A Qualitative Study into the Impact of Outcomes Based Education on Engineering Educators and Engineering Education in the Technical Higher Education Sector in Ireland

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Finally, I wish to dedicate this thesis to the memories of my brother Damien, my father Christy, and my aunty Patsy who helped me to value education in the way that I do.

Answers

I kept my answers small and kept them near;
Big questions bruised my mind but still I let
Small answers be a bulwark to my fear.

The huge abstractions I kept from the light;
Small things I handled and caressed and loved.
I let the stars assume the whole of night.

But the big answers clamoured to be moved
Into my life. Their great audacity
Shouted to be acknowledged and believed.

Even when all small answers build up to
Protection of my spirit, still I hear
Big answers striving for their overthrow.

And all the great conclusions coming near.

Dame Edith Sitwell

Abstract

This thesis considers the effect the transition to outcomes based education (OBE) has had on engineering educators and engineering education in the Institutes of Technology (IoTs) in Ireland. Whereas engineering education research into learning outcomes largely focuses on how teaching may better align with their use, the focus of this research, the effect OBE has on both engineering educators and engineering education, receives little attention in the literature. I conduct this research as an engineering educator seeking to understand how we have been shaped by OBE, and how this is affecting the education of future generations of engineers. My research employs a qualitative methodology, in which I consider this impact as perceived and experienced by a sample of IoT engineering academics.

My research highlights the influence of the market in shaping engineering education, which can be regarded through Bernstein's (2000) concept of engineering as a region, facing inward to academia, but outward to the market, mediated by the professional bodies. This leads me to draw selectively on social realism, alongside my experience as an engineering educator, as a conceptual framework. This emphasises the need to gain comprehensive understanding of the historical context in which my research is situated, for which my literature review encompasses a number of inter-related socio-historical accounts: of the early development of Irish engineering education; of the establishment of the Regional Technical Colleges (which became the IoTs) to implement government policy that saw education, particularly technician education, as key to improving the life of the citizenry through economic advancement; the later development of the National Framework of Qualifications (NFQ) as part of a skills-focussed reorientation of higher education; and the reasons for, and consequences of, the adoption of OBE for engineering accreditation, internationally and in Ireland.

The fieldwork, comprising interviews and a focus group with engineering academics, reveals the perceptions of my research participants of the effect that OBE is having on their academic identity, including their approach to curriculum and pedagogy, and provides insight into the structure of engineering education, and the identity formation of students. I will show that my interviewees regard OBE as effective, in terms of: facilitating communication; improving access to education; impacting positively on pedagogy; and as a framework for curriculum design. However, my research critiques the assessment focussed pedagogy that they appear to have adopted as a consequence, questions the appropriateness of the 'language of levels' related to NFQ terminology that has emerged in our pedagogic discourse, and raises concerns about the impact on curriculum and the structure of engineering education.

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Acronyms

ABET	Accreditation Board for Engineering and Technology
ACM	Association for Computing Machinery
ASEE	American Society for Engineering Education
BFUG	Bologna Follow-Up Group
BTech	Bachelor of Technology
CAO	Central Applications Office
CDVEC	City of Dublin Vocational Educational Committee
CEDEFOP	Centre européen pour le développement de la formation professionnelle (French: European Centre for the Development of Vocational Training)
CEVA	Council for Educational and Vocational Awards
CSO	Central Statistics Office
DES	Department of Education and Skills
DIT	Dublin Institute of Technology
EER	Engineering Education Research
EHEA	European Higher Education Area
EI	Engineers Ireland
ENAEE	European Network for Accreditation of Engineering Education
EQF	European Qualification Framework for Lifelong Learning
FDI	Foreign Direct Investment
FET	Further Education and Training
FETAC	Further Education Training and Awards Council
HEA	Higher Educational Authority
HEI	Higher Education Institute
HETAC	Higher Education Training and Awards Council
HoD	Head of Department
IEA	International Engineering Alliance
IBEC	Irish Business and Employers Confederation
ICEI	Institution of Civil Engineers of Ireland
ICT	Information and Communication Technology
IDA	Industrial Development Agency
IEEE	Institute of Electrical and Electronics Engineers
IEI	Institute of Engineers Ireland

IGIP	International Society for Engineering Pedagogy
IoT	Institute of Technology
ITB	Institute of Technology Blanchardstown
LO	Learning Outcome
NAE	National Academic of Engineering
NCEA	National Council for Educational Awards
NCVA	National Council for Vocational Awards
NFQ	National Framework of Qualifications
NQAI	National Qualifications Authority of Ireland
NQF	National Qualifications Framework
NVQ	National Vocational Qualification
NSF	The USA National Science Foundation
NZQF	New Zealand Qualifications Framework
OBE	Outcomes based education
OECD	Organization for Economic Cooperation and Development
ORF	Official Recontextualising Field
PRF	Pedagogic Recontextualising Field
QQI	Quality and Qualifications Ireland
RCSI	Royal College of Science of Ireland
RTC	Regional Technology College
SAQA	South African Qualification Authority
SCQF	Scottish Credit and Qualifications Framework
UCG	University College Galway, now National University of Ireland Galway (NUIG)
VEC	Vocational Educational Committee
VR	Virtual Reality

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Chapter 1 Introduction

Engineering faculty, of course, will be on the front line of any change.
National Academy of Engineering (NAE, 2001, p. 23).

1.1 The Research Question

This thesis considers the effect the introduction of outcomes based education (OBE) has had, and is having, on engineering educators and engineering education in the Institutes of Technology (IoT) sector in Ireland. I conducted this research from the perspective of an IoT engineering educator seeking to understand how we have been shaped by the introduction of OBE in engineering education, and how this is affecting the education of future generations of engineers. My research employed a qualitative methodology, in which I considered the impact of OBE as perceived and experienced by a sample of engineering academics drawn from the IoT sector.

Engineering is concerned with the creation and maintenance of artefacts for practical usage, through the use of tools, technology, methodology, skills and knowledge, where, however, the engineer is concerned not with "better and deeper knowledge, but better ends" (Poser, 1998, p. 85). Engineering education, with which my thesis is concerned, and which broadly comprises professional and technician engineering education, provides graduates to meet the market requirement for engineers. In Ireland, the IoTs and Technological University Dublin provide both technician and professional engineering education, whereas the traditional universities focus on the latter.

In order to position my research in relation to the field I consider the expansion of activity in engineering education research (EER) since the mid-1990s, initially in the USA but later on an international basis, and in which I note the development of an OBE approach to engineering accreditation (Riley, 2012) was highly influential. EER into the use of learning outcomes (LOs) largely focuses on how teaching may better align with their use. However, the focus of this study, the effect of OBE on both engineering educators and engineering education, receives little attention in the literature.

The literature review considers the formation of related educational policy, the policies themselves, and their implementation, beginning with developments leading to the creation of the technician education system in the Regional Technical Colleges (RTCs) in the 1960s. The literature review highlights the importance of considering the role of market forces alongside the academic aspects of engineering education. This can be conceptualised through Bernstein’s (2000) characterisation of engineering as a ‘region’, facing inward to academia and outward to the market, mediated by the professional engineering bodies. This led me to choose to draw selectively on Bernstein and other social realist researchers, alongside my experience as an engineering educator, in the research design and analysis. This allowed me to conduct the research from a standpoint that emphasises the importance of considering the role of power relationships in the adoption of OBE, and the influence this might have on the structure of engineering education.

My role as a head of department of engineering (HoD) in the IoT sector provided me with the opportunity to gain privileged access (Brinkman & Kvale, 2011) to my colleagues’ experience of OBE, through fieldwork consisting of individual interviews and a focus group. This highlighted the effect OBE was having on their academic identity, including their approach to knowledge, curriculum, and pedagogy. It also provided insights into their views of the structure of our engineering education system and the identity formation of our students.

1.2 Outcomes Based Engineering Education

In 2004 IoT engineering transitioned to OBE (Riley, 2012, Walsh, 2018), aligned with the levels of Ireland’s National Framework of Qualifications (NFQ) (QQI, 2014b), and Engineers Ireland’s (EI’s) LO based accreditation processes (EI, 2014). LOs describe education in terms of competencies, what a graduate will know and be able to do when they complete a programme of study, or what a student will know and be able to do on passing a module.

