7 are the outcome of the history discussed in this chapter. The main argument I will be making in this chapter, is that from its very beginnings engineering education developed out of two competing fields, and although the practice tradition dominated the early engineering profession, the engineering science tradition ultimately became the dominant paradigm in engineering education. I will argue that while this paradigm shift was in part necessary, it was also largely driven by social factors and the engineering profession’s perceived need to improve its social standing. In fact, the profession’s struggles with status, and its place in society, are a recurring theme in the literature. I conclude with an argument that when engineering computing later became the dominant paradigm in engineering practice, this was not reflected in engineering academia.

This chapter takes a mostly chronological approach as follows:

- The origins of engineering and links to social status
- The origins of engineering as a modern profession
- The early development of engineering education
- The rise to dominance of the engineering science paradigm
- The advent of the digital computer and how it revolutionised engineering practice

The origins of engineering

The previous chapter discussed some of the difficulties with finding a universal definition of engineering, and it follows that similar issues will also affect perspectives on the origins and development of engineering. In a history of engineering that is written with a civil and structural engineering slant (Wells, 2010) the origin story begins with reference to prehistoric construction of stone circles, Egyptian pyramids and early bridges, and so connects the origins of engineering to that of builders and architects. In contrast, McMahon (1984, p. 1) positions the ‘dawn of electrical engineering’ as a profession at around 1884, pointing to scientists of the previous hundred years or so as its progenitors, with the technological advances of the industrial revolution as its bedrock.

Both of these visions of the origins of engineering have validity but are also heavily influenced by their desire to connect to progenitors that relate to their specific disciplinary knowledge. Historians have shown how early Royal families mythologised their linage and history to connect it to something that was ancient, as this increased their credibility and status amongst their subjects and peers (Marsden, 2010; McHardy, 2011; Watson, 2011). I would suggest that there is something similar at work as modern engineers seek to increase the perceived status of their profession through connections to the past. Civil and Structural engineers can thus point to a very long history, as boats, bridges and buildings have been constructed for millennia. However, while these builders, architects and craftspeople contributed to disciplinary knowledge and the origins of the profession, they would probably not have called *themselves* engineers. The same can be said of the physicists and mathematicians who developed many of the theories used by modern electrical engineers.

Armytage (2003) takes a more holistic view of engineering history and while again the term *engineer* is being used retrospectively, in this vision the early engineer used naturally occurring resources such as wood, clay and stone to make fire, pottery, structures and weapons, later manipulating natural resources to irrigate crops and divert floodwater, and modifying natural resources to produce metal (2003, pp. 17–22). The early engineer equivalents came first, solving real problems through experimentation, experience, aesthetics, but without understanding why their solutions worked. Later Greek philosophers started to establish scientific rules and theories to explain these phenomena (2003, pp. 23–28) and this science influenced later engineers in turn. Although these figures from early history would be unrecognisable to the engineers and scientists of today, I would argue that it is important to consider that the origin story, whether perceived or real, has an impact on how the profession views and organises itself today. Most of this chapter will focus on engineering as an organised profession, which locates its professional origins in or around the early nineteenth century, but the people who founded the profession did not exist in a bubble and would have been influenced by the values of their time and social group. As discussed below, aside from the practical connection to the scientists of

Ancient Greece, Victorian society also felt a social connection to what was probably a heavily romanticised version of Greek society.

The Ancient Greeks provide some of the earliest evidence of a class-based separation between practice, and the philosophical view of science. For the aristocratic Greeks, according to Armytage, 'life was to be understood, not changed'(Armytage, 2003, p. 26) and in Greek society thinkers who aimed at 'utility' were considered less wise, and of lower status (Aristotle in Armytage, 2003, p. 26). Plato's writing also infers a similar distaste for practice with his opposition to 'practical testing of hypothesis by mechanical devices', which he felt was 'vulgar' and 'fit for slaves'(in Armytage, 2003, p. 24). The relevance of this today might at first appear tenuous, but the influence of ancient Greece on European thought is well documented (Penn, 1938), and it was not uncommon for post renaissance Europeans to 'draw moral and intellectual authority from the writers and historical precedents' of Ancient Greece (Bell, 2006, p. 736). In fact, at a conference marking the birth of one of the early electrical engineering institutions in 1884, one of its leading figures, Professor Henry A. Rowland, used his keynote address to regurgitate this aristocratic Greek argument and to argue the value of pure science over application. In this instance he claimed that Archimedes refused to record his engineering accomplishments, 'repudiating as sordid and ignoble, the whole trade of engineering' and suggested that the practical artefact could only appeal to a 'vulgar and uneducated taste' (McMahon, 1984, p. 4).

It's important to note that this period, where the nobility of science is contrasted against the vulgarity of practice, is also the period when the engineering institutions, and their professional identity is being formed. I would suggest that the shared habitus of the profession begins to develop at this point, and their point of reference in society would be established, respectable professions, such as medicine and law. The new professional engineers are also likely to be conscious of the practical, or trade based associations that engineering had only recently grown out of and how this would affect their standing as a profession. As the professions of medicine and law were built on the cultural capital of formal university education, it is likely that engineers would seek to replicate this, and the increasing need for science and mathematics would provide a connection to the academy, and an elevation in status.

Two traditions: Engineering science and practice

Aside from the continuing development of Civil Engineering, many of the technological advances through the middle ages were focused on agriculture and war (White, 1962), and these were in effect early examples of mechanical engineering. Armytage (2003) sees engineering advances in each age as a direct response to social, political and economic conditions but the opposite could also be argued using the example of the printing press, developed from around 1440, at the close of the middle ages. According to Dittmar (2011, p. 1133), European cities with established printing presses grew '60% faster than otherwise similar cities' and this engineering artefact preceded a period of rapid social, political, economic, cultural and technological change, including the enlightenment, the scientific revolution, the industrial revolution and a number of social revolutions. It is against this backdrop that engineering started to become identifiable as a profession, one that was inextricably linked to the industrial revolution, and by extension to capitalism and business interests, and to the ideas that Marx and others were beginning to develop around Economic Capital.

As the importance of engineering to society (and the economy) became more pronounced during the industrial revolution, celebrated engineers such as Brunel, Locke and Stephenson became situated in the top levels of society (Bailey, 2009) and so engineering became more recognisable as a word, and as a profession. The nineteenth century also witnessed the formation of the discipline-based engineering institutions that remain at the forefront of professional engineering today, including the Institution of Civil Engineers (1818), The Institute of Mechanical Engineers (1847), The Institution of

Electrical Engineers (1871, now the Institute of Engineering and Technology), ushering in the ‘general-professional period’ (Armytage, 2003, p. 356). Engineers of this period, who did not have the status afforded by a university education, began to use the social capital of their collective to institutionalise their cultural capital, and Institution membership, rather than a degree is how this was formalised for professional engineers.

Although membership of these institutions today would almost certainly require a degree, engineering knowledge was not covered by the ‘ancient universities’ (Lundgreen, 1990, p. 34) and only three of the first ten presidents of the ‘all powerful’ Institution of Civil Engineers, was ‘university trained’ (“Engineering Education,” 1964, p. 392). Many engineers from this period came from a background in ‘skilled crafts’ (Johnston and King, 2008, p. 66) with celebrated figures such as James Watt starting out as an instrument mechanic (Armytage, 2003, p. 88) and Thomas Telford as a stonemason (2003, p. 119). Telford was to become the inaugural president of the Institution of Civil Engineers and was a giant in that field, but was ‘disdainful of mathematical studies, and preferred the reassurance of physical tests of materials and models’ (Ferguson and Chrimes, 2011, p. 50). There were of course exceptions and John Smeaton who preceded Telford, and is considered by some to be the founder of Civil Engineering as a profession ‘differed completely from most of his contemporaries’ in that he had a formal education that allowed him to read, untranslated, the writings of his contemporaries on the continent (2011, p. 17).

Alongside the practice tradition, particularly in continental Europe, an ‘engineering science model’ was developing (Issapour and Sheppard, 2015, p. 10; Johnston and King, 2008, p. 66), although I would contend that many of the individuals who are celebrated today by this tradition including Maxwell, Volta, Faraday and Ohm, would have been more likely to have referred to themselves as scientists. However, some also did important engineering work and Sir William Thomson, more well known as Lord Kelvin, became the ‘father of electrical engineering’ when he accepted a position with the Atlantic Telegraph Company, to solve the technical problems involved in laying the first Atlantic telegraph cable (McMahon, 1984, p. 6). This exemplifies why the engineering science tradition was starting to become important. This would not have been a project that could have been tinkered with in a lab or a workshop as it would be impossible to replicate the conditions at the bottom of the ocean. The involvement of a physicist who could theorise in advance on the technical issues that might arise, would help to ensure that the hugely expensive cable would be designed correctly before production and installation.

Despite the rise of the scientist-engineer, some of the leading figures from the history of electrical engineering continued to come from practical occupations. Telegraph operators who also repaired became known as ‘electricians’, with some developing into technical advisors and consultants (McMahon, 1984, p. 8). The most famous of these early telegraph operators come electrical engineers was Thomas Edison (1984, p. 7), one of the most important figures in electrical engineering. Despite Edison’s practical background he clearly also recognised the contribution that more formally educated staff could make, and as Edison’s developments in electric lighting became more complex, he found himself hiring mathematical physicists (McMahon, 1984, p. 23).

A clear conflict developed as the two traditions jockeyed for position. I have already discussed Rowlands’ argument for pure science in the establishment of the electrical engineering profession in the USA. On the other side of the Atlantic the fledgling Institution of Civil Engineers (ICE) also debated the merits and drawbacks of formal education. This is illustrated via contrasting quotes from two ICE members, Sir John Fowler in 1865 and Sir Benjamin Baker in 1895. The suggestion from Fowler was that the only reason his generation did not benefit from ‘systematic training’, was that it didn’t exist, but that future generations should not suffer that drawback. However, thirty years later Baker was still cautioning against formal education, or at least not at the expense of practical training and experience (Ferguson and Chrimes, 2011, p. 48). The emphasis that the institution placed on practice over theory, is highlighted by the fact that the renowned engineer, and eventual Regius Professor of Civil Engineering and Mechanics, WJM Rankine, was never admitted to full membership because it was felt that he hadn't 'completed enough large scale projects' (Marsden, 2013, p. 442). Considering the regard Rankine is held in today by the now dominant engineering science tradition, his astonishing lack of standing seems to suggest that his academic background excluded him from being considered a *proper* engineer. This presents a stark contrast to today, where institution presidents are often drawn from academia, and those without a degree are the ones who are not considered *proper* engineers by the institutions. The early engineering profession was not only firmly rooted in practice, but appeared to have an outright hostility to academic and theoretical approaches to engineering.

The practice-based education of the UK and the USA was in marked contrast to that which had developed in continental Europe. Following the model of the Ecole des Ponts et Chaussées which was established in 1747, institutions dedicated to formal engineering were established in Prague, Berlin, St. Petersburg, Vienna and Copenhagen (Ferguson and Chrimes, 2011, p. 51; Harnow, 1997, p. 226). However, in spite of the lack of formal education, it was the practice-based engineers of the UK who were the more innovative and this may be in part because the theory of the time was not yet fully developed or reliable (Ferguson and Chrimes, 2011, p. 51). Practice-based engineers could not wait for science to catch up and craftspeople, such as the Ironmonger Newcomen, invented the first practical steam engine through patient experimentation, long before the scientific field of thermodynamics had even been established (2011, pp. 49–50). However, an alternative view is recorded by a visiting German engineer, who noted the extravagance of British bridge designs and the excessive use of Iron. His feeling was that British engineers were getting away with this because of the wealth of industry in the UK, while the German engineer with more limited resources had to take an analytical approach and carefully design every bridge so that the minimum of material was used while the bridge still met its loading requirements (2011, p. 51). It could be argued that as efficiency and complexity became more important, the very practical UK engineering sector fell behind, while the formally educated German engineering system over the course of a few decades produced household names such as Siemens, Weber, Bunsen, Daimler, Opel, Bosch, Diesel, Haber, Planck and Hertz (Armytage, 2003, p. 194), with the proviso that some of those that Armytage lists as engineers were arguably scientists, not engineers.

Early development of engineering education

As in industry, practice also dominated early engineering education in the UK (Johnston and King, 2008, p. 66; similar in Tulkki, 1999). While there is significantly more literature covering the development of engineering education in the USA, than in the UK, both appear to follow a similar pattern and are often contrasted together, against the continental model. Early engineering education in the USA was informal and skills based, but colleges offering engineering courses started to become more common after the Morrill act of 1862 (Issapour and Sheppard, 2015, p. 1). There was some formal engineering education prior to this date but these tended to be either military academies modelled partly after the French style/partly traditional apprenticeship (2015, p. 4), or the British style vocationally orientated technical colleges (2015, p. 5). The demand for an engineering education, and the financial incentive, led to engineering courses being offered by traditional universities, but these were initially only certificates, or options within a degree. There appears to have been some confusion about where to fit engineering and it initially appears to have been an option in a Bachelor of the Arts, but concerns that it would ‘dilute’ the prestigious classical education of the former, seems to have been the main reason for alignment with the Bachelor of Science curriculum (2015, p. 7). However, engineering continued to be ‘looked down upon’ and these colleges were kept separate from the main university, with complete integration not coming until the middle of the 20th century (2015, p. 8).

Prestige and status appears to have been an issue of great concern from the birth of professional engineering in the nineteenth century, and for some 'the evil complained of' was because engineering was seen to be taught 'only as a trade' (Ferguson and Chrimes, 2011, p. 14). Those members of the Institute of Civil Engineers, may have been referring to the 'socially inferior', emerging mechanical engineers, later to form the Institute of Mechanical Engineers (Hirose, 2010, p. 6). Hirose suggested that even within professional engineering there were different classes of engineer, and the Civils were middle and upper class people who could afford the costs of pupillage, while the Mechanicals were from the lower middle to working class, and entered through a company apprenticeship. Early attempts at formal engineering education in the UK appear to have failed, partly because the established engineering profession rejected them in favour of the systems of pupillage and apprenticeship (Smith, 2001), and partly because the concept of vocational education appears to have been lost on the culture of the time. According to Beder (1999, p. 14), 'gentlemen' were educated, while common people were trained for a vocation. If young people had the funds to pay to go to college they wanted the 'prestige of an education', not practical skills they could get 'on the job' (Beder, 1999, p. 14).

Formal engineering education as a discipline started to become more prominent in UK and US universities around the late nineteenth century (Seely, 1995, p. 742) but it is reported to be as late as 1935-1955, before American Universities such as Stanford took the lead in 'replacing machine shop, surveying and drawing classes, with science and mathematics' (Froyd et al., 2012, p. 1345). During the same time period in the UK social class appears to have continued to play a role and 'elites took full-time degree courses followed by two years (or more) of systematic training, while the rest went through an apprenticeship of five years or more, supplemented by part time technical education and career experience (Hirose, 2010, p. 401). Froyd *et al* (2012, p. 1345) consider the move from a practice base to an engineering science base to be the 'first major shift in engineering education', with the curriculum moving from a ‘hands on, practice based curricula to ones that emphasized mathematical modelling and theory based approaches’.

Although the engineering science model has been said to have developed on the continent, the original Humboldt model of engineering education developed in Germany stressed the ‘need for theory and practice in university education’ (Marjoram, 2015, p. 114). Marjoram argues that when this model was transferred out of Germany, that the *practice* element was diminished, ‘with an increasing focus on theory, less on student-centred practice’ (2015, p. 114). The reasons for this are not completely clear but Harwood (2006, p. 61) suggests that when Rankine developed his own form of engineering science education in the 1850’s he ignored the practice element, only because the students he ‘sought to attract were already experienced via apprenticeship’. Rankine ‘never claimed’ his engineering science model ‘could provide a complete training for the engineer’ (Marsden, 2013, p. 448). Harwood (2006) makes it clear that engineering science developed differently at other institutions in Britain, but it is easy to see how a theoretical model of engineering education that was designed for already practising engineers, might over time be the same model that is offered to school leavers without any prior practical experience to relate this to.