The NFQ (QQI, 2014b) has 10 levels (see Figure 1-1), with qualifications placed at the appropriate level through being described in terms of LOs that must be achieved in order to attain the award. In the IoTs, awards are made at level 6 (higher certificate), level 7 (ordinary degree), level 8 (honours degree), level 9 (master’s) and level 10 (doctorate). Engineers Ireland (EI) accreditation, which is now outcomes based, is the other key driving factor. Accreditation by professional bodies of qualifications from higher education institutes is important for engineering education, and is regulated internationally through a series of accords to which EI is a signatory (IEA, 2016). Although EI accreditation does not quite fall into the category of a compulsory accreditation process (Friedman et al, 2017), in practice all of engineering higher education in Ireland engages with it (EI, 2018).

As an engineering academic and academic manager I helped implement the transition to OBE for engineering education. I encouraged, led, and cajoled on occasion, my department staff into the use of LOs, in replacement for our previous, content, based curriculum approach. I initially accepted OBE in the positive, progressive, terms in which it was presented, although I also associated it with the ongoing pervasive expansion of quality assurance into academia (Kenny, 2010).

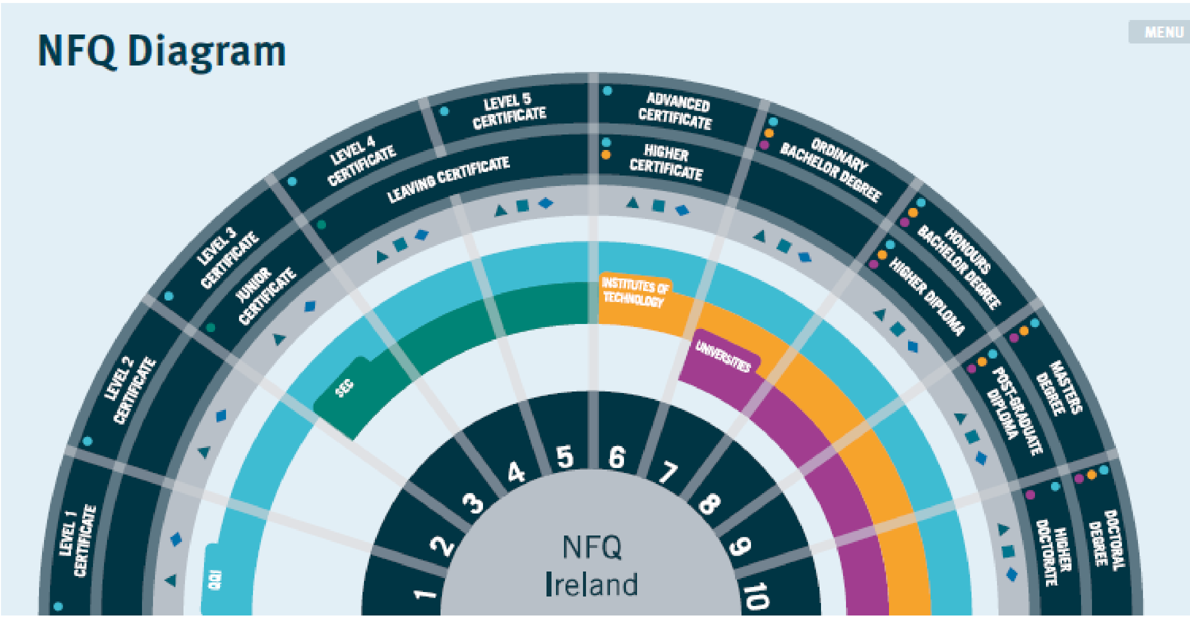

Figure 1-1 NFQ Level Diagram (QQI, 2016a)

We engaged with LOs on the basis that they were government policy (NQAI, 2002b), that they were enshrined in statute (Irish Statute Book, 1999b) and that they had become the cornerstone of the professional recognition of our programmes (EI, 2014). The use of LOs was going to make it clearer to prospective students, employers, parents and professional bodies what it is that graduates of our programmes would be able to do (NQAI, 2003a). LOs would assist lecturing staff in selecting what they should teach, how they should assess, and make programme design more straightforward (Kennedy et al, 2006). Their encapsulation within the NFQ would make for clearer progression pathways for students (DES, 1998) and provide a basis for the up-skilling of the population as required for the' knowledge economy' (HESG, 2011). The NFQ would be part of "the development of a lifelong-learning society" (NQAI, 2003a, p. 10), and would place the learner at the centre of education.

As I read deeper into the topic, and as I carried out the fieldwork for the thesis, discussing with my peers their experience of OBE, I came to the view that OBE is associated with fundamental change in IoT engineering education. Part of the reason OBE has been widely accepted by engineering faculty may be as simple as 'engineers like frameworks' (i.e. the idea that engineers have an affinity for clear and defined structure), but, regardless, we appear to me to have, at this stage, wholeheartedly adopted a LOs approach to education. My research suggests that, 12 years after the Collins et al (2009) report, which found that academics had not then fully bought into the LOs approach, the situation has changed quite considerably.

With hindsight, I believe that neither I nor my colleagues took too much trouble to consider whether OBE would really have all the positive influences that were put forward for its adoption, or indeed, what other consequences there might be. What was the effect on the education we were trying to offer and on the type of graduate we were hoping to produce? How was this affecting our pedagogy as engineering academics, and what influence might it be having on our approach to our epistemology in our own particular fields of engineering?

A further issue important to this research concerns the stratification of engineering education into technician and professional engineering education (Dempsey, 2017, 2018; McLaughlin, 1999; NAE, 2017), the latter of which is part of the pathway to Chartered Engineer. Prior to the introduction of the NFQ, the IoTs offered ladder programmes of engineering education (McLaughlin, 1999). This allowed those who technician graduates to continue their studies to gain honours engineering degrees, placing them on the path to Chartered Engineer. This is in contrast to the traditional universities, where all undergraduate engineering education enrolments are on honours degrees. The introduction of the NFQ, which promoted improved progression opportunities for students, would have been expected to reinforce this approach by the IoTs to engineering education. However, in parallel, and as a counter pressure to the NFQ concept of progression, EI, in adopting OBE for accreditation, increased the educational requirements for Chartered Engineering to master's degree (EI, 2012). My research provided an opportunity, through working with my peers in IoT engineering education, to explore their impressions of the effect of this, and related, issues.

The research takes place in a context where the use of OBE is only part of the pressure on Irish engineering education, only one of the tools used to promote the skills agenda of government policy towards higher education (DES, 2016; HESG, 2011), and there is also pressure from industry (IBEC, 2015). This thesis will show that there is a longstanding policy trail[1] emphasising the linking of education in the IoTs to industry requirements, beginning with the very establishment of the sector (the Regional Technical Colleges). My research, through considering the effects of OBE on IoT engineering education, serves partly to examine the overall effect of government policy, as influenced by the market, on educational practice.

The use of OBE can be regarded as a manifestation of neoliberal influences on Irish higher education (Lynch, 2012), and in general on engineering education (Matos et al, 2017). Neoliberalism is a phrase which carries ideological connotations of the power of global capitalism in influencing and directing education policy, with a corresponding influence on public policy and education in Ireland (Lynch, 2012). A neoliberal perspective on education is that it should align with labour market requirements, emphasising accountability and the skills development of the individual for employment, rather than the content of the curriculum being led by disciplinary experts in universities or other educational institutes (Allais, 2014). OBE, with its output emphasis, is attractive from this perspective where it is seen to "ensure that curricula are more responsive to the needs of employers and learners" (Allais, 2014, p. 51). However, as will be further discussed later, OBE is also attractive to educational reformers through offering a 'student-centred' approach, and improved access to education (Allais, 2014). In Ireland this has meant that the NFQ also received support, indeed welcome, from this perspective, although, over time, the dominance of the neoliberal drivers, the reality of the industry/jobs/output focus, and the controlling boundaries the NFQ places around education, became apparent to some (Finnegan, 2016; Fitzsimons, 2017a).

This research speaks to my lived experience as an engineering academic. As an insider (Leckie, 2001), in researching the effect of OBE on engineering academia I was researching the effect it had had on me. Given my role as an academic manager, I was also researching the effect that I, in promoting the use of LOs, had had on others. This implied that, as I conducted what became at times a quite critical study of the effect of OBE, I would have to acknowledge that

[1] The *policy trail* concept takes cognizance of the increased importance of market influences and transnational organisations in determining government policy (Cort, 2014).

I had helped to implement something that I began to question some aspects of quite strongly.

1.3 Being an Engineering Educator

Qualitative research requires that the researcher situate themselves in relationship to the study and those being studied (Denzin & Lincoln, 2011; Leckie, 2001). As noted in O'Reilly and Kiyinba (2015), a qualitative researcher's axiology influences their view of the world they are researching, and their approach to the research process. For example, McNutt (2010) relates an insight in his methodology development, the need to include a "key component in this work – myself - my own beliefs, values and assumptions" (p. 78). In my research I had to ensure that I understood my values and beliefs with regard to education and engineering, and how they had been influenced by the LOs approach. These values and beliefs, which form my personal axiology, have been developed through my time as an engineering student, an engineering practitioner in industry, and through my time in academia.

My engineering education was oriented towards engineering science and mathematics, with some elements of engineering practice, inculcating strong positivist and rationalist facets to my epistemology, alongside some constructivist influence. Knowledge, aligned with the engineering worldview, was that which was seen to be useful (de Vries, 2006; Gallery, 1989; Korte, 2015; Montfort et al, 2014).

My subsequent industrial experience as a professional engineer and research scientist with Philips Research Labs (Walling, 2005) initially emphasised the development of my engineering problem solving abilities (Fink et al, 2005). However, I grew beyond that later in research into virtual reality (VR) (Gallery & Gibson, 1993), where we considered epistemological and ontological aspects of immersive VR systems (Brey, 2014; Gallery, 1999; Morie, 2008; Niiniluoto, 2011). In our research we were conceptualising new realities (Gallery, 1996), investigating the challenges within them, and the experiences people could have (Crogan, 2010), rather than regarding VR as an engineering problem to solve (Gallery & Gibson, 1993). This inculcated within me the importance of relating engineering knowledge to engineering practice, which is something I have brought with me to academia. However, my work in VR also made me more aware of who I was doing the engineering for, which had been somewhat lacking in my earlier engineering education (Johnston et al, 1996).

My principal experience as an academic has been acquired since my time in industry, joining the nascent Institute of Technology Blanchardstown (ITB) (Irish Statute Book, 1999a) in 1999. Initially I focussed on “becoming a good academic […] caring for the students, being research active and finding joy and contentment in this work” (Fitzmaurice, 2013, p. 621). In common with other academics (O'Byrne, 2009), I emphasised the relevance of my industrial experience in teaching, developing a pastoral care element to my professional identity, being interested in research, and actively participating in course design.

Becoming head of department (HoD) of engineering brought new responsibilities. I am expected to have considerable leadership skills (O'Sullivan, 2014), above and beyond that of academic leadership, with staff expecting the HoD to represent the department to advance its cause, provide strategic direction, to act as a role model and to protect staff autonomy, amongst others. However, the day to day role is dominated by administration and fire-fighting, where, it is suggested, that HoD’s are “increasingly involved in administration to the detriment of leadership” (O'Sullivan, 2014, p. 182), which administrative duties often come under the guise of quality assurance (Kenny, 2010; Kenny et al, 2015). I feel that a HoD is a difficult position: where workload leads to a situation where we do not always provide the leadership we should to our staff, and restricts the time we can spend on research or teaching, i.e. where it is “difficult to balance each aspect” (Kenny et al, 2015, p. 92).

Much of my time is spent on matters concerning programme design and delivery. As an IoT engineering department we have focussed on programmes which offer students technology oriented careers, responsive to industry requirements. Within the programmes I have helped design and deliver we emphasise the use of theory and practice together. Whilst I can identify significant positivist and rationalist aspects in our programmes, there is also a pragmatist influence (Korte, 2015). This includes the use of problem based learning (McCabe et al, 2009), famously described and theorised by Dewey (1916). I view our graduates as differently positioned than I was on graduation, in particular more knowledgeable of engineering practice. Edström (2017) considers engineering education in terms of the tension between academic and professional values, “the analytical and practice orientation” (p. 40). I believe my educational values in this regard have largely achieved balance, reflected in a pragmatist facet in my epistemology, which brings more weight to the linking of theory with practice.

I thus approached this research on a personal level as an engineering educator immersed in the field I am researching, and, on a theoretical level, as an engineering educator conducting practitioner research using ideas from social realism to assist me in trying to understand that which I am researching. My epistemology combines elements of rationalism, positivism, constructivism (pragmatism) and managerialism, which in themselves can have tensions, for example between positivism and constructivism. However, they also lead to different expectations within an OBE engineering education.

From a managerial perspective, OBE provides an industry focus to our educational efforts, valuing the job-readiness of our graduates, which, at one level I welcome. However, as I will demonstrate later, it leads to contradictory policy goals that act against the promised efficacy.

From a rationalist perspective I regard it as important that engineering education has an emphasis on theory, in particular mathematics, whereas from a positivist perspective I look for an emphasis on experimentation and verification of theoretical postulates. Conducting this research has caused me to reflect on the underpinnings of various aspects of my work as an engineering educator in a new way, and, as I will argue later, the LOs concept is overly skills focussed, at the expense of theoretical knowledge. My constructivist aspect sees some benefit from competencies defined through LOs, given skills are important not only to technicians, but to all engineers. The LOs concept also takes into consideration that there is more than one way for an individual to construct their personal engineering worldview, which mirrors my experience as an educator.

1.4 The Fieldwork for the Thesis

The primary fieldwork consisted of a series of semi-structured interviews with fifteen engineering academics drawn from six of the fourteen IoTs. The majority of my research participants were engineering lecturers, from whom I was seeking to gain insight into their perception of the effect of OBE on themselves and the education they offer. I also invited some engineering academic managers[2] to take part, as they would provide a complementary viewpoint of their experience of helping to lead the implementation of OBE.

I chose a one-to-one interview approach for data-gathering to allow me to explore details of the effect that each of the interviewees perceived from the use of OBE. Although I framed the interviews within a consideration of their experience of OBE, the interviews also allowed me

[2] In the IoT sector the Engineering academic manager role, graded as Senior Lecturer 2 or 3, comprises both academic and management duties.

to discuss their impression of more general effects on engineering education. I followed an open coding approach (Lichtman, 2014; Saldaña, 2009) in the initial analysis of the interviews.

I used a focus group formed from the interviewees to review my draft findings (Kamberlis & Dimitriadis, 2011). This enabled me to provide an opportunity for feedback to those who had been so helpful in my fieldwork regarding what had emerged from the initial analysis. In the focus group we explored the validity of my draft findings, and their group voice on these matters emerged. It provided a different scenario to the individual interviews, allowing points to be raised and emphasised within the focus group that might not have emerged otherwise. It also provided a political and pedagogising opportunity related to my findings. As I had begun to draw conclusions with regard to my research, I found that I actively sought out conversations with my colleagues with regard to my draft findings, on the basis that I felt that these were things that ought to be known and discussed, and consequently, I welcomed the opportunity to present these to the group. A draft finding from the analysis of the interviews was that a *language of levels* had emerged in the pedagogic discourse, and the focus group, in addition to providing insight into the drivers for its use, also allowed me to regard this language in action as my focus group participants made use of it in our discussion.

1.5 Drawing on Social Realism

A key driver for OBE in IoT engineering education that my research identified is the government higher education policy emphasis, driven through economic concerns, on skills. Allais (2014), in considering the policy drivers for OBE, writes that the “emphasis on the intertwining of education and economy explains the focus of policy makers on qualification reform and outcomes-based qualifications frameworks” (p. xvii). It also became apparent that market influences had been similarly influential in the adoption of OBE for engineering accreditation. As I have indicated, this can be conceptualised through Bernstein’s (2000) characterisation of engineering as a region, which recognises the influence of both external and cognitive interests on engineering education.