From the above discussion, it is clear that the early engineering profession in the UK was originally based in practice, and to a degree was also hostile to an academic version of engineering. As previously discussed there was also resistance from the academic community to a discipline that was seen to be beneath a classical education, or alternately because it was encroaching on the territory of the pure scientists. The political struggle faced by the early engineering professors at Glasgow to establish an engineering degree, culminating in the ‘complex of arguments’ (Marsden, 1992, p. 326) used by Rankine to skilfully position *engineering science* as the harmony of theory and practice, was only successful because it satisfied the academics that it was not ‘pure science’ and the engineers that it was not ‘pure practice’ (1992, p. 327). Thus the Universities in the UK began an uneasy relationship with engineering as a discipline, although the apprentice based system for training engineers continued in industry until ‘well into the 20th century’ (Tulkki, 1999, p. 36).

The rise to dominance of the engineering science paradigm

In the 20th century two new engineering disciplines grew in prominence. Chemical engineering went from being unheard of, to the 4th largest engineering specialism by the middle of the century and had grown out of a combination of mechanical engineering, burgeoning chemical industries, and of course the science of chemistry (Divall et al., 1999). Electronics engineering came out of the field of electrical engineering, and the practical experiments of Edison and others, but was also heavily reliant on the science of physics (Chapter 7, McMahon, 1984). While other engineering disciplines were also affected by increasing complexity, these two disciplines have a very clear connection to science, and in particular the story of electronic engineering demonstrates some of the practical reasons for the rise to dominance of the engineering science paradigm in US and UK engineering education.

The development of electronic engineering by the nineteen thirties was driven in part by the growing radio, television and communications industries, but was accelerated by the importance of related technologies to the war effort in the forties (Chapter 7, McMahon, 1984). At these high frequencies electricity had started to behave unpredictably and it was becoming necessary for electrical engineers to refer back to the ‘fundamental equations’ developed by the nineteenth century mathematical physicist James Clerk Maxwell (McMahon, 1984, p. 233). For an engineer to be able to use Maxwell’s’ equations they would in turn require an understanding of Vector Calculus, which would in turn require fluency in the prerequisites of calculus such as algebra, trigonometry, logarithms etc. In effect a complete classical mathematics education was required, as well as a connected understanding of physics. The ‘sheer complexity of the new electronics’, was raising anew the question of what constituted engineering knowledge (McMahon, 1984, p. 232).

In the USA a debate raged within the electrical engineering institutions about the content of engineering education, and the engineering science agenda was particularly driven by the California based academic institutions (Chapter 7, McMahon, 1984) that were to play a major part in the forthcoming electronics revolution. A series of reports culminated in the Grinter report in 1955 which ‘firmly rooted the study of engineering in the sciences’ (Berry et al., 2003, p. 468). The report heavily criticised the traditional view of engineering education which had ‘expressed the interests of self-educated ‘practising engineers’ (McMahon, 1984, p. 235). They complained about the dilution of engineering curricula with the inclusion of ‘fringe areas’ such as accounting and business. They worried that the modern engineer was at risk of ‘obsolescence’ and the conclusion of the committee was that to protect against this, engineers must ‘undergo rigorous instruction in the basic sciences, especially in mathematics’, leaving practice, or ‘the art’ to be ‘acquired in the field’ (1984, p. 235).

As this debate raged on some engineering academics went even further and argued that electrical engineers should be prepared to undertake ‘pure research’, including ‘the discovery of new knowledge of nature’, transcending the conventional boundaries between science and engineering (McMahon, 1984, p. 237). Another senior academic who was driving the engineering science agenda at the time complained that ‘most of the major advances in electronics were made by physicists and people of that type of training’. These comments appear to stem from an academic, or ‘science envy’ (Harwood, 2006, p. 58) of physicists leading the way, instead of taking an engineering view, which might be to take those scientific advances and do something practical with them. This may point to the beginning of a period where engineering academia starts to become influenced by the values of academia, where academic reputation and status is linked to research. These issues are discussed in more detail in the next chapter, but it is clear that in this time period, engineering academia was starting to feel a need to compete with scientists for prestige, and as such this may also coincide with the beginning of a disconnect from the world of engineering practice.

From previous discussion, it is clear that unlike some continental models, engineering science and practice do not appear to have been able to find a natural balance in the UK/USA, and instead were locked in a battle for dominance within engineering education. In such a battle, with the increasing complexity of problems engineers needed to solve, and the prestige of scientific research, the engineering science paradigm was the inevitable winner. However, according to Crawley this ‘shift in the culture of engineering education’, also ‘diminished the perceived value of key skills and attitudes that had been the hallmark of engineering education until that time’ (2014, p. 3). Although engineering science had its origins in Germany, as previously discussed, the German engineering system had from the outset incorporated practice. The UK system of engineering science was originally intended to supplement the apprenticeship system, so when the apprenticing system disappeared from engineering practice in favour of a longer period at university (the Master of Engineering degree is now the nominal standard), the practical aspect was lost from education, in favour of more theory. Another difference is that the continental institutions responsible for the formal education of engineers such as the previously mentioned Ecole des Ponts et Chaussées were established specifically for science, technology and engineering. Separate technical colleges were also established in the UK, in some cases bearing the continental style appellation of *Polytechnic* but never achieved the high status of their continental counterparts. A final and important difference is the social and legal status of engineering graduates in the UK, versus other countries in Europe, and this will be explored in a more detail in the next chapter.

This section so far has charted the development of engineering from practice, and the ‘tension between theory and practice’ (Crawley et al., 2014, p. 3). I have shown that sometimes practice led the way, with science struggling to keep up, but by the mid twentieth century theoretical science was clearly preceding engineering innovation. As engineering became more complex and costly, and safety became a greater consideration, it became necessary to ‘model’ (Johnston and King, 2008, pp. 66–67) engineering structures using mathematics prior to constructing them. This led to an era where scientific advances were often worked out and proved mathematically first on paper, before engineers and experimentalists would attempt to implement them, and engineering education gradually ‘moved from a practice-based curriculum to an engineering science-based model’(Crawley et al., 2014, p. 3). I have briefly touched on how engineering academia was influenced by the prestige associated with scientific research, and this is clearly a factor in the rise to dominance of a mathematical science based approach to engineering education. However, I would argue that there were also practical reasons, because prior to the advent of computers, the only way for the engineer to solve these problems, was on paper, mathematically. In the same way that the eighteenth century engineer would have needed a skilled craft base in order to build physical models, engineers now needed to be able to mathematically model their designs. However, things were about to change again, with the introduction of the very device that could be seen as the primary achievement of the field of electronic engineering, the digital computer.

The advent of the computer in engineering practice

The computer had been around in some form or another since 1791 (Ryder and Fink, 1984, p. 178), but they were initially mechanical and would have been very limited in their practical application. Electronic computers had started to be developed in earnest by the forties, but by the mid-fifties a typical computer weighed around three tons and cost around $200k (1984, p.

183). By the early eighties a far more complex computer could be purchased for around $80 and was of a size that could be picked up and carried around (1984, p. 184). The invention of the integrated circuit by Jack Kilby in 1959 was the enabler for this transformation, and would also enable everything from weapons technology, to space exploration and the miniaturisation and popularisation of the computer (McMahon, 1984, p. 226), and thrust electronics to the forefront of engineering. For the modern engineer this new electronics age had two major implications. The first is the obvious use of desktop and laptop computers to perform tasks in seconds that in the past would have required hours of manual calculations. The second and more discrete implication is the ubiquity of embedded electronics and computers in almost everything a modern engineer has to deal with, regardless of discipline. Engineering disciplines such as Civil, Mechanical and Chemical, which in the past would have had limited need for electronics knowledge, would not only begin use computers for their calculations and design, but also have to deal with electronic devices that monitor bridges and safety systems, automate and control chemical processes and collect and process data in ways that would previously have been impossible.

It is clear that the mathematical and scientific knowledge that drove the engineering science model in middle of the 20th century, has now largely been captured in engineering software programs, and by the nineteen nineties, ‘the computer has become an omnipresent tool for increased productivity in engineering practice’ (Kantor and Edgar, 1996). In a sense there is an irony that while it is clear that modern technology and computers could not have been possible ‘without advanced scientific mathematical modelling’, it is also now true that modern science, mathematics and engineering depend heavily on that same technology (Pedersen, 2015, pp. 179–180). By the nineteen nineties’ most engineers were already averaging 20-40% of their time at the computer (Kantor and Edgar, 1996, p. 17), and the Boeing 777 was making headlines as the first commercial airliner designed entirely using computers (Holusha, 1994). Eshbach’s long established bible of engineering fundamentals gives much of its preface over to the restructuring in this edition (Eshbach and Tapley, 1990, p. xi) due to the ‘dramatic change’ that computers have made to engineering practice, including the substantial reduction of a chapter on mathematical tables. By 2003, Russell states that the capabilities of modern computers ‘liberate’ the structural engineer from the ‘laborious’ tasks involved in stress analysis and allow them 'to concentrate on the more creative parts of the design process' (Russell, 2003, p. 131).

It is very clear that as the previous century drew to a close, computers rather than traditional forms of mathematical analysis, were establishing a hegemony in engineering practice. Kent and Moss summarise this transition below:

> *We know that in the past, thirty or forty years ago, engineers emerged from university armed with a body of mathematics-based analytical methods, intensively practised those methods for a period of years as junior engineers doing practical design calculations, and out of that somehow emerged engineering expertise. In the modern state of civil engineering practice, another model is needed for how mathematics fits into the development of engineering expertise, which recognises the ubiquitous presence of IT tools.*
>
> (Kent and Noss, 2002b, p. 27)

In other words, before the introduction of computers to engineering practice, engineers learned how to solve problems mathematically and then used that in practice, thus retaining and developing that knowledge into engineering expertise. In the era of engineering computing, engineers now use computers to solve the mathematical aspects of engineering problems, and with reference to the discussion in the previous chapter, it is clear that as a result many modern engineers do not practice or retain that classical mathematics education. While there is little doubt that computers now do most of the mathematical calculations in engineering practice, there is a question mark over how engineering education has responded to this change. Engineering computing is certainly a major part of the modern engineering curriculum, but classical mathematics remains core to the teaching of engineering concepts.

Summary

I have shown that engineering has its roots in practice, but that a theory and mathematical focussed *engineering science* approach eventually rose to dominance in the UK. There were practical reasons for this, and there came a point in history where mathematics was *the* indispensable tool for the professional engineer, allowing potentially expensive, time consuming projects, to be designed and tested on paper before being put into practice. However, it is also clear that even before the turn of the last century, computers had already replaced traditional mathematical analysis for most graduating engineers. Although computing is now part of the engineering education curriculum, the fundamental nature of engineering education and its use of classical mathematics as its base, does not appear to have changed. In the paper 'Five major shift in 100 years of engineering education', of which the first *shift* is the adoption of the engineering science paradigm, it is notable that the authors (Froyd et al., 2012) don't record a *shift* in engineering education that corresponds with the indisputable change to engineering practice brought about by the ubiquity of the personal computer and engineering software. There appears to be very little in engineering education literature to address what to all intents and purposes is a paradigm shift in engineering practice, beyond the introduction of the odd programming or engineering software class (Kantor and Edgar, 1996).

The history of engineering shows that while practice resisted the move towards formal university education of engineers, and the engineering science paradigm, that the significant benefits of these approaches eventually overcame. However, I would argue that the now established, research focussed engineering science paradigm has also become resistant to change, and has become disconnected from the practice of professional engineers. If the arguments of this and the previous chapter are accepted, and the reader agrees that there is evidence of a disconnect between engineering education and practice, then the remaining questions are how is this disconnect maintained, and could it be otherwise? A clue to the former question may be drawn from the history discussed in this chapter, as there is very clear evidence that engineering has long perceived a lack of status compared to other professions. These social reasons appear to have been as persuasive as the practical reasons for the migration towards university education for professional engineers. It is also clear that there were social factors driving the engineering science paradigm within engineering education, and the prestige of scientific research was becoming a major draw for engineering academics by the nineteen fifties. The next chapter moves from the past to the present, and will conclude my Bourdieusian analysis of engineering education and practice. I will argue that the habitus and fields, which are partly defined by the history discussed in this chapter, continue to shape engineering education today, and contribute to maintaining a disconnect between engineering education and professional practice.

Chapter 7: Permanence in change? A field analysis of the relationship between engineering education and professional practice

Introduction

The previous chapter discussed the historical development of engineering education and practice, in order to inform how history and social factors, have shaped the formation of these two seemingly disparate fields, and the habitus of its members. In fact the previous chapter ended with an argument that there is a tension and a disconnect between these fields, and that this has become more pronounced with the advent of engineering computing. This chapter seeks to explore how a disconnect such as this is maintained, and the Bourdieusian concepts of fields, habitus and doxa in particular are key to this discussion. I begin this chapter with a brief discussion of engineering education through the lens of 'signature pedagogies' (Shulman, 2005b) and 'constructing images' (Haggis, 2003), and explain that while these discuss how reproduction can occur within education, they do not offer a complete way to describe the impact of wider social factors. I then move on quickly to a conceptualisation of the traditions of academia and practice as distinct Bourdieusian fields. This in turn informs a discussion about the habitus of the agents operating within those fields, before reviewing some of the literature on other professions. The main argument made in this chapter is that a habitus formed in a field, will develop a view of engineering that is shaped by that field and the valued forms of capital within that field. My contention is that it is the disconnect between these two fields, and the resulting habitus of their members, that drives and maintains the disconnect between engineering education and practice.

Signature pedagogies and constructing images

Before continuing with the Bourdieusian approach I want to reflect on two concepts which as discussed in my autoethnography, were part of the original spark that set me on the path towards this PhD programme. Although these are two separate concepts, in the context of the argument that follows they are quite closely related. Although I have since taken a Bourdieusian approach, these concepts remain a useful starting point in describing how educational practices might be cyclic, and how academics may be repeating patterns from their own education.

I begin by discussing signature pedagogies (Shulman, 2005b), a concept that explores why individual disciplines develop and maintain particular pedagogical styles. Signature pedagogies is an important starting point because the concept indicates a recognition in the literature that there can be a cyclic nature to education, where the student becomes the teacher and repeats the pedagogy through which they learned themselves. This may be more likely in a discipline like engineering, where academics' own education and research is focussed on natural science, rather than practice or pedagogy. Compared with the discipline of education where academics are being exposed to new pedagogical concepts as a matter of course, and have closer links to practice, it is harder to see how this cycle would be broken in engineering education. The concept of constructing images also has a role to play, as it points out that academics may be trying to produce students in their own image, and pointing forward to the section on academic habitus, in engineering this is likely to mean a science and theory focused student, who will go on and complete a PhD, rather than a professional engineer.

It has been suggested that the concept of signature pedagogies is particularly applicable to reforming engineering education (Lucas et al., 2014, pp. 42–44). In Shulman's own paper (2005b, p. 53) he paints a picture of a fluid dynamics lecturer 'furiously writing equations on the board' with the students 'either writing as furiously as their instructor', or 'sitting quietly planning to review the material later in study groups' (2005b, pp. 53–54).

Shulman notes that there is ‘almost no reference to the challenges of practice in this teaching - little sense of the tension between knowing and doing’ and the ‘focal point of the pedagogy is clearly mathematical representations of physical processes’ (2005b, p. 54). While there is some implicit criticism here, there is also a sense that this is simply part of the *signature* of engineering, which Shulman sees as one of the ‘mathematically intensive disciplines’ (2005b, p. 54). I would suggest that this is because Shulman is himself an academic, observing engineering as taught, not as practised and would understandably presume that both are closely connected. Lucas argues, that despite what Shulman is witnessing in engineering classrooms, that this is not the ‘signature of engineering but of one very specific kind of mathematics’ (2014, p. 43). Reflecting back on my autoethnography, what Lucas describes is very close to my experience, where in education I learned the required mathematics to pass the assessment, then forgot most of it because I didn’t use it as a practising engineer. Lucas refers to another scenario described in Shulman’s (2005b) original paper, that of the design studio, where ‘students are experimenting and collaborating, building things’ and where ‘the focal point of instruction is clearly the designed artefact’, and argues that this is a more accurate reflection of the true *signature* of engineering practice. Again reflecting on my autoethnography, Lucas description does seem closer to my experience of the signature of engineering practice, while Shulman’s is a closer match to my experience of the signature of engineering education. The below quote describes the signature pedagogy of engineering education, if it goes unchallenged, and remains isolated from outside influences:

> *When we walk into an arbitrarily chosen engineering classroom in 2000, what do we see? Too often the same thing we would have seen in 1970, or 1940. The professor stands at the front of the room, copying a derivation from his notes onto the board and repeating aloud what he writes… At the end of the class students are assigned several problems that require them to do something similar to what the professor just did or simply to solve the derived formula for some*

> *variable from given values of other variables. The next class is the same, and so is the next one, and the one after that* (Rugarcia et al., 2000, p. 1)*.*

I would suggest that a limitation of *signature pedagogies* is that it starts with the premise that a signature pedagogy develops because it is, at least for the most part, reflective of the *signature* of that profession and Shulman is clearly working on that assumption. His focus is really on how educators can learn from each other's *signatures*, and the ways in which different disciplines convey knowledge and skills, but questions around the origin of that pedagogy, or whether that pedagogy reflects the realities of practice, are outside the scope of his work. It's also clearly a generalised, stereotypical view, not taking into account individual differences in educators, or for example the differences between teaching chemical engineering versus civil engineering. However, signature pedagogies is useful because it describes how the nature of teaching differs between disciplines, and the 'inertia' (Shulman, 2005b, p. 58) that acts against change. The quotes above from papers that utilise this concept also provide a timely reminder of the signature pedagogy of engineering education, and how it contrasts with the description of engineering practice discussed in Chapter 5. However, the discussion in the previous chapter shows that the signature pedagogy of engineering education may owe as much of its origins to social factors, as it did to the needs of engineering practice at the time.

Signature pedagogies could be described as a cyclic process where academics teach in the same way that they were taught. A slightly different way of describing this is offered by Haggis (2003), who suggests that academics design their teaching for learners who are *like them*. Haggis is heavily critical of certain concepts that are being presented as 'outlining a kind of 'truth' about student learning' (2003, p. 97), which may instead be an articulation of pre-existing values for those who were educated prior to the era of mass higher education. She suggests that there is a tacit acceptance within academia of a one size fits all model of learning that presumes 'that students' aims are, or can be made to be, the same as the aims of academics' (2003, p. 97). It is this point that originally made me reflect on my own motivations for learning, and ultimately led to this PhD and the writing of my autoethnography. Later it also led me to consider how the aims of my colleagues in engineering academia compare to my experience of engineering as a practitioner.

As engineering academics have themselves successfully completed an intensively mathematical and theoretical education, it's not unreasonable to suggest that this is a learning style that they are suited to, and they may also believe that this is the best, or even the only way to understand and describe engineering concepts. As Haggis suggests, they might attempt to construct an image of themselves in their students, and if they did so, the image that would likely be reflected would be someone with a scientific, theoretical and objective approach, someone likely to graduate with a PhD in scientific research and possibly develop a career in academia. This is not unreasonable behaviour, and while working in industry I would probably have trained people to my own image of how an engineer should operate. However, as a practising engineer I was training students to be practising engineers, and if engineering education has different aims and values to engineering practice, then academics may be constructing images of something that is not necessarily a good match to engineering practice.

Both signature pedagogies and constructing images describe a way in which education can potentially replicate practices for no other reason than the fact that this was the way it was done in the past. Haggis' argument that the aims and values of higher education are closely related to wider class and social structures, links more closely to a Bourdieusian view of education than Shulman's signature pedagogies, which is limited to a presumption that the pedagogies are established based solely on a reflection of the professions. Shulman's description of the 'inertia' of signature pedagogies that act against change, is in some ways related to the deterministic aspects of Bourdieu's habitus, and Haggis is clearly presenting the accepted truths of education as something that Bourdieu would refer to as doxic knowledge. However, although these concepts could combine to give a complete description of how, to a certain extent why, engineering education might continue to replicate a disconnect with practice, they do not offer a complete framework for analysing the social factors that establish and maintain it. In this thesis I present an argument that social, historic, cultural and economic factors combine with, and sometimes work against the practical aspects, to shape engineering education. A Bourdieusian approach offers a way to expand on the impact of, and explore the origins of these phenomena, through the way that they shape the construction of social fields, and the habitus of the agents within those fields.

Engineering conceptualised as fields

From the literature discussed in Chapter 5, engineering and its relationship with other disciplines could reasonably be represented visually in the figure below. The degree to which each field in the below figure overlaps with engineering practice would of course vary depending on the specific engineering discipline or role, but it is a reasonable generalisation with which to open discussion. This is also a reminder of the image presented in the literature and in my autoethnography, of engineering practice as a profession with a very broad knowledge base, and a social and subjective nature.

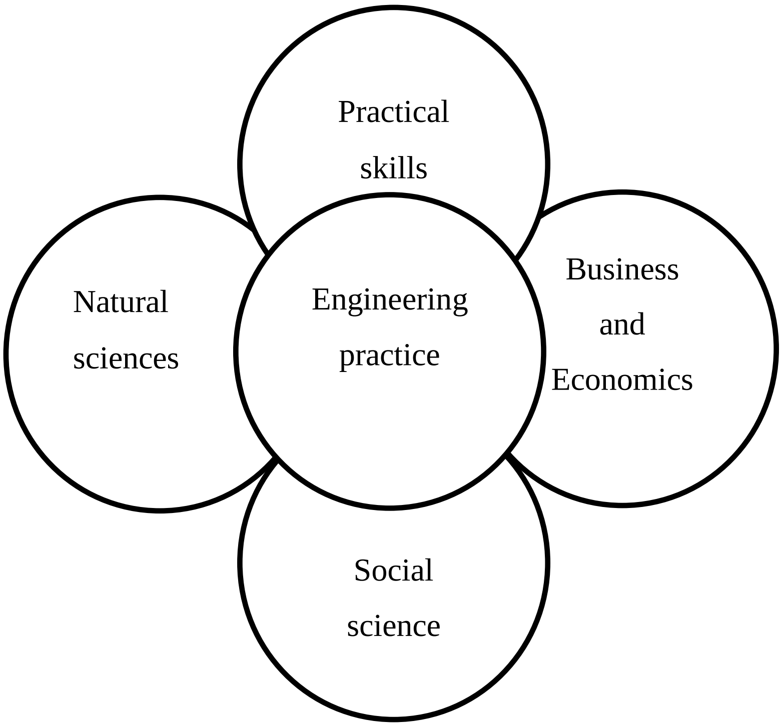

Figure 7-1: Skills and knowledge required for engineering practice

In contrast, if professional engineering practice is conceptualised as a Bourdieusian field, its relationship with academic fields could look something like the figure below. This figure is primarily based on the literature discussed in Chapters 5 and 6, but it is also partly influenced by my autoethnographic account of my experience. In twenty years working in industry I don't recall a single occasion where I, my colleagues, or my company had any contact with a university or academic, beyond staff like myself taking part time degree courses, or placement students and graduates coming in the other direction. When I entered academia from industry in 2009 it was an unusual move. No-one I was personally aware of had moved in that direction and the academic department I joined only had one other member of staff who had spent any significant periods of time in industry.

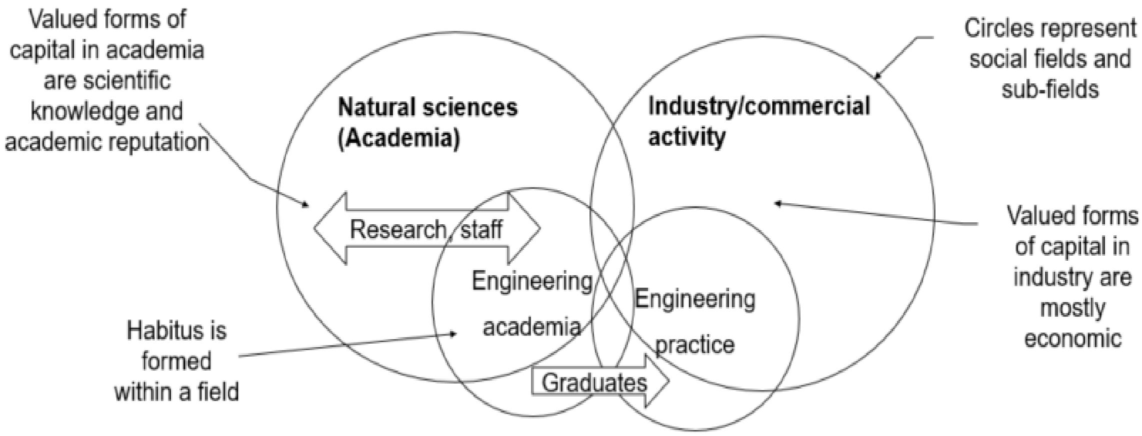

Figure 7-2: Engineering conceptualised as Bourdieusian fields

As with figure 7.1 the exact amount of overlap could be debated, and will vary between disciplines, engineering departments etc., but the contrast is visually stark. The knowledge exchange arrows in the figure indicate the natural research links that engineering academics will have with academics in the natural sciences, and many engineering academics are in fact graduates of the natural sciences such as chemistry and physics. In contrast, and as discussed in more detail later in this chapter, the knowledge relationship between engineering academia and engineering practice is mostly one way, through the supply of engineering graduates to industry. The above visualisation is based on the literature reviewed and discussed within this thesis, but I would suggest that on its own it is not controversial, or likely to be disputed, but rather that it is a reasonably self-evident representation.

The key point from this conceptualisation is that engineering is not represented as a single field, consisting of the sub-fields of industry, academia, institutions etc, but that engineering practice and academia are distinct, separate fields, with very different goals and motivations. The institutions link them to an extent, and would sit within the overlap in the previous diagram, but unlike law or medicine, there is no single disciplinary body to unite engineering practice and academia. The engineering institutions, while powerful, are far from all encompassing, as many academics and practising engineers are not members of any institution.

Although based on literature and analysis, and autoethnographic data, this of course remains *my* conceptualisation. I have therefore given reflexive consideration to whether I am leading the subsequent analysis of the habitus of the agents within those fields, by not representing engineering as a single larger field comprising academia and practice. However, I reflected that prior to making the final decision to use a Bourdieusian analysis, I was already referring to the two traditions of engineering science/academia, and engineering practice/industry, and that this terminology had emerged from the literature surveys. In both the literature discussing the development of the engineering profession in Chapter 6, and that discussing contemporary engineering practice in Chapter 5, there is a repeated description of the 'tension between theory and practice' (Crawley et al., 2014, p. 3). The historical development of engineering education discussed in the previous chapter, has been a story of competing paradigms, and the rise to dominance of engineering science over engineering practice. As this developed into a Bourdieusian analysis it became clear that what I had been thinking of as two disparate traditions or paradigms, was best represented as two distinct fields. The field of engineering academia, as discussed in the previous chapter, is clearly the custodian of the engineering science paradigm, while the engineering profession developed out of the practice tradition.

Although these fields are disconnected, an important point is that the field of engineering practice is heavily influenced by engineering academia, because most practising engineers are a product of that field through their degree education. As will be discussed, agents moving in the opposite direction is not common, so the knowledge exchange between fields is mostly one way. While the habitus of the typical engineering professional is partially formed in engineering academia, and partly in industry, in contrast, the professional habitus of a typical engineering academic is formed almost exclusively within academia. This means that the habitus formation of the members of these fields must be considered differently, as doxic knowledge present in academia, will inevitably transfer to the field of engineering practice. While the new field might alter these doxic beliefs, it might not. Bourdieu's description of doxa as unquestioned knowledge (Garrett, 2007, p. 231), means that if something is unquestioned it remains unchallenged, and even if agents become conscious of this, how willing will agents be to challenge the validity of the cultural capital on which their professional standing is based? The discussion in the second part of Chapter 5, particularly Gainsburg (Gainsburg, 2015, 2007) would seem to indicate that increasing time in practice does modify the habitus of practising engineers with respect to the nature of engineering knowledge. However, industry experience is reported to be rare (Dales and Lamb, 2010, p. 8; Johnston and King, 2008, p. 27), and in decline (Johnston and King, 2008, p. 78; Lamb et al., 2010, p. 3) amongst academic staff. With very few of graduates ever returning to, or interacting with academia, there are few opportunities for this modified habitus to influence the field of engineering academia.

Inferring the habitus

The idea that the habitus of academics can promote a certain insularity is not a new one and Bourdieu devoted an entire book, entitled 'Homo Academicus' (1988), to his analysis of the academic world as a field of power, where exchanges of capital take place and reputations are cultivated. The book opens with a quote from Peguy; 'historians don't want to write a history of historians' (1988, p. 1), suggesting that historians want to analyse history, but don't want their own role in that history to be included in the analysis. This is a clear allusion to academics who want to study society, but may not be as comfortable if they become part of that study. It is a reminder, along with the title of Chapter 1 (a book for burning), that the arguments I am making about the nature of engineering will be somewhat heretical for many engineering academics, and that analysing the habitus of a group, some of whom are my colleagues, is not a comfortable position to be in, either for them or for me. However, I would argue that I am in a strong position to make that analysis for the following reasons.

1. I am not a typical engineering academic, at least in the sense that I am not active in researching the natural sciences, so I don't feel the risks of reputational damage, or alienation, to the extent that an engineering academic might.
2. As discussed in Chapter 2, I am a typical ethnographer, an outsider immersed within a group that I don't originate from.
3. By conducting and presenting this research within social science, rather than as engineering education research, it is less likely to be constrained by doxic beliefs present in engineering, and more likely to be evaluated based on the analytical process and referenced sources.

Habitus is something that exists at an unconscious level and cannot be explicitly expressed, so it must be inferred 'indirectly, from the way in which it manifests itself' (Spence and Carter, 2014, p. 952). In this chapter the habitus of the engineering academic, and later the engineering professional, is inferred through the nature and the values of the field that they operate within. Inferring the habitus of a group of individuals is clearly a subjective process which requires a great deal of generalisation, but it is also the only way, and Bourdieu himself accepts that he only learned about his own habitus through the 'gaze of others' (2007, p. 89). Taking a reflexive position, it is important to recognise that the arguments that follow partially originate in my own ethnographic observations of engineering industry and academia, observations that are coloured by my own habitus as an engineer from a very strong practice base. However, taking this reflexive stance led me to re-evaluate my original approach, which was focussed on the habitus of the engineering academic, and to instead take the approach which I have presented in this chapter, which is to start by considering the fields that relate to engineering, and to also include an analysis of the factors that influence the habitus of the engineering professional, which is discussed in the next section.

It's important to note when considering Bourdieu's position on the academic world, that 'Homo Academicus' was first published in French in 1984, and is effectively his analysis of French academia as he experienced it roughly between the fifties to the early eighties. Bourdieu's specific observations won't necessarily translate well to engineering academia in the 21st century, but the conceptualisation of academia as a field of power remains valid and continues to be used in more recent work (Grenfell and James, 2004; Mendoza et al., 2012; Naidoo, 2004). Although Bourdieu's concepts are widely used in education, and have been used to analyse academia, there is very little that relates directly to engineering education (Devine, 2012a), and my searches on this theme found nothing of relevance to this study. In this chapter I will argue that this conceptualisation, and the insular aspects of the habitus, are particularly relevant to exploring a disconnect between engineering education and practice because of two key and related factors alluded to in the field diagram of the previous section:

1. The closeness of the fields of scientific research and engineering academia, driven by the growing importance of research to universities, for both funding and reputation, and exhibited by the number of scientists working as engineering academics.
2. Separation of the fields of engineering academia and engineering practice, exhibited by the lack of engineering industry links to academia, and particular the lack of academics with industry experience.