Alongside my personal epistemology, my positioning as an engineering educator interested in policy formation and the impact on engineering education, I drew selectively on social realism to consider the policies that led to the adoption of an OBE approach to engineering education in the IoTs and the subsequent implications. Young (2008), in describing the basis for a social realist theory of knowledge, emphasised the importance of “detailed historical and ethnographic studies that can make explicit the contested character of intellectual fields” (p. 29). This suggested that, in order to answer my research question, it would be crucial to understand the socio-historical context (Young & Muller, 2010) in which IoT engineering education is situated. This concurs with Edström (2018), who, writing from an EER perspective, considers it “makes sense to develop a historical awareness, particularly to illuminate current efforts of engineering education development” (p. 38), identifying the need to consider organisations, vested interests and competing initiatives that contribute to this.

A social realist position acknowledges the social nature of knowledge, whilst at the same time accepts that there is “context-independent knowledge” (Young, 2008, p. xii). This leads to concern not just with what constitutes knowledge but also with the social-political issues and structures within which it is framed (Barrett & Rata, 2014a). In emphasising the importance of power relationships in determining access to knowledge through the curriculum (Bernstein, 2000), social realism provides a perspective from which to consider the formation and implementation of educational policy, and the stratification of knowledge in educational systems such as engineering.

Bernstein’s (2000) pedagogic device models the power relationships and communication structures of an education system as a pedagogic discourse. The means of communication, and who controls them, are considered as important as the message. The pedagogic discourse that arises is regarded as constituted through the official knowledge[3] of the official recontextualising field[4] (ORF), alongside the instructional discourse of the pedagogic recontextualising field (PRF). Engineering education such as that in the IoTs can be represented as a pedagogic device (Klassen, 2019; Moodley, 2014), where official knowledge of the state, EI, and the market, influences the cognitive interests of engineering academics and the identity formation of engineering staff and students.

Initially I struggled with how to approach my research from a theoretical perspective. Drawing selectively on social realism, and in particular the pedagogic device, led to a resolution,

[3] Bernstein used the phrase ‘official knowledge’ to refer, in an educational context, to government policy and associated organisational and legislative structures.
[4] Recontextualisation was used by Bernstein (2000) to refer to the manner in which curriculum is formed from disciplinary knowledge and additionally the instructional approach that is used to teach it.

providing an analytical framework within which my fieldwork could be considered (Bernstein, 2000) and from which the impact my interviewees perceive from OBE could be regarded. It not only allowed me to draw on my experience and knowledge as an engineering educator in the research, but, in emphasising the importance of the socio-historical context, and the power-relationships and vested interests within the field, made it essential that I do so.

1.6 Why This Research is Important

This research is primarily for myself, as I seek to become a better engineering educator through developing a fuller understanding of the challenges, tensions, and opportunities facing the sector within which I work, and the power relationships which act to determine and influence those. In providing a perspective of the impact that OBE has had on engineering education I also intend it to be of value to my colleagues. It suggests areas where engineering academics could consider how their identities may have been shaped by the use of OBE, and may provide insight into their own professional development. I provide engineering academic management with a perspective which they may find of value in considering the profile of their staff, the structure and aims of the engineering education they offer, and how they might approach programme design and renewal in such a system. It will also inform their approach to staff recruitment, and their provision of professional development opportunities for staff. Given that engineering education is a significant part of the IoT sector, this research is also of relevance to wider academic management in the IoTs.

My research is a contribution to policy analysis in relation to engineering education. In researching the development of the NFQ, and how, alongside EI's LOs based accreditation, it has affected engineering academics and engineering education, it provides a case-study of the different manners in which engineering educational policy can impact on practice.

The research also informs my colleagues in their role as members of EI, the engineering professional body, with regard to the influence that my research suggests LOs based accreditation is having on the structure and aims of engineering education.

Engineering education researchers will also find my research of relevance. The critical perspective into the impact on academics from the use of OBE shines a light on this under-researched facet of the field of engineering education research (EER).

This research, which grew from my own interests as an engineering educator practitioner-researcher, focusses on the impact of OBE on our engineering education system. However, it will also be of broader interest to educational researchers considering the impact of OBE on academic identity. Building on earlier research on changes in academic identity in the IoT sector (Hazelkorn & Moynihan, 2010; Kelly, K, 2009; Kelly, M, 2005; Kenny et al, 2015; Moynihan, 2015; O'Byrne, 2009, 2011), my research investigates the impact on academics' perceptions of knowledge, their pedagogy and the balance of knowledge and skills in the curriculum they design.

This research is also of interest to social realist scholars. It shows how the development of a socio-historical perspective (Young, 2008; Young & Muller, 2010) of technical engineering education in Ireland was key in allowing me to contextualise my research into the impact of OBE on that education system. My research can be regarded as a case-study which draws selectively on aspects of social realism as a lens through which to consider the experience of a sample of engineering academics of OBE. In using Bernstein's pedagogic device as an analytical framework in qualitative research into IoT engineering education, my research extends earlier research (Klassen, 2018; Moodley, 2014) which proposed its applicability as a theoretical model for engineering education systems.

1.7 Key Findings and Contributions to the Literature

The engineering education literature contains some critique of LOs (Heywood, 2016; Wolff, 2015; Woolston, 2008), but generally reflects a positive view of their effectiveness (ABET, 2006; EI, 2017a; Froyd et al, 2012; Owens, 2016a). Through taking a critical perspective, this thesis contributes to the field of EER in providing insight into the impact of OBE on the identity formation of engineering educators and on the nature and structure of engineering education, as evidenced through the views and practice of a sample of engineering educators. My research suggests that the adoption of OBE has had profound effects on IoT engineering educators and education, although the fieldwork provides evidence that my interviewees regard the NFQ and EI as only some of the drivers for change that they experience.

A finding from the fieldwork is that my research participants have given a positive, if at times qualified, acceptance to the NFQ and LOs, regarding this as an effective aspect of the overall structure of IoT engineering education. This effectiveness is perceived in: heightened consideration of pedagogy; promoting academic rigour in curriculum design; clarity for students on what is expected from them; and improved equity of access to education and progression. However, my research also sets out a critical view of the impact that can, at least partially, be attributed to OBE, including: regarding the type of pedagogy that has resulted; the appropriateness of the NFQ derived language of levels that has come into usage; and the impact on the technician identity and the structure of engineering education. A contribution to the literature is to demonstrate the manner in which OBE has been largely positively accepted by my research participants as part of the fabric of IoT engineering education

The professional bodies have a significant supporting role as communities of trust in the adoption of OBE (Tuck, 2007; Young, 2008), particularly in engineering education (Brent & Felder, 2003; Heywood, 2005, 2016). EI promote the adoption of LOs through their accreditation processes, which forms part of the official knowledge of IoT engineering education (Klassen, 2018; Moodley, 2014). The fieldwork provides evidence that this has been a significant factor in my interviewees' acceptance of OBE, particularly for course design. A contribution to the literature is to provide evidence, through the views and practice of my interviewees, to support the contention of the key role EI, as an engineering professional body (ABET, 2006; Brent & Felder, 2003; Heywood, 2005, 2016; McLaughlin, 2001; Owens, 2016a), play in the adoption of OBE by engineering academics.

Changes in the pedagogic identity of faculty as the IoTs expanded their role (Hazelkorn & Moynihan, 2010; Moynihan, 2015; O'Byrne, 2009, 2011, 2014) can be regarded through the concept of pedagogic identity changing under the influence of the pedagogic discourse (Bernstein, 2000). The workload associated with the use of LOs is often characterised as quality assurance (QA) (Kelly, 2009; Kenny, 2009). However, the use of LOs is much more than a QA and workload matter. As part of the official knowledge that acts to assert control over the pedagogic discourse, it would be expected to have a significant effect on the manner in which engineering academics approach their role. The fieldwork provided evidence of my interviewees actively changing their pedagogic identity under the influence of OBE. Findings relate to the usage of the language of levels in their pedagogic discourse; the impact on their pedagogic practice itself; their view of the balance of knowledge and skills; and the impact on their regard for knowledge and the curriculum.