The next section considers each of the above aspects in turn, aspects that I will argue are key to understanding the habitus of a generalised engineering academic, and therefore their understanding of the nature of engineering education.

Factors that influence the habitus of the engineering academic

As discussed previously, habitus can be inferred by the way that it manifests itself, but that in a sense is the end point of the discussion, or the output of a habitus, and history could be considered to be the input to habitus. History in this context means two things, firstly it is the social history of the field and secondly it is the social history of the individual. I reviewed the social history of the field in Chapter 6, where the history of the field of engineering academia, as a university discipline, was shown to be relatively recent. I also discussed how the engineering science paradigm rose to dominance in engineering education, and how this brought engineering academics much closer to the field of the natural sciences. As esteem in academia is closely linked to research and publication, engineering academics found themselves doing basic research, crossing a line from what would traditionally have been considered engineering, into a form of applied science. The social history of the field, and the cyclic effects discussed earlier in this chapter will clearly shape the habitus of an engineering academic, but only once they have become part of that field. Their social history prior to entry to the field will also be important, but unless an academic has spent a significant portion of their career outside of academia, it is reasonable to suggest that their habitus, as it relates to engineering will be formed almost exclusively within academia. In this section I will argue that the fields of natural sciences and the fields of engineering academia are extremely close and in some aspects indistinguishable, and therefore the habitus of an engineering academic is perhaps closer to that of a scientist, than an engineer.

There is corroboration from the literature that *scientific research* is the main priority for many engineering academics and the main focus of the field of engineering academia. Graham (2015, p. 3) found that ‘an overwhelming emphasis on research reputation and income is seen by many to pervade all aspects of university culture’ and that ‘that teaching was afforded little or no value in academic promotion procedures’. Presenting data from an empirical study, Mendoza *et al* (2012) argue that within engineering academia ‘one of the most important forms of symbolic capital is the prestige associated with different types of activities such as teaching and research' (2012, p. 561). However, despite the use of the word 'teaching' in the previous statement this word appears on only one more occasion in the entire paper, while the word research is used ninety-three times. It is interesting to note that in a paper that discusses how engineering faculty and academic staff maintain their standing in terms of symbolic capital, that almost the entire paper is concerned with research and related topics such as grants, intellectual property rights etc, and when students are discussed (2012, pp. 573–575) they are primarily discussing PhD students and research opportunities, not students who are planning to become practising engineers. It is clear that engineering academics are primarily in their positions because of their scientific research and Lamb *et al* confirm that 'research-led universities tend to favour staff with profiles likely to be highly rated in the research assessment exercise' (Lamb et al., 2010, p. 47).

The previous discussion argues that research is the primary driver for most engineering academics, but this argument could be made of all university disciplines, so why should this be a particular problem for engineering? I would suggest that this links back to my discussion in Chapter 5, about what engineering is. As discussed there, engineering in practice is a very broad discipline, with its origins in practical skills and trades, connections to science, mathematics, business and social science, and in the modern era, heavily reliant on computer science. On the other hand, modern scientific research is necessarily deep and very narrowly focussed. As discussed in Chapter 5, one of the modern definitions offered by the engineering science tradition, is that engineering is the *application of science*. This presents an apparent contradiction. If engineering is the *application* of science, then what is *engineering research*? Following a logical progression you could say that engineering research should therefore be research into the application of science in the field. If this was the case then it would mean that engineering academics would be researching engineering practice and my argument that engineering academics have little knowledge of practice would be redundant.

However, engineering academics do not generally research engineering practice. A recent, comprehensive study of research by engineering academics over the previous 20 years makes no mention of either engineering education or engineering practice (Banal-Estañol et al., 2015). Engineering education journals are ‘relatively few and largely unknown to the majority of engineering educators’ (Nyamapfene, 2016) and those that do exist have a relatively low impact factor compared to engineering and science publications. Engineering education researchers also complain of a ‘lack of acceptance’ in engineering academia or recognition in REF (Shawcross and Ridgman, 2013, p. 11). Generally speaking, Engineering academics research scientific phenomena and I would argue that when engineering academics conduct *engineering research*, they are in fact doing *scientific research*, and by discovering, rather than applying scientific knowledge, they are principally scientists rather than engineers.

Arguably engineering researchers may be more focussed on applied, rather than theoretical science (Banal-Estañol et al., 2015, p. 1164) so my previous statement can to an extent be challenged, but I make it mainly to illustrate that if engineering academics are focussed on research, then the larger field that they operate within is science, and this contributes to their habitus, or the window through which they view engineering. It also informs the *signature pedagogy* (Shulman, 2005b) of the academic discipline of engineering, and if their goal is to *construct images* (Haggis, 2003) of themselves in their students, then a successful student in their eyes will be one who has a scientific focus and is a potential PhD research student. An academic quoted in Mendoza *et* al stated (2012, p. 573), ‘a big part of my mission here is to produce PhDs that go off and do research’. If engineering academics need to produce research focussed PhD students, then this must influence the signature pedagogy of engineering. Natural research collaborations will also exist between for example chemical engineering and chemistry departments, electronic engineering and physics etc, so the more an engineering academic is focussed on research, the closer to the field of scientific research they will be, and therefore further from the field of engineering practice.

There is an argument that research compliments and improves teaching. This argument is often based on the Humboldt model which promoted the integration of research and teaching, where student and academic are jointly focussed on ‘the common pursuit of knowledge’(Arimoto, 2015, p. 96). Firstly, I would question whether the nature of university education from two hundred years ago can be usefully related to the modern mass higher education system. It can also be argued, particularly at undergraduate level, that the fundamentals of engineering science are long since established and therefore no longer the focus of active research. However, while the previous two points are open to debate, the critical requirement for integration of teaching and research is surely for the academics’ research to be relevant to the profession that the student is being trained for. Academics from the discipline of education might research aspects of teaching practice or learning motivations, and academics from the discipline of law might research aspects of legal cases or precedents. While some aspects of this research could be beyond the grasp of an undergraduate student, the findings can still be related directly to professional practice, and the same could be said of engineering, if engineering research was focussed on engineering practice. However, if as I have suggested in this section, an engineering academics’ research is focussed on for example mathematical modelling, or natural science at the molecular level, then can this be directly related to the work of a professional engineer as described in Chapter 5? This research is of course useful, but University research conducted by engineering academics ‘generally focuses on solving fundamental scientific questions’ (Banal-Estañol et al., 2015, p. 1162). As discussed in Chapter 5, what is important to engineers is knowing how to use this research in order to design a solution or solve a problem. While the answers to these scientific questions might eventually become the inputs to engineering solutions, they are likely to have a long way to travel from basic to applied research, then through research and development, before they become relevant to general engineering practice. Reports that engineering academics are struggling to find practice relevant examples for their teaching (Broadbridge and

Henderson, 2008, p. 16), would appear to support this and to suggest that many academics cannot connect their own research to engineering practice.

The close relationship between the fields of engineering and science in academia discussed in the previous section, is in stark contrast to the relationship between engineering practice and academia. Many reports from engineering bodies cite the lack of industry experience in engineering academia or are lobbying for closer links between academia and industry in order to make engineering education more relevant (Graham, 2015; Johnston and King, 2008; Lamb et al., 2010; Spinks et al., 2006 etc). It has been suggested that these connections have been in decline since around the nineteen seventies (Rugarcia et al., 2000, p. 5) and Lamb suggests that this is an issue 'particularly in research-led universities' (Lamb et al., 2010, p. 3). Some sources have complained that 'academic performance and esteem indicators were operating against efforts' to promote links with industry and actively criticising academics who focussed more on 'building links with industry rather than writing research papers' (Lowden et al., 2011, p. 16).

According to Ann Watson, COO at SEMTA (Science, Engineering, Manufacturing and Technologies Alliance), 'There is real concern within the engineering profession that an increasing number of higher-education staff teaching engineering have no industry knowledge or experience' (Excell, 2013). Lamb *et al* claim that 'it is crucial that academic staff have either prior experience of industry or access to opportunities to gain insight into industry' (2010, p. 46), however 'the current funding models of universities act against this' (2010, p. 47). Lamb *et al* also note that the 'situation at UK universities is in contrast to German universities of applied science, where staff are usually only recruited if they can demonstrate at least five years' practical experience in industry'. I would argue that prior experience of industry is not a prerequisite for *all* academic staff, but would agree with Lamb *et al* that those who teach engineering must have some mechanism by which they gain insight into industry. Without an insight into the skills required by practising engineers, either through experience of industry, or study of practice, I would question the degree to which educators can prepare students for that role.

Factors that influence the habitus of the professional engineer

In the previous section I discussed the generalised habitus of the engineering academic, and a key point was that in relation to engineering, most academics form their habitus almost exclusively within academia. For engineering professionals the converse is not true, because the vast majority of engineering professionals also have their formative experiences of engineering in academia as undergraduate students. As discussed in Chapter 6, the professionals of the past started in practice, taking science and technology classes on an ad hoc basis, but this system has long since disappeared, and the vast majority of today's engineering professionals will have started their career with a university degree. This means that for most engineering professionals, their initial understanding of what engineering is, the initial formation of their engineering habitus, is in academia. As discussed previously, doxa has a tendency to perpetuate a belief in the legitimacy of the established order. It is therefore not unreasonable to suggest that regardless of their later experiences in industry, many of those students may continue to adhere to the belief that the way they were taught engineering, is the legitimate and 'natural order' (Bourdieu, 2010, p. 166).

However, regardless of whether they will later question their formal education, once they have left academia, few will return or engage directly with that field, and their habitus will now begin to be shaped by the field of engineering practice. It is logical that increasing experience, or increasing time in practice, will increasingly modify that habitus, and as Gainsburg (2015, 2007) has shown, experienced engineers have a very different epistemological position to engineering undergraduates. The valued forms of capital have also changed and as most graduates will now be working in commercial industry, economic capital takes precedence. Instead of being rewarded for an ability to solve mathematical and theoretical problems that usually have a single right or wrong answer, the graduate will now be working in an environment where there may be multiple possible right or wrong answers. However, the answer that is perceived as bringing the most financial gain to the company, with the least amount of risk, will be the ultimate goal. In my autoethnography I mentioned a project that resulted in cost reductions of ~$20m worldwide. The science behind this project was well established and while a novel application, it was a simple circuit, made from off the shelf components. There would have been little or no esteem in academia for such a project. However, for my company, I did what they expected an engineer to do by solving a problem. The significant financial implications also caught the attention of senior management, and was a key factor in a subsequent promotion to a more senior engineering grade. Of course there will be other esteem factors in industry such as quality, safety etc, but in a capitalist society an engineering firm is in business to make a profit, and all of those other esteem factors are therefore in some way linked to the firm's ability to charge a certain price, and therefore increase their economic capital.

While their relationship with their employer is driven by the accumulation of economic capital, the engineer's habitus is also formed within broader social fields. In the UK and other countries there are longstanding relationships between class and social status, and the type of education or career an individual follows, and it has been suggested that engineering can have an 'inferiority complex' (Törnkvist, 1998) amongst professions. I would have been aware of this from the repeated discussions within my engineering institution about professional recognition and status, but I would suggest that the root of this inferiority complex can be traced through the history of engineering. As discussed in Chapter 6, from ancient Greece, through Victorian Britain and beyond, there are continued examples of engineering being considered a base occupation because of its roots in practice. Engineering as a profession was born in the 1800's, a time in Britain where social class divisions were established and evident, and engineers would have been conscious of their place in the social hierarchy of the workplace. Those who had the means to do so sought to distance themselves from the 'technicians, mechanics, and skilled craftsmen' (Beder, 1999, p. 14) through the formation of a professional identity.

> *Engineers had for some time been determined to achieve the recognition, prestige, and professional status that society accorded law, medicine, and other professions. To do so, engineers distanced themselves from craftsmen and workers using the certification of higher education* (Seely, 1995, p. 742).

As discussed in Chapter 6, while one reason for the emergence of the engineering science approach in education was 'to distinguish the emerging scientific approach to engineering from other trades-based approaches' (Christensen et al., 2015, p. 6), there were also social reasons. This is starkly evident from the 1903 proceedings of the society for the promotion of engineering education, which records the desire to protect the title of engineer from those less worthy, such as 'the man who fires the boiler' or the 'barefooted African' (Seely, 1995, p. 744). As Seely notes, the 'racist and sexist character' of their argument, 'only amplifies the defensiveness of engineers concerning professional status' (1995, p. 744). While such attitudes were widespread at that time, this is the backdrop against which the engineering profession is being formed and structured, and similar (minus the racist and sexist element) arguments continue to dominate the debate around professional status today.

There are some indications that class and status issues were particularly relevant in Britain. In Chapter 5 I discussed how the etymology of the word engineer differs in English to other European languages, and how this might affect the public perception of engineering in the UK. However, despite a shared language, Marjoram (2015, p. 113) suggests that the word engineering carries greater 'cultural esteem' in the USA, and that this is indicated by a tendency in the UK to drop the 'E' from the acronym SET

(Science, Engineering and Technology). Although this statement by Marjoram highlights a perception held by engineers in the UK that their profession is not esteemed, it has to be treated with caution, as although SET is not common in the UK, STEM (Science, Technology, Engineering and Maths) has become common in recent years.

The engineering science paradigm that was intended to elevate engineering as a profession beyond its practical background, originated in continental Europe, but engineering education there has a different history. As discussed in Chapter 6, the Humboldt model which developed in Germany and spread through continental Europe, emphasised both theory *and* practice, and in a perhaps crucial difference, engineering education was delivered by technical schools, rather than traditional universities. Although the German system of engineering education is not delivered by the traditional universities, the 'cachet Dr. Ing' was awarded to graduating engineers, and established in law as far back as 1899 (Armytage, 2003, p. 193), and similar titles exist in Italy and France. It is interesting that German Engineers of the nineteenth century do not appear to have felt the need for the prestige of being associated with the traditional faculties of law, medicine, and the humanities. It is equally notable that German society, was willing to accept these new engineers being awarded the prestigious title of Dr, and that the government felt it was important to legally protect their title and profession in law, a long established goal that continues to evade engineering in the UK. It is also notable that while institutions such as the École Polytechnique in France have been seen as a model for engineering education, the term Polytechnic in the UK has become discontinued, in part due to the perception of being at a lower status than a university, a distinction that continues to apply to former polytechnics (Scott, 2012). It is clear that in the UK there is a social stigma related to technical work and engineering that is, if not specific to the UK, certainly more prevalent.

In Chapter 5 I argued that there was a disconnect between the dominant engineering science paradigm of engineering education, and the practical realities of engineering practice, and most of the sources I presented to back up that claim came from industry and practising engineers. However, it is clear from both the history discussed in Chapter 5, and the preceding discussion in this chapter, that like academia, the engineering profession has also sought a connection to science in order to elevate its social status. It has been suggested that engineering has something of ‘inferiority complex’ (Seely, 2005, p. 116; Törnkvist, 1998, p. 10) that is based in part on its historical origins in practice, and the public perception of engineering as something dirty and hands on (Beder, 1999, p. 13; Christensen et al., 2015, p. 46; Cronin and Roger, 1999, p. 648). It has used an association with science, and the cultural capital of the university degree, to distance itself from those origins, but has never attained the legal and social status that engineering holds in some other countries. I would argue that there is a conundrum for the profession, in that it can describe the kind of practice-based education that it needs, but social issues demand that it must achieve that within the constraints of a university degree. The emerging degree apprenticeship may offer the compromise between the institutionalised cultural capital of the degree, and the embodied cultural capital of practice. Degree apprenticeships, as an emerging issue and possible area for future research, will be discussed briefly in Chapter 8.