Kenny (2006) reported the embedding of LOs in the academic language of Irish higher education, as was revealed as an intended outcome of the NFQ by Collins et al (2009), and as is proposed will, in general, result from the use of qualification frameworks (Allais, 2010b; Raffe, 2011). A finding from the fieldwork is that my research participants have adopted the use of a language of (NFQ) levels in their pedagogic discourse. They use it as a language of engagement with the regulative, or policy, discourse, and also in the instructional discourse of their academic practice. A contribution to the literature is to provide evidence, through the fieldwork, consistent with Biesta's (2005) learnification, that suggests the emergence of a language of levels (Raffe, 2011) in consequence to the introduction of the NFQ.

A finding is to show that pedagogy received little attention during the development of the NFQ (NQAI, 2001a, 2001b, 2002c, 2003a), although a few voices raised concern (APEL, 2001; Connolly, 2001; HETAC, 2001; ITT, 2001). Considering IoT engineering education through the lens of the pedagogic device leads to the expectation that, constituted as part of official knowledge, OBE would have a significant impact on pedagogy. The fieldwork reveals that the majority of my interviewees acknowledge the implicit influence of the NFQ over their pedagogy, regarding this in a positive and constructive manner. For my research participants the use of LOs appears to promote a teaching to assessment oriented pedagogical approach. Where previously we assessed what we taught, now we teach towards what and how we will assess. Relating my findings to the literature (Deacon & Parker, 1999; Havnes & Prøitz, 2016; Muller, 1998; Rajaee et al, 2013; Torrance, 2007), suggests that, consequent to OBE, my interviewees have adopted performance oriented pedagogies (Bernstein, 2000). A contribution to the literature is to provide qualitative evidence, supported by related studies (Muller, 2004a; Rami, 2012) to support the contention (Muller, 1998) that a potential consequence of OBE is to influence educators to adopt performance pedagogical approaches.

A set of related findings emerged with regard to my interviewees' views on the role of OBE in curriculum. For the majority, the NFQ has not had a significant impact on the acquisition of new knowledge. However, they now perceive LOs (influenced by the NFQ and EI) as the key driver for the recontextualisation of knowledge in the curriculum, with, for some, knowledge secondary to LOs. Although the use of LOs was seen as a prescriptive process, for some academics, LOs themselves, if not written to be overly precise, can be enabling, facilitating them in bringing their individual expertise to teaching. A contribution to the literature is to provide evidence, based on the views of my research participants, of the strong influence they experience from OBE over curriculum design, and the different modalities this takes.

Progression, in providing all students the opportunity to progress to level 8 degrees, acts to reconfigure the stratification inherent in engineering education. However, through the literature review I show that EI's interpretation of the Bologna declaration (European Ministers of Education, 1999) was to raise the educational requirement for Chartered Engineer to master's degree (IEI, 2001d). This precipitated a structural effect on IoT engineering education, reinforcing the stratification of engineering education into technician and professional engineering. IoT engineering students pursuing five years honours degree were now required to spend at least another year in education in order to continue on the track to Chartered Engineering. The impracticality of this resulted in many such degrees being discontinued, as predicted by McLaughlin (2001), with the four year honours degrees that replaced them not suitable for accreditation towards chartered status. A related contribution to the literature is to demonstrate the dramatic change, since the NFQ's introduction, in the orientation of IoT engineering education, from being technician education focussed, to where the majority of engineering students are now enrolled on honours degrees (HEA, 2018).

A finding from the fieldwork is that, for my interviewees, progression is perceived as causing technician programmes to orient towards serving as pathways to higher qualifications. This is a contribution to the literature in providing qualitative evidence to support research that suggests that level 7 engineering programmes were moving to become precursors to level 8 programmes rather than educational ends in themselves (Llorens et al, 2014).

My research confirms that the NFQ is one of the principal tools to enable the government skills agenda for higher education, and a contribution to the literature is to confirm, in applying Corbell's (2014) methodology to NQAI (2003a), the skills focus of the NFQ. The international experience is that NQFs are often associated with policy conflicts (Allais, 2010a; Fernie & Pilcher, 2009; Havnes & Prøitz, 2016), and I show that in the case of the NFQ conflicting government policies are evident, as reflected in the experience of my research participants. The national requirement for a continuing supply of level 6 and 7 technician graduates (DES, 2016) appears at odds with the evidence from my interviewees that the NFQ concept of progression (NQAI, 2003a) has led to a more theoretical, less skills focussed, technician education. However, the analysis revealed conflicting opinions amongst my interviewees with regard to the balance of knowledge and skills in curriculum: some considered there to be an insufficient emphasis on skills, whereas others felt the NFQ promoted an appropriate balance. I suggest the policy conflict between maintaining the supply of technicians (DES, 2016) and progression (NQAI, 2003a) is reflected in these differing attitudes. A contribution to the literature is to suggest this represents a manifestation of the pedagogic schizoid position (Bernstein, 2000) where market pressures conflict with the discourse of the discipline: contradictory educational policies simultaneously promote more skills, whilst orienting programmes to become more theoretical.

I will make the case that Bernstein's pedagogic device provides a framework within which the impact of the NFQ, and EI's accreditation requirements, on a sample of IoT engineering academics, can be regarded and critiqued. The views and practice of my research participants lead to a further claim, in that they provide evidence that in adopting performance pedagogical approaches under the influence of assessment focused OBE, the field of reproduction of the pedagogic device has become oriented towards a field of evaluation.

A further contribution to the literature is from a policy perspective, where I provide a critique of the effectiveness of OBE from the perspective of the technical engineering education sector in Ireland, which stands in comparison with QQI's largely positive recent review of the impact of the NFQ (QQI, 2017), and EI's similarly positive view of OBE (EI, 2014).

1.8 Structure of the Thesis

Chapter 1 introduces the research question, and how I am situated with regard to it as a practitioner researcher. I explain why this research is important, and who it may benefit. I provide an overview of my research methodology, findings and contributions to the literature.

In *Chapter 2* I provide an overview of engineering education, and I establish how my research is positioned with regard to the field of EER. I provide a brief history of the genesis of Irish engineering education, and describe the development in the 1960's of the RTC technician education system. I discuss the contemporary IoT engineering education system that has evolved from this, with particular attention to changes post-NFQ, and the pressures we experience as IoT engineering academics.

Chapter 3 describes the global rise of OBE, including for engineering accreditation. I discuss the development of the NFQ as part of a skills focussed re-orientation of Irish higher education, and EI's adoption of OBE for accreditation of engineering programmes.

In *Chapter 4* I develop a conceptual framework based upon my experience and epistemology as an engineering educator interested in research into engineering education, drawing selectively on social realism as a theoretical framework.

Chapter 5 details my research methodology, a qualitative approach using interviews and a focus-group. I discuss the choice of data gathering and analysis techniques, selection of research participants, ethical considerations, and the implementation of the methodology.

This is followed by five chapters in which voice is given to the research participants' views of the impact of OBE, on themselves, their colleagues, and on our engineering education.

In *Chapter 6* I illustrate the manner in which the influence and prescription of the NFQ over IoT engineering education is perceived by my research participants. EI is shown to be a significant factor in IoT engineering academics largely positive acceptance of OBE.

Chapter 7 reveals the use by my research participants of a language of levels derived from the terminology of the NFQ, as they engage with the pedagogic discourse.

Chapter 8 examines the impact of progression, revealing my interviewees' perception that level 8 honours degree awards are the aspirational target for all undergraduates, with higher certificates and ordinary degrees now stepping stones towards this. The analysis considers the effect on how and what students are taught.

Chapter 9 reveals the change in the pedagogy of my research participants subsequent to the change to an OBE approach. The analysis shows that they have consequently adopted pedagogical approaches focused around teaching towards assessment.

Chapter 10 considers how OBE has affected my interviewees' relationship to knowledge, skills, and the curriculum. I examine their approach to knowledge acquisition, and explore their views of the appropriate balance of knowledge and skills in engineering education.

Chapter 11 discusses the research findings through the themes of: the effect of OBE on IoT engineering education; the overall effectiveness of the NFQ; and the implications for the relationship between engineering and society. I include a reflection on the use of the pedagogic device as a model for IoT engineering education.

Chapter 12 discusses my research journey, and describes limitations of the study. I present the contributions to the literature and discuss their significance. I provide suggestions for future directions of related research. I conclude with a reflection on what I have learned personally through carrying out the research.