Parallels with other professions

Reflecting back on my autoethnography, and the various job and professional titles I have held, I am conscious of how my perceived status has changed quite dramatically depending on whether I held the title of Production Operator, Motor Mechanic, Maintenance Technician, Chartered Engineer, Course Director or Associate Dean. The power or symbolic capital of a job title, is exhibited to me in certain social settings where my current answer of “Course Director”, to the “what do you do?” question, is met with comfortable ease and interest, and makes me contemplate how that reaction might differ if I was still a Motor Mechanic. While all of these jobs are related to engineering, I have been left with the impression that those which carry the greatest prestige, are those that are furthest away from practice, and those with the least prestige are the ones where my hands were most likely to come in contact with the engineering artefact, particularly if my hands became dirty in the process.

Whether described in terms of class, status, professional recognition or capital, such issues have had a clear impact on the historical development of engineering, how the profession has developed, its self-image, and the image and status of the profession in wider society. Much of this thesis is concerned with the impact of these social issues on engineering education, but the fields of engineering education and practice do not exist within a bubble, they exist within broader social fields, so it follows that similar issues may affect other professions. Studies of engineering practice are not commonplace and Bourdieusian analyses of the profession appear to be almost non-existent. The purpose of this section is to briefly review some other professions, and to consider what parallels may be drawn with engineering.

In my review of literature on the professions I drew parallels between the nursing and engineering profession on two distinct levels. The first is the parallel between the status of nurses versus doctors in the field of medicine. This is analogous with professional engineers, and as previously discussed, those who they would prefer did not use that title and instead called themselves technicians or mechanics etc. However, it is also analogous to issues within professional engineering, and how status within a profession can be based on the perceived value of practical skills versus academic knowledge. The second parallel, and the primary focus in this section, is how nursing education, like engineering education many decades before, has moved from a technical or clinical base, to an academic structure, with the introduction of the requirement of a university degree for practice. One of the reasons that a study of the literature relating to the nursing profession is useful, is that although there are clear parallels with nursing, there is a far greater body of sociological work relating to the nursing profession than that relating to engineering. I would suggest that this may be in part due to the public visibility of nursing, and also because nursing has a much closer academic connection to social science, due to the focus in both fields on the welfare and wellbeing of people.

McNamara (2008) discusses the changing identities and motivations of nurses and nurse educators as they entered academia. He argues that the discourse positions nursing as ‘either sacred, and under threat from the academy, or profane, and unworthy of a place in it’ (2008, p. 458). The former position is strikingly similar to that of the early engineering practice tradition discussed in Chapter 5, and the latter to the resistance to engineering as a degree bearing subject and later attempts to make it more scientific and academic. Although some of the dichotomies discussed in this paper are strikingly similar to engineering (practice/theory, art/science, doing/thinking, vocation/profession (McNamara, 2008, p. 459)), the fact that this debate was played out by politicians and the media is strikingly dissimilar to the ‘invisible profession’ of engineering (Johnston and King, 2008, p. 62), in which such debates go largely unnoticed by the general public, or by social science research.

One of the arguments against nursing becoming an academic subject was that it might prevent ‘less scholarly’ individuals (Devlin in McNamara, 2008, p. 459), who would otherwise make good nurses, from entering the profession. This is again similar to engineering, where ‘students are forced to make their choice on criteria other than the sort of work they can expect to do as engineers’ (Beder, 1999, p. 14). Students who might have all the relevant attributes for a career in engineering practice, could be barred entry, or put off, by the mathematical nature of an engineering degree which, as discussed in Chapter 5, does not reflect practice. McNamara also reports how commentators react with ‘horror’ (2008, p. 464) when they realise that students are beginning to be taught by nurse educators who have never worked in a hospital, and have no practical experience, a transition that is long complete within engineering.

In a Bourdieusian analysis of nursing, it has been suggested that before entering academia, the ‘valued forms of capital related to hospital reputation, clinical competence and pedagogical skills’, and ‘hands-on patient care’ was considered to be of ‘primary importance’ (Petit-dit-Dariel et al., 2014, p. 1370). After entering academia, nurse educators found themselves within an environment where these forms of capital were no longer valued, and instead ‘prestige and honour’ was primarily associated with ‘research, publications and grants’ (2014, p. 1370). However, the move into academia provided nurse educators with an overnight increase in salary and status (McNamara, 2008, p. 464), but while some would have seen this move as a way to obtain a ‘new form of capital (academic recognition)’ (Petit-dit-Dariel et al., 2014, p. 1371), it was also recognised as being in conflict with their original professional habitus (O’Connor, 2007). The implication of this is that over time the educators who embrace these new forms of capital are likely to become the dominant force, and the practice-based educators who experience this conflict are likely to leave or retire over time. This situation has been rather dramatically characterised as ‘Faustian pact’ with academia, resulting in nursing selling its soul in the interests of pursuing the cultural capital endowed by academic status (Fabricus in McNamara, 2008, p. 464).

It could be argued that a similar Faustian pact was made between engineering and academia, but unlike nursing this would have happened out of the public eye, and was clearly a more gradual transition as engineers and employers slowly came to expect a degree as the standard qualification. It is probably not unreasonable to suggest that when engineering made a similar transition, the pressure for research publications, global reputation etc, may not have been as strong, and teaching and industry connections may have been a higher priority. Certainly at the outset of university level engineering education Regius Professor William Rankine, one of the early pioneers of engineering science, and giant of the field of thermodynamics Lord Kelvin, were both heavily involved in professional work (Marsden, 2013; McMahon, 1984, p. 6).

Fulton (1998) has described academia as being ‘stratified into “noble” and “less noble” disciplines, ancient and parvenu universities, professors (or their chairs) and lesser staff’, and the perception that nursing was not held to be in the former category (in Petit-dit-Dariel et al., 2014, p. 1371) is clearly one that also weighs on the minds of engineers. The ‘bedpans’ discourse recounted by McNamara (2008) and used to ‘symbolise the polluting nature of nursing work, and to position nursing education as unworthy of a place in the academy’ (2008, p. 463), has clear parallels with perceptions of engineering as a dirty hands-on profession. This is of course in contrast with the desired image of a ‘professional in a grey flannel suit’ (Walker, 1971, p. 823), that some in engineering would prefer to cultivate. I also suspect the parallel the engineering profession would probably prefer to make, and has been working towards since its initial development as a profession, is to equate engineer with medicine rather than nursing. In engineering the professional hierarchy that is forming in this respect is Chartered Engineer (CEng), Incorporated Engineer (IEng) and Engineering Technician (EngTech), roughly in order of decreasing status, pay and connection to academic and scientific related forms of capital, and increasing practical skills and direct contact with the artefacts related to engineering.

The debate around the characterisation of nursing as a ‘Trojan horse’ (Topping, 2004; Watson and Thompson, 2004), ‘smuggled into academia’ and ‘diminishing the status of traditional forms of capital’ (Petit-dit-Dariel et al., 2014, p. 1371) also has parallels with Engineering. Watson and Thompson (2004) argue that the sudden mass introduction of practice based nursing educators to academia, has diluted the academic nature of the few university nursing departments that existed prior to this policy change. The suggestion is that these practice-based nurse educators had ‘no interest’, or were even ‘hostile’ to research, causing huge problems for universities in a ‘UK climate where research competitiveness is all important’ (Watson and

Thompson, 2004, p. 73). Transferring this scenario to engineering, the same perceived issue could arise if large numbers of practice based engineers were to enter the university environment in order to address the disconnect between education and practice. From my own experience of both industry and academia, and the literature surveyed for Chapter 5, I would suggest that the type of scientific research required for a career in engineering academia would be completely alien to the experience of practising engineers. If experienced engineers were to enter academia to help address the disconnect, they would clearly be disadvantaged, possibly second tier academics, in an environment where scientific research and publication is privileged. There are many questions that could be drawn from this discussion around the nature of practice-based professions such as nursing and engineering: Do vocational professions belong in an academic environment at all? Should engineering research be more relevant to engineering practice? Should/can the connection between research and reputation be different for subjects like engineering that are broad and practical? These are not questions that I can fully answer within this thesis, but they highlight the issues for professions that are not traditionally part of academia, and where there are issues of fit with an academic, research focussed environment.

In a Bourdieusian analysis of the accountancy profession, Spence and Carter (2014) uncover a number of features that can be related to engineering. The accounting profession was founded on the principle of ‘acting in the public interest’ (2014, p. 947) and retains this wording in jurisdictional statements, but this study of the habitus of employees of the ‘big 4’ accounting firms reveals that the real focus is on keeping the client happy. Keeping the client happy, can of course be in direct conflict with the stated aim of ‘acting in the public interest’, as was exhibited during the financial crisis, and in particular Enron (Spence and Carter, 2014, p. 947). This is a reminder that what a profession says it does, or the image that it attempts to convey, is not necessarily the same as what it does in practice. I would relate this back to Chapter 5, and the institutional definitions of engineering that attempt to grandly present engineering as the application of science, that can be contrasted against the realities of practice also discussed in that chapter, and the repeated calls of industry for more relevant content and less science and theory.

Spence and Carter also compare the technical-professional logic which privileges the ‘application of accounting standards’ and accountability, with the commercial-professional logic which ‘privileges client interests and revenue generation over the interests of the wider public’ (Spence and Carter, 2014, p. 948). In this study, perhaps unsurprisingly, the technical-professional logic was exhibited by the habitus of accountants at the lower levels of the organisation, with the commercial-professional logic exhibited by those who rise to the upper levels. The technical work in these firms was routinely disparaged by partners as ‘second order activity’, conducted by ‘geeks’, ‘boffins’ and ‘second class citizens’ who are ‘ten a penny’ (Spence and Carter, 2014, p. 958). The lower status afforded to those who conduct the practical work, regardless of how much skill or technical knowledge this might require, appears to be a common theme in sociological literature on nursing and accountancy, and can also be related to engineering. In the study by Spence and Carter, being a specialist was ‘far from a compliment’ in a big accounting firm, and in fact carried the curse of ‘negative symbolic capital’ and the implication that ‘one does not quite have what it takes to lead’ (2014, p. 958). They also make the point that it is the partners, who have the ‘monopoly of legitimate naming’ (Bourdieu in Spence and Carter, 2014, p. 958), so it is the partners who decide what job functions are performed by different job titles.

Although the practice of accountancy is very different from engineering, the similarities are quite striking in terms of the relationship to commercial interests. Engineering institutions also make statements about ethics and the public interest, and engineering firms have also been compromised by commercial-professional logics, that in some cases have resulted in significant loss to life and the environment (Bhopal, Deep water horizon, Challenger shuttle etc). If the scenario described by Spence and Carter is reflected back towards engineering, then it could be considered likely that those who rise in engineering firms also display commercial-professional logics with some of the associated traits described above. These are also likely to be the people that rise to senior positions in the engineering institutions, alongside senior academics, with one group potentially representing commercial-professional interests, and the other representing academic-professional interests. If, as discussed in the previous section, engineering academics are focussed on symbolic capital associated with research and academic reputation, and senior engineering interests, representing engineering through the institutions, are focussed on economic capital, then who represents the technical engineering professional? I would expect that the institutions would argue that they do, and certainly the members have a voice, and a vote in the institutions leadership. Prior to conducting this research I would probably have agreed with this more completely, partly because I was less aware of the extent to which academics now feature within the leadership of engineering institutions, and partly because I thought of the institutions as being focussed on the engineer, and engineering, rather than commercial industry. This is tempered by the analysis I have conducted, and in particular the dominance of economic capital in the field of industry, which almost completely encompasses the field of professional engineering.

Issues of conflict between research and teaching have been discussed previously in relation to nursing. Practising teachers transitioning into the culture of academia, and balancing the demands for research activity has also been reported (Baumann, 1996; Larocco and Bruns, 2006). Most professions, such as law, medicine and teaching, can be considered to varying degrees to be vocational, so engineering is not unique in that respect either. It has been suggested that ‘Universities welcome surgeons and barristers to part-time teaching in a way they do not professional engineers’ and that there may be a ‘class issue’ here related to ‘dirty hands’ and status (Anonymous Academic, 2014). However, although it is beyond the scope of this thesis to explore these issues in other disciplines, it is my sense that academics in law, research law and legal practice, in medicine, research medicine and medical practice, and so on, while engineering academics research science, not engineering or engineering practice.

Having conducted this PhD within a school of education, I have been able to consider how academics interact with, and spend time in schools, are often former teachers themselves, and research teaching and learning. Researchers in education are actively involved with, and reacting to, the changing landscape of practice (Brown et al., 2014). In contrast, from both my experience, and the literature discussed in this thesis, engineering academics do not typically spend time in, or have experience of industry. They do not typically research engineering practice, or even engineering education practice. So perhaps rather than this being an issue of research, or academia, being in conflict with teaching, it may be a question that is more specific to engineering, related to the *focus* of engineering research. Do engineering academics research engineering, or natural science? If engineering is simply applied science then the distinction would be moot, but I have argued in Chapter 5 that this is not the case. Ultimately, a habitus is the product of experiences, and if a discipline's academics and practitioners have similar and shared experiences, then they will have a shared habitus, a shared habitus that views the profession in a similar way. Conversely, if academics and practitioners do not have a shared habitus, they will understand the nature of a profession, and the goals of its education differently.

Abbott's system of professions

It is important to note that there could be alternative approaches to the Bourdieusian approach that I have used to frame my analysis of engineering. In particular, Andrew Abbott conducted extensive sociological research into professions in general. In 'The System of Professions' he focusses on issues of jurisdiction, and that as the boundaries and links between jurisdictions are neither ‘absolute or permanent, the professions make up an interacting system, or ecology’ (Abbott, 1988, p. 33). According to Abbott, ‘the tasks of professions are human problems amenable to expert service’ (1988, p. 35), which is interesting to relate to my definition of engineering in Chapter 5, as being related to solving problems. For Abbott, professions define themselves by establishing jurisdictional control of these areas of expertise, through possession of abstract knowledge.

Abbott sees issues of professions as being primarily related to jurisdiction, with the USA as the primary context (Abbott, 1988, p. 327). One issue with this is that, unlike the USA, engineering in the UK has no legal jurisdiction. As discussed in Chapter 5, there is no legal protection in the UK of either the title engineer, or the practice of engineering, and so even referring to engineering as a profession is problematic in some contexts. There is also the issue that engineering, as already discussed, is not by any means a single unified profession and so cannot exclusively claim any area of jurisdiction. Even if this is not legal jurisdiction, and Abbott does consider other social and cultural forms (Abbott, 1988, p. 60), the issue of jurisdiction is further complicated by the multitude of disciplinary institutions, and the fact that many degree qualified, practising engineers, are not part of any institution. Abbott’s work could clearly be useful in the study of engineering as a profession. However, in a sense, applying Abbott to the engineering profession in the UK, simply highlights something that is already known to the profession, that unlike for example Law and Medicine, it has been unable to formalise, either legal, or cultural, jurisdictional control of its own area of expertise.

Even if engineering is a profession in the context of Abbott’s work, another issue is that this thesis is not a study of a profession; it is an investigation into the relationship between education and professional practice. The system of professions provides a useful framework for studying a profession, how it establishes its position in society through jurisdictional claims, and protects that jurisdiction through the abstraction of knowledge. However, although Abbott's professional requirement for abstraction of knowledge can be linked to the requirement for degree education, there is little else in Abbott's framework that considers the relationship between the profession and its education. Arguably, engineering education and engineering practice could be conceptualised as separate professions, with the former making claim to educational jurisdiction, and the latter to jurisdiction over practice. However, it is difficult to see how this would add something beyond that which is achieved by conceptualising these as fields. I have also previously argued in Chapter 4, that an advantage of field theory is that it removes preconceptions of considering engineering as a profession. As previously discussed, this led me to considering education and practice to be separate fields with different goals, rather than one profession, and to the arguments subsequently presented in this chapter.

Finally, the main reasons why Abbott's work does not fit well alongside a Bourdieusian analysis, come from Abbott himself. Abbott explains that while there appear to be similarities 'between Bourdieu's conception of social structure and my own', that this is more of an 'accidental resemblance', and they 'come by quite different roads to a somewhat similar place' (Abbott, 2005, p. 6). Abbott sees the 'root metaphor of Bourdieu's field concept' as 'economic', although he does acknowledge that Bourdieu would not agree with this (Abbott, 2005, p. 2). He also claims that his 'metaphoric universe is much broader than Bourdieu's' (Abbott, 2005, p. 2). I disagree with both of these statements, and would suggest this might be attributed to his own admission that his 'reading and use of Bourdieu's work has been quite limited' (Abbott, 2005, p. 7). In my own experience, a combination of the way that Bourdieu writes, and the fact that his theories have developed over unconnected publications spanning decades, limited reading of Bourdieu can very easily lead to misconceptions. Domination is a clear theme in Bourdieu's work, while Abbott sees jurisdiction as less exclusive than dominance, and that jurisdictional settlements often allow for sharing of work between professions (Abbott, 1988, p. 87).

Ultimately, the incompatibility between Bourdieu and Abbott is highlighted by Abbott as a ‘fundamental difference of theoretical orientation’, with Abbott pointing to a ‘classical European theoretical tradition’ and ‘Hegelianism and Marxism just below the surface’ of Bourdieu’s ideas (Abbott, 2005, p. 6). Likewise, it could be argued that what Abbott calls his ‘pragmatist’ mix of American and heterodox European philosophical thought (2005, p. 6), is actually a rejection of Marxist based philosophy, in favour of a neoliberal approach. In systems of the professions he certainly presents the ‘ecology’ of professions as something that happens naturally, and this potentially misses the external social factors and history that are recognised through habitus in a Bourdieusian approach.

Abbott’s approach to professions could be usefully applied to some of the ancillary issues raised within this thesis, particularly those related to the perception that the profession has of a lack of status. His work shows how control of jurisdiction is critical to a profession, and it is clear from the previous discussion in this thesis, that engineering as a profession has struggled to establish jurisdictional authority, both in the legal frame, and in the public imagination. Abbott also considers abstraction as a key component in establishing the authority and success of a profession, and notes himself that engineering has struggled to compete with scientists in this area (Abbott, 1988, pp. 180–182). All of these points are relevant to engineering as a profession, and Abbott’s theories could usefully be applied in a study of the engineering profession, or could be applied by the engineering profession in formulating strategies that would help it to establish jurisdiction as a profession. However, my concern in this thesis it not solely the profession itself, it is the connections and interactions, or lack thereof, between a profession and its education. I would argue that Bourdieu’s approach, and habitus in particular, is better placed to account for the myriad of social factors that influence this, beyond just the interaction between a system of professions.

Conclusions

From the discussion in this chapter I would argue that the main contributing factor to the disconnect between engineering education and practice, is the separation of the fields of engineering academia and professional practice. In contrast, the closeness of the fields of engineering academia and scientific research, causes the habitus of the generalised engineering academic to develop an understanding of the nature of engineering, which is very different to the real nature of engineering practice. I would argue that the signature pedagogy of engineering in academia, is as Lucas (2014, p. 43) states, not the signature of engineering, but rather a form of mathematical science. The challenge to this situation should come from engineering practice, from the engineers themselves, their institutions and companies, and as exhibited in Chapter 5 they do frequently challenge the goals of engineering academia. However, they are also constrained by their social need for the cultural capital in the form of the university degree, and the credibility that an association with science lends them. It is very clear from the discussion in Chapter 6, that the engineering profession courted academia in part due to the increased social standing that it would bring them. However, the parallels with nursing discussed in the previous section show how the values of the educators of a practice-based profession can change as they enter academia. The forms of capital valued by engineering academia, are clearly very different from those which are valued in industry. I argue that as discussed in the previous chapters, there are many social and cultural issues that affect engineering, and that these are at the root of the problems that face the profession, rather than technical issues that can be fixed by simply tweaking a curriculum.

The above discussion may seem fatalistic or deterministic, but while the ‘dispositions of habitus are enduring’, they are not unchanging (Edgerton and Roberts, 2014, p. 199). Bourdieu says of habitus that ‘being a product of history, that is of social experience and education, it may be changed by history, that is by new experiences, education or training’ (In Garrett, 2007, p. 229). Reay suggests that ‘disjunctures can generate change and transformation' (2004, p. 436) and I have previously suggested that given my background, my presence in engineering academia, combined with my decision to do a PhD in the discipline of Education, could be considered a disjuncture. However, this is currently a small and localised disjuncture, that will struggle to compete against the 'structurally situated roots of habitus' that 'favor stability over change' (Edgerton and Roberts, 2014, p. 199). Isolated staff from industry returning to academia, or academics making occasional site visits, is also unlikely to bring about the level of disjuncture required to transform the habitus of the agents within those fields. This is where, as Bourdieu suggests, 'political intervention' becomes important (in Ovenden, 2000, p. 19). Recent developments during the course of this PhD may be evidence of that intervention, as the UK government, in response to pressure from industry, has created an apprenticeship levy to fund industry focussed training. Although this is not engineering specific, it has resulted in a focus on degree level apprenticeships, and a need for academia to engage with industry to agree on the structure and content of those apprenticeships. This is discussed briefly in the following chapter as a subject of future research, and only time will tell as to whether this is the type of disjuncture that Reay suggests is needed to generate change. However, the issues discussed in this chapter will clearly come into play in the negotiations that are beginning to take place in relation to degree apprenticeships, as the fields of industry and academia will now have a direct relationship like never before, with direct exchanges of capital between the fields.

In brief summary, the main arguments in this chapter have progressed as follows:

- Drawing from previous chapters, I have conceptualised engineering academia and practice as two disparate fields, and shown that the habitus of the typical engineering academic is almost exclusively formed in academia
- I have argued that esteem in engineering academia is linked to basic scientific research and publication, and that the habitus of the

engineering academic is much closer to that of a scientist than a practising engineer

- While it is clear that the engineering profession has encouraged a connection to science and academia in order to increase its cultural capital, its attempts to re-exert influence on engineering education must also be treated with caution, because its connection to industry, will mean that its goals are heavily influenced by the accumulation of economic capital.
- Analysis of other professions, and in particular nursing, can be used to draw parallels with engineering, of which little sociological analysis has previously been conducted. These disciplines have very different goals, skills and knowledge, and do not offer instant solutions to a problem specific to engineering. However there are some indications that these academic disciplines have closer connections between research and practice, and to social science.

Relating all of this back to the initial discussion on signature pedagogies and constructing images, academics who have had their habitus almost entirely formed in academia may be developing a signature pedagogy of engineering education that is disconnected from the signature of engineering practice. Their focus on scientific research, may encourage them to construct images of themselves in their students, and that image is more likely to be that of a scientific researcher, than a practising engineer. Bourdieu has asserted that a habitus is difficult to change, but can change. The key finding of this chapter, which is itself a conclusion to part 2 of this thesis, is that a disconnect between engineering education and practice, can only be effectively addressed through the changing habitus of the engineering academic. However, that is unlikely to happen unless there is political intervention that will cause a disjuncture. That disjuncture may be engineering degree apprenticeships, but it would be easy to speculate how this might just reduce the number of academic hours in a degree, without any real change to the taught content.

I would suggest that a change to the habitus of the academic, will only develop if there is a change to the power relations within the academic field. If the esteem factors in academia are altered to allow agents to accumulate social and cultural capital through research into engineering education and engineering practice, then academics who excel in those areas may rise within, and influence the field, and practitioners may also be more likely to be attracted into the academic field. The economic capital and closer connections to industry from degree apprenticeships may in part help to alter those esteem factors, but as I discuss in Chapter 8, Bourdieusian concepts may offer a way to open debate in engineering academia, through knowledge exchange and publication. There are likely to be challenges to many of my assertions in this chapter, and in Chapter 8 I discuss how I plan to embrace those challenges through further research, publication and knowledge exchange.

Chapter 8: Reflections and future research

Original aims and the process of developing this thesis

Although the previous chapter concluded the Bourdieusian analysis, the purpose of this chapter is to close the thesis as a whole, including some thoughts on future research and knowledge exchange. As the thesis title suggests, this has been an unexpected journey, or as Muncey described autoethnography, an adventure without a clear destination (2010, p. 63). I had not even heard of autoethnography, or Bourdieu, prior to beginning this PhD, so the destination is far from anything I could have imagined. However, I do not see this thesis as an end, but rather a beginning. In part two of this thesis I have been developing arguments and theories, not stating facts. These theories need to be tested and challenged not just in the discipline of education, but also in the field of engineering, as without doing so there can be little impact from my work. I plan to do this through further research and knowledge exchange, and this chapter will outline my strategy in these areas. Before discussing these plans this section begins with a recap on the original aims, and a narrative, and reflection, on the process that led to the completion of this thesis.

This PhD has evolved significantly since it began. Part 2, which concluded at the end of the previous chapter, was a Bourdieusian sociological analysis of professional engineering and engineering education. This seems very far removed from the childhood learning experiences discussed in my autoethnography of learning in Chapter 3, and this is indicative of the ground covered since the start of this PhD. My original aim was very vague, but having been inspired by papers such as ‘Signature Pedagogies’ (Shulman, 2005b) and ‘Constructing images of ourselves?’ (Haggis, 2003), I wanted to somehow capture the perspective of the learner through my experience. More than that, I saw myself as a deviant case, someone whose route into engineering academia was very different from my colleagues. Ultimately this led me towards autoethnography, and its desire to connect the personal to the cultural, a method ideally suited to deviant cases (Muncey, 2010). I was struck by the power of emotive autoethnography (Ellis et al., 2010), but in terms of practicalities more influenced by its fusion with grounded theory (Pace, 2012) and a kind of analytic autoethnography (Anderson, 2006). I started to write my autoethnography of learning, originally focussed on my school experiences, and its scope grew, until it had covered over thirty years of learning-related aspects of my life.

Before completing the autoethnography I decided to complete an advanced draft of my methodology chapter. I wanted to make sure that I could make an argument for using what some might perceive as a controversial method, before I went any further. The drafting of the methodology in Chapter 2 was in many ways the defining part of the PhD process for me, both personally, and in terms of the direction of the thesis. I had to go on an epistemological journey from the very objective and quantitative approach of engineering academia, to the other end of the epistemological scale in order to argue for autoethnography as a method. This process told me a lot about my own epistemological position. Although I first thought of this as being out of step with the discipline I came from, I realised gradually that while engineering academia might be very objective, and quantitative, my experience of engineering practice was very often subjective and qualitative.

This epistemological epiphany about the nature of engineering had been gradual and subtle at the time, and its importance to part 2 of my PhD would not become apparent until later reflection. I first had to finish the autoethnography, complete the planned interviews, and then go through the difficult process of trying to analyse it, and decide which theme(s) I should concentrate on in part 2. I have discussed the main themes and the process of analysis in Chapter 4, but gradually through exploring the seemingly very disparate themes of motivation, social class and engineering education in parallel, I settled on exploring a perceived disconnect between engineering education and practice. This had been apparent to me through autoethnographic reflections on my experience of the aims of engineering practice versus the aims of engineering education, but later I also started to reflect on the epistemological disconnect that I had started to notice while writing my autoethnographic methodology in Chapter 2.

The previous paragraph might give the impression that the transition from autoethnography to Bourdieusian analysis was very clean and this was far from the case. A significant period of time elapsed between completion of the autoethnography and interviews, and settling on the Bourdieusian analysis of engineering. My first difficulty was that I was far more interested personally in the themes of social class and motivation, and as I began the autoethnography I hadn't intended or expected to focus on engineering at all. I was also initially resistant to the need to frame my experiences with any kind of sociological framework. Autoethnography and the ideas discussed in the related literature had had a significant effect on me and the mantra's from the field, such 'the autoethnographer does not privilege traditional analysis and generalisation' and 'refuses the impulse to abstract and explain' (Ellis in Pace, 2012, p. 3), were still very much at the forefront of my mind. I was thinking about what I was doing in the context of the connections that these authors were making between autoethnography, art (Muncey, 2010, p. 49) and literature (Ellis, 1999, p. 669; Ellis and Bochner in Hunt, 2009), and the idea of framing and analysing seemed sterile and generalised in comparison. It would also be very clean to say that everything fell into place when I chose to complete a Bourdieusian analysis, but that would not be true either and I struggled through what sometimes felt like a second PhD, rather than a second part! I am proud of what I have achieved in part 2, I have learned a lot and I believe that my work will have value for the engineering profession. However, I can honestly reflect that the most personally engaging part of the PhD, was my investigation of issues related to autoethnography, such as epistemology, and the connections between art and science, truth and fiction.

In part 2 of this thesis, I began to explore whether the disconnect that I had experienced had also been experienced by others. I expected this to lead to focussed interviews, perhaps with engineers working in industry, but there was no need as there was an abundance of literature, some of which is discussed in Chapter 5, arguing that education was in many ways out of step with engineering practice. However, it was notable that my references came from industry sources, institutional and government publications and even academic research conducted by mathematicians, but engineering academia appeared to be relatively silent on the issue. Instead of asking *if* there was a disconnect, the question started to evolve towards asking how this disconnect between engineering education and practice was being maintained? It was this question, and a feeling that there was a powerful force resisting change, that started to lead me towards a Bourdieusian approach. My perception from my experience amongst colleagues in engineering was that this resistance, while powerful, was by no means deliberate or malevolent. It seemed rather a close fit to the deterministic aspects of habitus. There seemed to be doxic, unchallenged beliefs in academia about the nature of engineering practice.

Chapter 6 tracks the history of engineering, and the literature reviewed for this chapter made me consider the extent to which social and class issues had impacted the development of the engineering profession, and its relationship with academia. During the literature review for this chapter, I was taken aback by how similar some of the comments and issues being discussed by engineers in historical documents, were to the issues I was used to seeing discussed by engineers in the letters and articles of my engineering institute's monthly publications. It seemed as though there were deep rooted issues relating to the engineering profession's perception of its own status, and its relationship with academia, and that many of these issues were related to class and social status. My explorations around what engineering is, its definitions and the impact of language in Chapter 5, and my exploration of the social history of the fields of engineering education and practice, started to be reconsidered as the inputs to habitus, and the impetus behind the formation of fields.

In Chapter 7 I considered engineering education and practice to be two separate fields, with limited interaction beyond the one way supply of graduates from education to industry. I concluded that while professional engineering education is a part of the larger field of academic scientific research, the profession of engineering is generally situated within the field of commercial industry. As the social history of these fields differ greatly, so will the habitus of their members. The rules of the game, the valued forms of capital, are distinctly different. While academia prizes forms of capital related to the esteem of research and publication, professional engineers are normally part of commercial industry, where economic capital is key.

The generalised habitus formed within each of these fields may result in a very different understanding of what engineering is, and what engineers need to do. In Chapter 5 I argued that in practice ‘solving problems and designing solutions’ is the key definition of engineering, and the methods, disciplinary knowledge, and skills applied to solve that problem are secondary. An engineering academic, with a habitus formed within the field of academic scientific research, will understandably emphasise a research focused, engineering science vision of engineering, which if they have always worked in academia, may be the only vision of engineering they have been exposed to. However, despite the engineering profession’s long standing complaints that engineering education is disconnected from practice (discussed in Chapter 5), Chapter 6 highlights its long history of relying on a connection to academia and science to give engineering credibility and status. This highlights the complexity that viewing academia and practice as fields can help explore.