Chapter 2 Engineering Education and Ireland's Technological Education Sector

Deprived of the past, the moment - the present -has little meaning, if any.
Philip K. Dick (1966. p. 17).

2.1 Introduction

In this chapter I consider the development and evolution of the engineering education system in the Institute of Technology (IoT) sector in Ireland. In order to contextualise the research, I first discuss what is meant by engineering, which is stratified into technician and professional engineering. I argue that the epistemologies of engineers are multi-faceted, the influence of which is apparent in engineering education. This education is also strongly shaped through engineering's *raison d'etre* of productivity improvement (Trevelyan, 2019), encompassing the design, production and maintenance of artefacts for practical usage, and thus by its ties to the market. I explain how my research is situated in the field of engineering education research (EER).

Engineering education in Ireland prior to the establishment of the Regional Technical Colleges (RTCs) consisted of university education, principally accessible to the middle and upper classes, and a small, Dublin-centric, technical college sector. The formation of the latter was associated with the 19th century Mechanics' Institutes, which provided technical instruction to artisans, and which were themselves an arena of class-struggle and ideological conflict.

I discuss the socio-historical events, beginning in the 1960s, which led to the formation of an engineering technician education system in the RTCs, which were later to become the Institutes of Technology (IoTs). A guiding theme that emerges from my research was the national requirement for a technician education system to support an expanding economy, coupled with a desire to increase access to education for under-represented socio-economic groups. This mirrored the reasons for the development of binary higher education systems across Europe during the 1960s and 1970s (Christensen & Newberry, 2015; Triventi, 2013).

I review the development of engineering education in the IoTs, from conception through to the current day, and I present the significant changes to enrolment patterns that have occurred in recent years. I outline the role of engineering academics in the IoTs, drawing on the literature and my personal experience, and I discuss changes in our academic identity as the RTC/IoT sector expanded its role.

2.2 Engineering and Engineering Education

Engineering can be described as the "planning, designing, building and operation of efficient and economic structures, machines, processes and systems, based on the application of mathematics and natural sciences combined with knowledge of technologies and exercised with judgement and creativity" (Christensen et al, 2007a, p. 411).

Engineering can be considered to consist of four main engineering categories, chemical, civil, electrical and mechanical, each with their own sub-fields (WhatIsEngineering, 2016), although as technology and its application in society evolves a multidisciplinary approach can be regarded as more relevant rather than "focussed practice within traditional disciplines" (Duderstadt, 2008, p. 3). The different categories reflect industry requirements for engineering specialists, and, generally, are associated with dedicated courses in higher education (EI, 2019c). From an educational and career perspective, engineering is stratified into professional (or chartered) engineering, and engineering technician/technologists (Dempsey, 2017; McLaughlin, 1999; NAE, 2017). Professional engineers and engineering technicians may all be concerned with, *inter-alia*, design, testing, engineering management, costing, maintenance, or production. Typically, professional engineers are more theoretically oriented, and technicians/technologists more practice oriented (Land, 2012).

Through their education, and later professional practice, engineers experience "an identity formation process involving an acquisition of engineering discourse and engineering ways of thinking and doing" (Haase, 2014, p. 84). An engineer can be characterised as having a distinctive mind-set, or engineering habits of mind, which reflect these influences, where "thinking like an engineer" (RAE, 2014; p. 1) encompasses:

1. systems thinking: being able to recognise interconnections between parts of a whole, and how these parts may interact;
2. adapting, or being able to test, analyse, reflect and reconceptualise;
3. problem-finding: being able to clarify requirements, verify existing solutions, and understand the context in which a problem is situated;
4. creative problem-solving: applying design techniques to solve engineering problems;
5. visualising: being able to relate abstract concepts to practical solutions and the understanding of the design processes associated with this;
6. improving: the process of applying engineering techniques to improve existing solutions and prototype new ones:

In order to understand this more fully I examine what these engineering ways of thinking and doing might be through considering engineering from a philosophical perspective. Considered somewhat of "a neglected sphere of interest in the thinking of engineering educators" (Heywood, 2011, section *Introduction*), in more recent times the role of philosophy in engineering has gained some attention (Christensen et al, 2007b; Guy, 2010; Heywood, 2011, 2016; RAE, 2008, 2010a, 2010b).

Comparison is often made between the philosophical basis of science and engineering (Coyle et al, 2007; Heywood, 2011; Lipton, 2010; Poser, 1998), where although both "are interested in the truth, they may not be interested in the same truths" (Lipton, 2010, p. 13). Physicists seek ways in which the world can be described and explained, through "theory - a set of propositions, a set of equations, a set of assertions" (Lipton, 2010, p. 8). For engineers "the ultimate output is an artefact" (p. 8), with engineering science primarily concerned as to how something may produce a useful effect, as opposed to why it produces that effect (Coyle et al, 2007).

Engineering can be conceptualised through a number of philosophical positions, including rationalism, positivism, empiricism, constructivism and in particular pragmatism (Korte, 2015), existentialism and transcendental idealism (Figueiredo, 2008; Grimson, 2007). A model where the engineer is, simultaneously, a sociologist, a scientist, a designer and a doer is suggested by Figueiredo (2008), which sees the engineer as working with epistemological stances appropriate to each facet. Grimson (2007) argues that "engineering uses knowledge in all its various forms and no special allegiance can be given to any one epistemological theory" (p. 99). He argues that, whilst engineering draws from science, art, nature, mathematics and architecture, it has its own "distinguishing features" (p. 90) from each of these, highlighting engineering's use of rules of thumb and approximations alongside theory, where:

> the very essence that is engineering – to proceed at all, some assumptions or approximations have to be made if 'things' are to be designed and built. And there is great art in being able to use gainfully those theories that are known to be imperfect and to judge the extent to which rules of thumb may be safely deployed (p. 90).

Grimson's (2007) contention that engineering is not reducible to being considered from a single philosophical position is commensurate with my own experience (Gallery, 2015) that being an engineer encompasses being able to work with consideration of various philosophies and epistemologies. However, the strong positivist and rationalist bases must be acknowledged, alongside constructivist influences.

Wolff (2015) advances the premise that "different forms of engineering disciplinary knowledge require different ways of thinking" (p. 197), and makes a distinction between the more practically oriented technician and the more theoretically biased professional engineer. Common to these differing but related, epistemological biases, which reflect the multifaceted manner in which engineering can be viewed from a philosophical perspective, is the engineering view of knowledge as that which is useful (de Vries, 2006; Montfort et al, 2014), with engineering inherently grounded in knowledge of technology and its application. Indeed, in reflecting on my own epistemology as a recently graduated engineer and postgraduate researcher, this view of knowledge was notably present in the title of my master's thesis (Gallery, 1989), which emphasised my contribution to engineering knowledge as "Development of a *practical* model of the cochlea using digital filters".

These philosophical considerations which provide a "conceptual basis for understanding engineering" (McGrann, 2008, p. S4H-32) have implications for engineering education. They influence how engineering academics approach curriculum development, raising questions about the control of, and responsibility for technology. This also gives rise to questions about who or what groups control the curriculum content (Edström, 2018), and the pedagogy used to deliver it, which are important for this research, A philosophical perspective gives rise to the fundamental question of 'what is the purpose of engineering' (McGrann, 2008), and situates engineering education in the societal area within which the engineering will be applied (Heywood. 2016). An overarching influence is that of educating the next generation of engineers (Haase, 2014), and philosophy helps define the research agenda in this regard (McGrann, 2008). This includes the questions as to how students "perceive technological artifacts" (McGrann, 2008, p. S4H-32), how they develop their ethical awareness, and how they understand the different natures of technological knowledge.

Engineering curricula provides the means to introduce students to engineering knowledge (Heywood, 2016), and are "the formal mechanism through which educational objectives are achieved" (Heywood, 2005, p. 3). They are principally comprised of: mathematics; engineering science; information systems; various aspects of technology; and design and engineering practice. Engineering graduates will be able to apply science, technology and techniques to the solution of real-world engineering problems, and in support of engineered processes as deployed in industry, business, military and civil activity. Heywood (2008, 2016) proposes *screening* (Furst, 1958) as an approach to engineering curriculum design. In this approach design aims and objectives of a proposed curriculum are first screened against institutional educational and social policy, and then against the educational philosophy of the academic staff. The first step acts to reduce a potentially large number of aims and objectives to a more manageable size, and the second recasts them within the educational philosophy and pedagogy of the academic staff who will deliver the programme.

Engineering curricula have strong discipline specific elements, with associated discipline specific literature on curriculum development, e.g. software engineering (Fox & Patterson, 2013), mechatronics (Gallery, 2013), sustainability in engineering (Heeney & Foster, 2010). Ruprecht (2000) argues that curricula should not be driven solely by technical, industry or political concerns and supports including generalists and other disciplines in the decision making process of what is included in an engineering curriculum.

However, the factors that influence engineering education and curriculum go beyond philosophical, scientific and technological matters. Engineering, as identified by Bernstein (2000) in his conceptualisation of it as a region, is closely tied to the market, and the professional engineering bodies have an important influence. This market influence has profound implications, as will be discussed later, in relation to the adoption of outcomes based education (OBE) for engineering, as has become prevalent internationally, as influenced by industry (ABET, 1998a; Prados, 1992), national policies, international and European agreements, and the professional engineering bodies (Heywood, 2005).

Bernstein's concept of engineering as a region brings other aspects of the social realism of which he was a leading proponent into consideration for engineering education. Social realism emphasises the importance of knowledge and the curriculum in education. It recognises the social context of the creation of knowledge, whilst acknowledging that some knowledge has an importance and truth outside of the context of its creation. Social realism foregrounds the importance of power relationships in determining the structure and impact of that education. Other key considerations include the role of cognitive interests and communities of practice; pedagogy and identity formation of academics; and the concept of recontextualisation of knowledge in the curriculum. From an engineering perspective social realism provides a framework within which the differing epistemological orientations and approaches of technicians (more practically oriented) and professional engineers (more theoretically oriented) can be conceptualised (Shay, 2012). Furthermore, it is argued it resolves the tensions between the positivist and constructivist facets of engineering epistemology (Wolff, 2015). This is important for IoT engineering education, with its tradition of providing pathways for technicians to continue their education to become engineers, and which, as will be shown, has been impacted by the introduction of OBE.

2.2.1 Technician Education vs. Professional Engineering Education

Professional degree curriculum have an initial theoretical basis, which is later built upon in theoretically informed practice. A graduate (such as myself in 1987), on the path to Chartered Engineering status, will be expected to have significant theoretical knowledge, but with a lesser emphasis on engineering practice (Shay, 2012). I certainly felt this lack of emphasis on engineering practice as a postgraduate researcher and as an early career academic in UCG in the late 1980s, where although I knew a lot of theory, I recognised I had very little idea what it was for. Indeed Johnston et al (1996) noted the dominant influence of engineering science in professional engineering education, to the neglect of engineering practice, and considered that "engineering teaching and scholarship […] to a large extent they have remained isolated from the pragmatics of engineering as a professional practice" (p. 128).

In contrast, the pedagogical basis for technician curriculum can be described as based on practical knowledge taught alongside theoretically informed practice (Shay, 2012). In comparison to a professional engineering programme, a technician programme emphasises engineering practice over theoretical considerations. This encompasses a skills focussed education, complemented by theory to contextualise these skills, giving the students sufficient theoretical grounding should they choose to continue study to more advanced technician (technologist) or engineering programmes (McLaughlin, 1999).

The International Engineering Alliance (IEA , 2016) accords set out standards for engineering professionals and technicians/technologists, where the difference between the capabilities of the different engineering strata can be characterised (Wolff, 2015) on the basis of their problem solving capability "Engineers - complex problems; Technologists - broadly-defined problem; Technicians - well-defined problems" (p. 2). Wolff explains the difference between the three tiers in terms of: "engineers generally seen as being responsible for conception and design, technologists and technicians for implementation". Technologists can be classed as technicians who have undertaken further education to degree standard, with a continued focus on the application of technology, as per EI accreditation regulations (EI, 2020a, 2020b). In the IoT sector we regard both higher certificate and ordinary degree holders as technicians, and I will generally use the term technician to refer to both technicians and technologists together, similarly to Wolff (2015), unless clarification is necessary.

The division of engineering education into professional and technical education can be regarded as a stratified system (McLaughlin, 1999; NAE, 2017), with technician education considered a lower tiered qualification. However, is this stratification a necessary approach to engineering education and the successful application of engineering? The distinction between the roles engineers and technicians may fulfil is not always fully defined (Lennox & O'Brien, 2013), with professional engineers and technicians in some cases, performing similar roles (Land, 2012; NAE, 2017). On the other hand McLaughlin (1999) places, in a typical engineering organisation, professional engineers in positions of authority over technicians.

Although USA and Irish engineering education are not fully aligned, their broad similarity allows for comparison, as evidenced by their respective professional bodies being signatories to the IEA (2016) accords. Dempsey (2018) believes the increased theoretical emphasis that developed in USA engineering education from the 1950s onwards was a consequence of engineering academics seeking to increase their status through ensuring engineering education contained "academic credentials deemed important by the scientific community" (p. 8). In 1955 the American Society for Engineering Education (ASEE) adopted the Grinter report, which proposed increasing the theoretical component of engineering degrees. An earlier draft also proposed a parallel, more practically oriented, technology focussed, degree, with equal weighting to that of a more theoretically focussed one (Dempsey, 2017; Seeley, 1999). Although this was identified as meeting the greater part of industry's requirements (Dempsey, 2017), the recommendation was discarded in the final draft (Seeley, 1999) of the report. The more theoretical engineering education that was adopted was designed, Seeley (1999) argues, "not to serve industry, rather to attract federal research funds" (p. 291).

However, Dempsey (2017) questions the continuing validity, in modern USA engineering education, of the current stratified structure, which can support the preservation of established interests and inequality of access. For example, although engineering technology degrees offer a viable career pathway for African Americans, who are an underrepresented group in engineering, Dempsey considers that they do not always receive parity of esteem from their peers with bachelor of engineering degrees. In identifying both "regulatory and reputational" (p. 24) causes, and noting the dual track approach suggested in a pre-publication draft of the Grinter report, Dempsey argues for equal treatment of pathways to professional and technician engineering education.

There has been debate on this In Ireland, where, in 2005, the IoT Heads of School of Engineering, identifying that there was an issue with professional recognition of engineering technicians in Ireland, proposed to the IEI the creation of the professional title of Chartered Engineering Technologist. The proposal recognised the contribution engineering technicians made to industry and the high level of the work they carried out. This would have placed engineering technologists and professional engineers with commensurate levels of education and experience on an equal footing from an accreditation perspective (IEI, 2005a). The IEI however decided that chartered status should remain the preserve of the professional engineer, of which they state "a Chartered Engineer has status across the globe" (EI, 2019b).

2.3 The Field of Engineering Education Research

I needed to understand how my research into the effect of OBE on engineering educators and engineering education was situated in relation to the field of engineering education research (EER). This was essential to allow me to build upon the existing literature, contextualise my research in the context of the research themes identified in the field, and to identify the theoretical and empirical research gap that my research question would address.

The field of EER has undergone significant expansion since the 1990s, as evidenced by: the establishment of professorships, departments, research centres and doctoral programmes in engineering education; the creation of special interest groups within professional bodies; the increased number of conferences specialising in EER or incorporating this as part of their theme; and an increased number of submissions to engineering education journals; (Bernhard, 2018; Borrego & Bernhard, 2011; de Graaff, 2017; Johri & Olds, 2014).

Froyd and Lohmann (2014) associate this expansion with the development of ABET's (the USA engineering accreditation body) learning outcomes (LOs) based accreditation process, EC2000 (ABET, 1998a; Prados, 1992). As will be discussed in more detail later, in the 1990s

USA engineering education attracted strong criticism of its preparation of students for the workplace (Prados, 1992), and in response ABET advocated a move to a LOs approach for accreditation. To support this the USA National Science Foundation (NSF) provided significant funding for research into the use of LOs in engineering education, which served to fuel the expansion of EER in the USA (Daniels et al, 2011; Edström, 2016).