The main conclusion from Chapter 7, was that the engineering degree is largely the result of an image of engineering, formed in a habitus based within the field of scientific research. That image of engineering, appears to be out of step with the reality of engineering practice discussed in Chapter 5, and if this thesis is accepted, it leaves the question of what can be done about this? Despite repeated calls for more industry experience in academia, the number of experienced practitioners entering academia appears to be falling, (Johnston and King, 2008, p. 78; Lamb et al., 2010, p. 3), and it seems unlikely that this will change. Industry, via the institutions can force through high level curriculum changes, but the habitus of the engineering academic will still guide what is seen as important, and how these concepts are taught. I argue that this is where the recognition of habitus can bring positive change from within engineering academia. If an engineering academic can take a reflexive step back from their own habitus, they may be able to see more clearly the factors that influence their understanding of what engineering is, and what engineers need to be able to do. Stepping out of their own habitus, and considering the habitus of the practising engineer, could lead to greater understanding of the future needs of their graduating students.

Key findings and contribution to knowledge

I believe that my autoethnography on its own is a contribution to knowledge. Many published autoethnographies simply tell a story that the authors, and presumably the publishers, think is important and do not offer a traditional analysis (e.g. Douglas and Carless, 2008; Wilson, 2011). According to Ellis 'the autoethnographer does not privilege traditional analysis and generalisation' and 'refuses the impulse to abstract and explain' (in Pace, 2012, p. 3). I would contend that my autoethnography gives voice to a number of social groups who do not often, if ever, have the opportunity to be represented in the first person in an academic text. Nurses (Gardner and Lane, 2010; Muncey, 2010), teachers (Wilson, 2011), academics (Ellis, 1999) and female professional golfers (Douglas and Carless, 2008) have all been represented in academic literature through autoethnography, and I have contributed the voices of a disengaged high school student, an apprentice motor mechanic and a professional engineer now working in academia. Ellis states that (2010, p. 10) autoethnography can be judged on whether 'it helps readers communicate with others different from themselves', and my literature review could find no similar work in the extant literature. However, autoethnographers must also ask the question of whether the story is useful (Ellis et al., 2010, p. 10), and I would suggest that my autoethnography in part 1 is too broad to deliver impact, and must first be narrowed to areas of focus. In this thesis I have narrowed the focus to a Bourdieusian analysis of engineering education, but there were other themes as discussed in Chapter 4, some of which I return to later in this chapter.

As discussed previously in this chapter, I was not aware of autoethnography or Bourdieu prior to starting this PhD programme; or ontology, epistemology objectivism, constructivism, and a host of other terms and methods for that matter. I would therefore suggest that another key contribution to knowledge, is that along with bringing voices from engineering into social science literature, I am also bringing social science in the other direction. As discussed in Chapter 4, although Bourdieu’s concepts are common in education, they are little used in engineering education, and may be inaccessible to engineering educators (Devine, 2012a). Through this PhD programme I have been exposed to the disciplines of education and sociology, enabling a Bourdieusian analysis of engineering and resulting in the following key contributions to knowledge. To my knowledge this is the only Bourdieusian or sociological analysis of the relationship between engineering education and practice, and one of very few Bourdieusian or sociological approaches to engineering in general. The ubiquity of the approach in the discipline of education, versus its lack of use in engineering education may also highlight a disconnect between the discipline of education, and engineering education, and may raise wider questions about the nature of the relationship between the discipline of education, and the teaching of other academic disciplines at university level.

While I would contend that the use of Bourdieu in this context is novel, and could also be applied to other professional disciplines and their relationship with education, I would suggest that my key contribution to knowledge is the conclusions that I have drawn around how the disconnect between engineering education and practice is maintained. My conceptualisation of the engineering profession and engineering academia as two separate fields, may be a useful framework for others seeking to investigate similar relationships. However, the main conclusion of the previous chapter, that the habitus of the engineering academic is the key to addressing a disconnect between engineering education and practice, has potential to shine a sociological light on this issue. While the perceived disconnect has clearly been highlighted in the academic and industry literature discussed in Chapter 5, many of the quotes that I drew on in Chapter 5, were drawn from larger reports, or side issues reported out in studies; for example the maths teachers who noted in passing that the levels of mathematics tuition seemed to be much higher than the professional engineers they spoke to would ever use (Berry and Whitworth, 1989).

To my knowledge this thesis is the first time that these issues have been compiled and formally addressed head-on as a disconnect between engineering education and practice. It also appears to be the first time that these issues have been examined using field theory, and the habitus of the engineering academic has been explored. Taking a broader view and considering the profession as a field, and as a part of wider society, has also highlighted other contributing factors that have been discussed in Chapter 7. However, there is much that is open to challenge, and in need of further development, in particular the arguments made in Chapter 7. As discussed in Chapter 5, without ‘adjectival qualification’ (Johnston and King, 2008, p. 90) the term engineering has limited meaning, so claims about the nature of engineering, or what is required in engineering education, may have varying degrees of relevance to different disciplines. My arguments need to be challenged by engineering educators and professionals, and although I have begun this process (Moffat, 2017a, 2017b) it is only through publication and knowledge exchange that I can generate impact from my research in this thesis. The publications cited are work produced from this PhD.

Research and knowledge exchange opportunities related to engineering education

As discussed in Chapter 5 there is much dissatisfaction and debate amongst professional engineering communities in relation to professional status and what it means to be an engineer. Much of this relates to the word, or title, 'engineer' and who should be allowed to use it. To my knowledge, Bourdieu's arguments about language as an object of power, with meaning and impact on reality (Bourdieu and Wacquant, 1994, pp. 141–150; Schinkel and Tacq, 2004, p. 65) have never been applied to this issue. I have considered this a starting point for post PhD publication, to explore and provoke debate around the question 'what is an engineer'? This may have potential for collaboration with a linguist. As discussed in Chapter 5, there has been support in the field of linguistics for the use of Bourdieusian methods (Chouliaraki and Fairclough, 1999; Robbins, 1999), and collaboration with a linguist might address the perceived lack of linguistic 'specificity' (Hanks, 2005, p. 69) in Bourdieu's work, and by extension my own. However, there is perhaps an irony to using Bourdieu's work, so often used to challenge dominant groups in society, as the engineering profession may be more likely to be classed as the dominant group, than those who they might wish to prevent from using the title of engineer, and this may present an alternative way to explore this issue.

As the use of Bourdieusian methods is so rare in relation to studies of engineering education or practice, there are likely to be many opportunities for research. However, following on directly from the work discussed in this thesis, and in particular in Chapter 7, it may be useful to conduct a narrowed analysis in a specific engineering discipline, or a specific academic department, school or faculty. However, prior to conducting further, narrowed research in this area, I believe that there is a need to present these ideas for critique by an engineering academic audience, through both publication in engineering journals, and knowledge exchange presentations. I would suggest that this model, delivered via the principles of knowledge exchange, to an engineering audience, may help engineering educators to think about the needs of graduating students from a different perspective, as well as to subject my work to further testing.

Discussing the issues that face engineering using the concepts of fields and habitus could offer a non-confrontational way in which to open up discussion with engineering academics, about the disconnect between engineering education and practice. Instead of saying “you’re wrong, this is the way we do it in industry”, the concept of habitus can offer more of a “we each see this differently, and here’s why” approach. If educators can be invited to consider their own habitus, to consider how their social history and the social history of their field shapes their understanding of what the word engineering means, then they might begin to see their definition of engineering as one possible definition, rather than *the* definition, and the way that engineering is currently taught to be one way, rather than the only way. Knowledge exchange is important, because Bourdieusian concepts may be inaccessible to an engineering audience (Devine, 2012a; Navarro, 2006, p. 13), and if the findings of this research are to have any impact in engineering, they must be made accessible to those who can effect change. Two-way knowledge exchange in this context is also important, as it may also make me aware of issues and perspectives that I have not yet considered.

Some of the literature that I have reviewed during this PhD has also given rise to possible future areas of research. Reading about how teacher educators react to the ‘changing landscape of teacher education’ (Brown et al., 2014), has made me think about how this could be related to engineering education. I expect to draw on my new connections within the discipline of education, to explore this and other possible areas of collaboration. Of the literature on professions that I reviewed, the paper that most aroused my interest, was surprisingly, the study of the accountancy profession and how staff displaying technical-professional logics, were subordinate to those displaying commercial-professional logics (Spence and Carter, 2014). There are clear parallels here that could be the seed for a Bourdieusian analysis of the relationship between the engineering profession and economic capital.

There are a number of areas of potential future research and knowledge exchange related to engineering education that can be derived from my autoethnography and the work I completed for part 2 of this thesis. Much of this is centred on the question ‘could it be otherwise?’, or how the analysis discussed previously could lead to positive change in engineering education. The ideas that I discuss in the remainder of this section represent a transition from the theoretical analysis and the “why is it like this” of this thesis, to more specific and practical opportunities for positive change.

A particular area of engineering practice that would benefit from a sociological approach is Safety Practices. Safety is a huge field within engineering practice, and having worked in extremely volatile engineering environments, I am very familiar with this area of engineering practice. While writing up this final chapter, I was asked by a mature, experienced engineer and educator, to supervise his PhD in this area. As an expert in his field, the support he seeks from me as a supervisor is a combination of my familiarity with safety practices in industry, but in particular the knowledge and skills gained through this PhD, in helping him to critically analyse, organise and frame his arguments. My personal experience of safety in industry is one where social factors are of critical importance, and while engineers can be very good at writing procedures that work well when followed exactly, in my experience they often fail to understand the culture of the work environment, and the social reasons why a procedure might not be followed. A Bourdieusian analysis of Safety Practices in industrial environments could frame these scenarios in relation to the forms of capital, and while the power of economic capital to override safety concerns has been widely discussed in engineering texts, the impact of social and cultural capital, habitus etc, is less well understood.

My exploration of the nature of practice in Chapter 5 has highlighted a gap in the literature, in terms of academic studies of engineering practice. I cited many industry sources discussing the skills that companies would like to see in engineering graduates, and some academic sources based on what engineers say that they do, but there is little in the way of ethnographic observation of how engineers understand and solve the problems that they face. There is evidence for example that few engineers explicitly use mathematics in practice, but do they use it implicitly, does it influence their thought processes? As discussed previously, the habitus of engineering academics develops a view of engineering influenced by their position within the field of academic scientific research. However, a senior representative of an engineering firm, the source of some of the complaints about engineering education discussed in Chapter 5, will be heavily influenced by the primary goal of their company, which is to increase its share of economic capital. Arguably, each of these sources only offers a partial view, influenced by the established habitus within each field. I would suggest that there is a need for ethnographic studies of professional engineering, linking this back to the curriculum and how the skills and knowledge gained during the degree, are, or are not, linked to the problems modern engineers need to solve.

Part 2 of this PhD has largely been based on a premise, taken from my autoethnography, that engineering education is disconnected from professional practice. I have focussed on the sociological factors that drive this disconnect, but there is also the practical aspect of how the curriculum could change to better represent the knowledge and skills that graduates need in the field. Reflecting on my autoethnography, the most stark difference between education and practice is the way in which mathematics is used. In the literature that addresses this, mathematics in engineering practice is often something that is used at a high level, where it is the computer that does most of the calculations. In contrast academia continues to put a great deal of emphasis on mathematics at the low level, working out problems on paper, a skill that, as discussed in Chapter 5, many engineers say that they forget through lack of use. Some of the questions that come out of this for me include:

- To what extent is advanced mathematics required for the understanding of engineering principles?

- Are there engineering disciplines where degrees could be taught without, or with minimal low level mathematics, focussing on the way mathematics is used in practice?
- Would such an approach have a positive impact on student retention and motivation?
- Are there opportunities here to widen access and address social reproduction issues in engineering?
- If the extent or type of mathematics used in education was a closer match to practice, would this attract students who currently find the profession unattractive?
- Would also this give more space in the curriculum for maths that industry does use such as statistics and probability, and more use of the type of software modelling that is done in the field?
- What are the risks? Would an engineering students with minimal mathematics be restricted in the ability to move into postgraduate study, or research? Would there be negative or positive implications in terms of how engineering concepts are understood by students?

This is a huge topic, and the answers to the above questions may vary significantly across disciplines, industry sectors and job roles. However, this is also a topic that is a very strong theme within my autoethnography and I would like to explore further the extent to which this matches the experience of other practising engineers.

These questions are important because they are related to ensuring that the engineering degree is fit for purpose, in terms of preparing students for professional practice, but also in helping to ensure that we attract and motivate the right students into the profession. Beder has written about students, particularly women, being put off a profession that is seen to be ‘overwhelmingly concerned with numbers, science, and mathematical analysis’ (1999, p. 14). Quotes such as 'if we gave the students more time, anyone could do it', and ‘90 percent of you would make good engineers, but only 40 to 50 percent will graduate', seem to sum up an attitude amongst some teaching staff, that appears to be more about academic elitism than tailoring education to the needs of the student, and of the profession (Hacker, 2017). The suggestion that what might make a good engineer, is different to what might make a good engineering student, should be of concern to both engineering educators and the engineering profession. Related to this is the apparent epistemological differences between engineering students and practising engineers (Gainsburg, 2015), discussed in Chapter 5. As so much of engineering is subjective, and has a connection to people, I would argue that aspects of qualitative social science and the humanities, and the related approaches to knowledge, could be important for engineering practice. Research is needed into how these concepts relate to engineering practice, and their place in an engineering curriculum. I also see this as a fertile ground for my own teaching in the engineering faculty, and I have a number of ideas for classes that explore the social and subjective nature of engineering practice, and may help graduates to bridge the epistemological gap prior to entering practice.

The emerging degree level apprenticeships in engineering are of interest for future research, and link very closely to the issues just discussed. If companies hire degree apprentices who perform very well professionally, but struggle with the academic aspects, this may start to raise similar questions to those discussed in this thesis. Will the power of economic capital be brought to bear if companies see students excelling in the workplace, but performing poorly on the degree elements? In Scotland the devolved control of education and training, means that as with degree places, the economic capital for apprenticeship places will be levered through the relationship between government and the universities. However, in England, where companies can choose to spend their credits at a university of their choice, the fields of industry and academia will be in direct contact, and industry will have direct control of the economic capital needed by academia. Power relations between industry and academia will clearly be very different in Scotland and England, and how this affects degree provision in each system is an area for potential research. As I am directly involved in adapting the distance learning chemical engineering degrees that I currently direct, for both the English and Scottish emerging markets, I expect to be in a position to compare and analyse the impact of these systems, and to have a valuable source of data through my direct contact with industry based students and their employers.

Reflections and other areas of research interest

As discussed in Chapter 4 there were alternative themes that could have been developed in part 2 of this thesis. Of these the one that continues to hold my interest is the connection between social theory and motivation for learning. I was struck by two things during my post-autoethnography literature surveys of these subject areas. Firstly, I noticed how intrinsic learning was repeatedly promoted as the preferred form. This contrasted with my own autoethnographic experience, where extrinsic learning was the reality. Secondly, I noticed how little attention the literature appeared to give to amotivation, the inability of students to ‘perceive contingencies between outcomes and their own actions’ (Vallerand et al., 1992), in comparison to intrinsic and extrinsic motivation. I felt that this was an important issue deserving of greater focus. These two issues link me back again to Bourdieu’s concepts of social reproduction, and how social class, social, cultural and economic capital ‘together shape the kinds of experience it is possible to have’ (Atkinson et al., 2012). In particular I am interested in how aspirational ideals of intrinsic motivation, and motivation theories such as flow (Csikszentmihalyi and Csikszentmihalyi, 1992), describe elite ideals of education (Haggis, 2003), and the forms of motivation that are only available to some in society.

Another theme from my autoethnography that I would like to revisit, is my experience as an apprentice motor mechanic. It struck me when conducting initial literature reviews that while the experiences and first person voice of nurses are well represented in academic literature, I could find nothing at all discussing the experiences of trades people or trades apprentices. This has made me think a lot about the balance of representation in social science literature, and how autoethnography might not be helping that situation if it is just another way to represent the same voices that are already well represented. I made a decision to focus this PhD on engineering education, but I remain interested in exploring how autoethnography could be used to explore worlds that are not well represented in social science.

My experience of actually *doing* this PhD as a mature student is another aspect that might be contributed. Unlike many younger PhD students, I was studying an area where I have vast personal experience of the subject being studied, whether that be my own personal story in part 1, or the world of engineering focussed on in part 2. This has clear advantages, but also disadvantages in terms of being able to distance oneself from the object of study, and in my case I chose to embrace the personal and subjective through autoethnography. While I had experienced the subjects I would study, I had very little experience of the sociological discipline of education and this was a huge learning curve in parallel with the PhD itself. There are two things that I take from the above. The first is that while I would propose autoethnography as a useful way to capture the experience of a PhD student studying a field of personal experience, there is very little published methodological advice about how to position an autoethnography within a PhD, and what to do next in terms of analysis. I would suggest that my grounded theory approach that was influenced by Pace (2012) could be developed into a methodological framework for PhD's and other large scale research that utilises personal experience. Secondly, the challenge of obtaining the necessary background knowledge of the discipline of education could potentially discourage people involved in the education of other disciplines from doing a PhD, or other research, under the discipline of education. I am personally aware for example of other PhD students who are doing an educational PhD, but supervised within the discipline of engineering. While I will admit to a certain amount of jealousy because this would seem to be, for want of a better word, easier, I also feel that the PhD might lack the knowledge of educational theory, and the rigour, that would be contributed by the discipline of education. Is there scope here for some form of collaborative PhD, where an engineering supervisor brings the discipline specific knowledge and experience, and an education supervisor contributes the sociological frameworks and general pedagogical knowledge?

A particular benefit of doing an autoethnography at the start of qualitative, subjective research, is that it situates the researcher in relation to the research. This enables the reader to see how the researcher's personal experience relates to the research. For me personally, whether I had decided to focus the latter part of this PhD on research related to my experience of class, my compulsory schooling experience, or anything else in my autoethnography, the reader would be able to consider how my life, my story, might relate to or bias my account. This almost forces the researcher to take a reflexive stance. In my case I was constantly aware that the reader would know that I came through a very practical route as an engineer, and this made me constantly reflect on how this might potentially influence my research. If I had focussed specifically on class, the reader could likewise have considered how my growing up in a working class area that would now be classified in the SIMD20 range, or alternatively how being part of a family who is moving away from that socio-economic grouping (my father becoming a nursing professional, myself going from mechanic to academic) might colour my research.

A final reflection on future research, is not the lack of potential research opportunities, but rather the opposite. The same challenge that I have had during this PhD of developing the broad focus of my autoethnography, into the narrowed focus of part 2, remains when I consider future research. I have discussed potential research from Bourdieusian analysis of professional engineering practice, to autoethnography, ethnography, social class and motivation theory, pedagogical practices in engineering education etc. The challenge for me might be, as it was within this thesis, narrowing the focus to find the depth required for academic research. Reflecting on my autoethnography of lifelong learning, from my earliest memories of learning, focus has always been an issue for me, and will potentially remain an issue in research, where depth and specialty is often required. Alternatively, I may be able to find a way to embrace the breadth of my knowledge and experience. Presenting on epistemological epiphanies, autoethnography, and engineering, at an arts and humanities conference, as I did early in my PhD experience, will in some ways sum the breadth of this PhD experience up for me. While the non-engineering related themes discussed in this section interest me greatly, I have to be realistic about what I can hope to achieve in these areas. I currently work in an engineering academic environment so I am more likely to be able to pursue the ideas discussed in the previous section. Barring a complete career change I would be unlikely to be in a position where I could pursue large scale research in these areas, although that may not prevent me attempting to publish papers that explore these ideas and to broaden my horizons across the academic disciplines.

Summary of immediate plans for future research

This thesis has been unconventional, and in particular, due to it being based on an autoethnography of lifelong learning spanning more than thirty years, it has resulted in broader and less focussed recommendations than normally expected from a PhD thesis. Some of the reasons for this have been outlined above, and has partly come from a desire not to hide from, or obscure, other possibilities outside of the narrowed scope of part 2. This thesis took seed from an autoethnography of learning, but as I come to the end, I have started to realise that the whole thesis is in some ways an autoethnography, and I am still writing my story even now. In completing this PhD, I am again at a crossroads, and the broad recommendations above reflect the various directions that I, or someone else, could go from here. Am I now a sociologist, with a background in engineering, or am I an engineer with a new social science toolkit at my disposal, or am I a combination of these things? The decisions I make, and career opportunities that come my way going forward, will to an extent decide the balance of the answer to the above question, and which of the opportunities described in this chapter I ultimately focus on. However, in the interests of providing continuity from the main findings from this thesis, I have summarised below my immediate plans following submission.

The key findings from the analysis of part 2 of this thesis is that the disconnect between engineering education and practice, is the direct result of a disconnect between the fields of engineering academia and professional engineering, differing esteem factors and valued forms of capital within those fields, and the resulting habitus of their agents. The question is what, in practical terms, I can do about that, in my current position within an engineering department? One thing that I can with almost immediate impact, is to develop some of my findings into a class for conventional, full time engineering students, that would help bridge the epistemological gap discussed by Gainsburg (2015). I intend to use my findings and recently acquired knowledge of social science, alongside my engineering experience, to develop a class for 5th year engineering students in my department. This class will focus on the less tangible aspects of engineering practice that the students will not have covered in their degree, such as engineering judgement, qualitative problem solving, and how sociology and philosophy underpin many of the activities they will be involved with as practicing engineers, from people management to ethics. I also intend to involve industry professionals in this class and have begun discussions in this respect. I expect this class to be offered from 2019.

My immediate research focus will be to build on and further mature the arguments made in part 2 of this thesis. The conclusions I have made will be controversial to many in engineering education, and I believe that I will first have to build a publication profile before I can make these arguments. In addition, my final argument in Chapter 7 builds on work that would be difficult to condense into a typical engineering paper of a few thousand words, while also explaining Bourdieu to an engineering readership. I will first attempt to publish papers relating to the supporting arguments from Chapter 5 and 6, which I can later reference. For example, I would seek to collaborate with a linguist to solidify my arguments made in Chapter 5 about what the word engineering means, and how it might be interpreted differently in English, as opposed to other European languages. There is potential to describe the disconnect between engineering education and practice, as perceived by industry, by collating the many references to this in industry and institutional publications, into an academic paper. I would also seek to use my autoethnographic engineering experience, in combination with published literature I have reviewed during this PhD, to publish a paper in engineering education journals, provocatively questioning whether classical maths is still necessary for engineering practice in the age of computers.

Building a publication record based on the development and maturing of the supporting arguments, may bring me to a point where I can better support my main argument that the habitus of the engineering academic is at the root of the disconnect. This will be a contentious statement in engineering academia, so it will be important that I have a publication record behind me. There may also be opportunities to gather further data on engineering practice to compare with the engineering curriculum, and ethnographic study of engineering practice, or interviews with practicing engineers would be two ways of achieving this, and the potential impact would make a strong case for research funding.

Final words

Although I began this thesis with a fairly open ended autoethnography of lifelong learning, I have ended it with a very specific argument, that there is a disconnect between engineering education and practice, and that the key contributor to this disconnect is the habitus of an engineering academic. It is not my intention to suggest that there is nothing positive going on in the field engineering education. Neither am I suggesting that the academic is to blame for any issues that I, or other engineers with an industry focus, perceive to be lacking in engineering education. My main arguments in relation to this have been summarised in the conclusions to the previous chapter, but I don't pretend to have all the answers. However, I hope that my autoethnographic account of the disconnect between engineering education and practice, and the Bourdieusian framing of the contributing factors, provide an alternative challenge to the dominant paradigms in engineering education. I have told my story of learning, and framed my experience academically in this thesis, but the unexpected journey continues, and unknown destinations await.

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Appendix A: NVIVO and word frequency analysis tables

Table A.1: Autoethnography word frequency (stemmed and related words)

Word	Length	Count	Weighted Percentage (%)	Similar Words
learning	8	226	1.88	learn, learned, learning, learning', learning’
electronics, engineering	11	117	0.97	electronic, electronics, electronics’, electrons, engine, engineer, engineering, engineers
students	8	105	0.87	student, students
school	6	96	0.80	school, schooling
work	4	96	0.80	work, worked, working
motivations	11	92	0.77	motivate, motivated, motivating, motivation, motivational, motivations
year	4	77	0.64	year, years
educator	8	74	0.62	education, educational, educationally, educations, educator
course	6	62	0.52	course, courses
using	5	62	0.52	use, used, useful, using
teacher	7	62	0.52	teacher, teachers
think	5	62	0.52	think, thinking
first	5	59	0.49	first, first’, firstly
interest	8	59	0.49	interest, interested, interesting, interestingly, interests
degree	6	59	0.49	degree, degrees
need	4	59	0.49	need, needed, needs
studying	8	59	0.49	studied, studies, study, studying
class	5	58	0.48	class, classes
thought	7	55	0.46	thought, thoughts
concepts	8	53	0.44	concept, concepts, concepts’
job	3	51	0.42	job, job’, jobs
get	3	51	0.42	get, gets, getting
way	3	51	0.42	way, ways
back	4	50	0.42	back

things	6	49	0.41	thing, things
just	4	48	0.40	just
like	4	48	0.40	like, liked, likely
experience	10	46	0.38	experience, experiences, experiment, experimenting
career	6	44	0.37	career, careers
distance	8	43	0.36	distance
high	4	42	0.35	high
part	4	42	0.35	part, partly, parts
much	4	41	0.34	much
seemed	6	41	0.34	seem, seemed, seeming, seems
well	4	41	0.34	well
differently	11	40	0.33	differed, difference, differences, different, differently
relatively	10	40	0.33	relate, related, relates, relation, relatively
subject	7	40	0.33	subject, subject’, subjects
music	5	38	0.32	music, music’, musical
want	4	38	0.32	want, wanted, wanting
reason	6	37	0.31	reason, reasonable, reasonably, reasoning, reasoning’, reasons
seeing	6	37	0.31	see, see’, seeing
good	4	37	0.31	good
many	4	37	0.31	many
maths	5	36	0.30	math, maths
practical	9	36	0.30	practical, practically, practice, practices, practising
understanding	13	36	0.30	understand, understanding, understanding’
making	6	35	0.29	make, makes, making
books	5	34	0.28	book, books
level	5	34	0.28	level, levels
industry	8	33	0.27	industry
academic	8	32	0.27	academic, academically, academics
number	6	32	0.27	number, numbers
something	9	32	0.27	something

end	3	31	0.26	end, end’, ended, ends
now	3	31	0.26	now
people	6	31	0.26	people, people’
points	6	31	0.26	point, points
project	7	31	0.26	project, projects
teach	5	31	0.26	teach, teaches, teaching
know	4	30	0.25	know, knowing
probably	8	30	0.25	probably
reading	7	30	0.25	read, reading
even	4	30	0.25	even, evens
coming	6	29	0.24	come, comes, coming
exam	4	29	0.24	exam, exams
writing	7	29	0.24	write, writing
later	5	29	0.24	later
looking	7	28	0.23	look, looked, looking, looks
computers	9	27	0.22	computer, computers, computing
going	5	27	0.22	going
often	5	27	0.22	often
qualification	13	27	0.22	qualification, qualifications
trying	6	27	0.22	tried, try, trying
although	8	26	0.22	although
become	6	26	0.22	become, becomes, becoming
approach	8	25	0.21	approach, approached, approaches, approaches’, approaching
clear	5	25	0.21	clear, clearly
mathematics	11	25	0.21	mathematical, mathematically, mathematics
take	4	25	0.21	take, taking
another	7	25	0.21	another
felt	4	25	0.21	felt
found	5	25	0.21	found
may	3	25	0.21	may
completely	10	24	0.20	complete, completed, completely, completing, completion
develop	7	24	0.20	develop, developed, developers, developing, development

higher	6	24	0.20	higher, highers
management	10	24	0.20	managed, management, manager, managers
realising	9	24	0.20	realisation, realise, realised, realising
grade	5	23	0.19	grade, graded, grades, grading
period	6	23	0.19	period, periods
reflects	8	23	0.19	reflect, reflected, reflecting, reflection, reflections, reflective, reflects
requirements	12	23	0.19	require, required, requirements

Table A.2: 20 most used words in Abdul interview (recent chemical engineering graduate)

Word	Length	Count	Weighted Percentage (%)	Source
maths	5	99	0.79	Abdul
engineering	11	88	0.70	Abdul
class	5	45	0.36	Abdul
teacher	7	45	0.36	Abdul
learning	8	43	0.34	Abdul
degree	6	41	0.33	Abdul
different	9	41	0.33	Abdul
job	3	39	0.31	Abdul
life	4	39	0.31	Abdul
need	4	39	0.31	Abdul
school	6	38	0.30	Abdul
understand	10	38	0.30	Abdul
use	3	38	0.30	Abdul
work	4	38	0.30	Abdul
example	7	36	0.29	Abdul
years	5	36	0.29	Abdul
idea	4	35	0.28	Abdul
industry	8	34	0.27	Abdul
real	4	34	0.27	Abdul
experience	10	33	0.26	Abdul

Table A.3: 20 most used words in Jason interview (school friend)

Word	Length	Count	Weighted Percentage (%)	Source
school	6	65	1.59	Jason
history	7	27	0.66	Jason
class	5	26	0.64	Jason
art	3	19	0.47	Jason
maths	5	19	0.47	Jason
different	9	18	0.44	Jason
point	5	17	0.42	Jason
want	4	17	0.42	Jason
years	5	17	0.42	Jason
high	4	16	0.39	Jason
never	5	16	0.39	Jason
parents	7	16	0.39	Jason
working	7	16	0.39	Jason
able	4	14	0.34	Jason
anything	8	14	0.34	Jason
even	4	14	0.34	Jason
interest	8	14	0.34	Jason
job	3	14	0.34	Jason
teacher	7	14	0.34	Jason
right	5	13	0.32	Jason

Table A.4: 20 most used words used in Mum interview

Word	Length	Count	Weighted Percentage (%)	Source
school	6	46	1.87	Mum
job	3	18	0.73	Mum
work	4	17	0.69	Mum
different	9	16	0.65	Mum
capable	7	15	0.61	Mum
able	4	14	0.57	Mum
course	6	14	0.57	Mum
wanted	6	14	0.57	Mum
want	4	13	0.53	Mum
teacher	7	11	0.45	Mum
college	7	10	0.41	Mum
computers	9	10	0.41	Mum
point	5	10	0.41	Mum
interested	10	9	0.37	Mum
learning	8	9	0.37	Mum
teachers	8	9	0.37	Mum
university	10	9	0.37	Mum
class	5	8	0.33	Mum
failure	7	8	0.33	Mum
Learn	5	8	0.33	Mum

Table A.5: 20 most used words used in Dad interview

Word	Length	Count	Weighted Percentage (%)	Source
learning	8	32	0.75	Dad
school	6	31	0.72	Dad
Pass	4	22	0.51	Dad
control	7	19	0.44	Dad
make	4	19	0.44	Dad
sense	5	19	0.44	Dad
use	3	18	0.42	Dad
want	4	18	0.42	Dad
fact	4	17	0.40	Dad
learn	5	17	0.40	Dad
different	9	16	0.37	Dad
used	4	16	0.37	Dad
work	4	16	0.37	Dad
working	7	16	0.37	Dad
read	4	15	0.35	Dad
context	7	14	0.33	Dad
failure	7	14	0.33	Dad
music	5	14	0.33	Dad
really	6	14	0.33	Dad
two	3	14	0.33	Dad