The American Society for Engineering Education (ASEE, 2019) *Journal of Engineering Education*, a key scholarly journal for EER (Edström, 2016; Lohmann, 2005), took a lead in promoting its expansion, publishing *The Research Agenda for the New Discipline of Engineering Education* (JEE, 2006). This identified themes for the discipline, comprising: epistemologies, or engineering thinking and knowing; learning mechanisms; pathways to diversity and inclusiveness; engineering education and institutional practices; and assessment and research methods (Johri & Olds, 2014, *Introduction*). However, Borrego and Bernhard (2011) characterise EER in the USA as being primarily concerned with how engineering is taught. They recognise the important role of engineering educators, but categorise related research as being concerned with how to assist them "improve their teaching" (p. 23).

The rise in EER in Europe is associated (de Graaff, 2017) with the European Society for Engineering Education (SEFI, 2019), a key objective of which is to connect those teaching engineering with relevant research (Edström, 2016). SEFI publishes the European Journal of Engineering Education, which, it has been argued (Edström, 2016), takes a less scholarly, more inclusive approach than the ASEE journal, with readers who are "engineering educators looking for inspiration, rather than researchers looking for references" (p. 976). Borrego and Bernhard (2011) characterise European EER as being concerned not just with how engineering is learned, but also with "what is taught and why" (p. 33), how engineering knowledge is recontextualised by the social context and pedagogy, how knowledge is selected, and how technology evolves and in turn helps change society.

2.3.1 Engineering Education Research in Ireland

Sorby et al (2014) review EER in Ireland through the lens of Fensham's (2004) framework for defining a research discipline, which identifies three sets of criteria. Structural criteria take such forms as academic recognition, journals, research centres, etc. Research criteria are associated with the intellectual coherence of the field, e.g. where groups of researchers reach consensus on research questions, their relative importance, how they might be solved, and, indeed agree what might constitute a solution (Borrego & Streveler, 2014). Outcome criteria consider the implications of research for the practice of engineering education (Froyd & Lohmann, 2014).

In considering EER in Ireland, Sorby et al note the presence of dedicated engineering education researchers in higher education e.g. Seery (TERG, 2019), or others such as Brabazon (DCU, 2019), Dempsey (NUIG, 2019), Curran (UCD, 2019) who publish on EER in addition to their technical interests. In addition, the significant contribution of Heywood (TCD, 2017b), must be acknowledged. In further alignment with Fensham's framework, Ireland is also graduating PhDs focussing on EER, albeit in small numbers (Duffy, 2017; Goold, 2012; Kelly, 2010). However, in the absence of the funding levels available in USA, the number of academics engaged in EER is relatively low (Sorby et al, 2014).

Perhaps the largest activity EER activity is associated with TU Dublin's CREATE (2019) group, which aims to bring together staff and students "engaged in education research in engineering and technical discipline areas". The research interests associated with CREATE are complementary to my own study, including the epistemology and ontology of engineering (Duffy & Bowe, 2014), the relationship between technician and professional engineering programmes (Llorens et al, 2014), academics' perception of the importance of professional skills (Beagon, 2018), engineering ethics (Conlon, 2008, 2015), and the effects of change in higher education in Ireland on faculty (Kelly, 2010). As an indication of the level of activity, in 2019 CREATE organised a workshop on EER in conjunction with the UK and Ireland Engineering Education Network which included the research topics of combining accreditation and programmatic review, engineering skills requirements, and pedagogy (UK & IEE EER Network, 2019).

2.3.2 Engineering Education Research and Learning Outcomes

The view of outcomes based engineering education in the EER literature is generally positive (ABET, 2006; EI, 2014; Froyd et al, 2012; Owens, 2016a), with the application of LOs in engineering education considered part of the "fabric" (Froyd et al, 2012, p. 1349) of engineering education.

The tone for USA engineering education research in this regard is set out in the first chapter of *The Cambridge Handbook of Engineering Education Research* (Johri & Olds, 2014), where

OBE, contextualised within professional body accreditation, is described as having "many aspects of a scholarly approach to educational innovation" (Froyd & Lohmann, 2014, p. 6). However, some critical voices (Riley, 2012; Wolff, 2015; Woolston, 2008) have spoken against the accepted wisdom of OBE, and Heywood (2016) considers it is often not applied effectively. Klassen (2018) reports on attempts (allegedly influenced by ABET) to supress a presentation by Riley at ASEE 2016 critical of aspects of EC2000.

A European perspective on the use of LOs in engineering education is provided by the papers published for SEFI (2018), approximately 30% of which discuss the use of LOs. However, this is generally with regard to how aspects of education, such as innovations in teaching and learning, or in assessment, can be utilised to better meet LOs, or how to improve the design of curriculum using LOs. Indeed, only one paper in SEFI (2018) can be said to raise a critique of LOs, in that Virkii-Hatakka (2018) questions whether the LO approach is fully suitable for the teaching of more advanced engineering topics. The evidence from analysis of SEFI (2018) is that use of LOs appears indeed to be generally accepted as "part of the fabric of the engineering education community" (Froyd et al, 2012, p. 1349).

2.3.3 Engineering Education Research and Engineering Educators

Jesiek et al (2009) categorised the field of EER through considering a sample of papers from journals and conferences. Research into methods of assessment was one of the most represented research topics (15%), alongside teaching (8%) and learning (12%). Curriculum constituted the principal topic of 8% of the papers, with research into engineering faculty representing only 3% of the papers.

In order to evaluate more recent trends regarding research into engineering educators, consider SEFI (2018), which conference included *Educational and Organisational development* as a theme. However, analysis of the conference papers on the basis of their titles suggest less than 5% being concerned with matters directly related to engineering educators' professional development or the impact of educational policy, consistent with Jesiek et al (2009). Analysis of the 2017 SEFI annual conference (SEFI, 2017) reveals a similarly low level of research interest into engineering educators themselves, although papers such as Nyamapfene (2017) and Niemi et al (2017) reveal some awareness of the need for research into the pressures on engineering educators in today's engineering education environment.

2.3.4 The Positioning of this Research in the field of Engineering Education Research

As an engineering academic, I wish to understand the effect that the change to OBE has had on my colleagues and on myself. Although there is considerable EER research which considers the use of LOs, this is generally on the basis of how to improve that education to further align it with an OBE approach to engineering education. Research into engineering educators, a focus of this thesis, has a relatively small footprint within the overall field. Such research as there is into the impact of OBE on engineering educators tends to be on how better to engage faculty with the use of OBE, particularly through appropriate training (Brent & Felder, 2003; Cross et al, 2017; Felder et al, 2014; Laguador & Dotong, 2014; McKenna & Light, 2009). In contrast, this research, undertaken from my perspective as an engineering educator interested in policy formation and its impact on engineering education, provides a critical view of the use of OBE for engineering and its consequences for educators’ approach to pedagogy, curriculum and knowledge. In considering the positioning of this research in relation to EER on Irish engineering education, it is complementary to Kelly’s (2009, 2010) research into the impact of change in higher education on engineering academics.

Furthermore, in my academic leadership role as a HoD, I am concerned with how the relationship between technician and professional engineering has changed under the influence of Ireland’s National Framework of Qualifications (NFQ) and Engineers Ireland’s (EI’s) OBE approach to accreditation. Building upon analysis of the structure of Irish engineering education (Bucciarelli et al, 2009; McLaughlin, 1999, 2001), my thesis adds to research on the relationship between technician and professional engineering education in Ireland (Llorens et al, 2014).

As an engineering educator, I am interested in what we teach to students on their journey to become engineers, and why we teach it (Borrego & Bernhard, 2011). My research investigates the impact of OBE on this through the views and experience of my research participants, engineering education practitioners.

I wish to acknowledge the significant contribution of Heywood to the field of EER, and to my own research, which draws on his publications into the philosophy of engineering (Heywood, 2011), assessment (Heywood, 2000, 2016), curriculum (Heywood, 2005, 2008), LOs (Heywood, 2008, 2016), and into professional bodies and accreditation (Heywood, 2005, 2016). My research is also complementary to the on-going research by Kyne (2019) into the possibility of amalgamating programmatic review and EI accreditation, both of which are LOs focussed processes.

2.4 The Establishment of Engineering Technician Education in Ireland

I now consider the engineering technician education system in Ireland within which my research is situated. In order to understand the socio-economic history that led to the development of this effective engineering technician education system, I consider the genesis of engineering education in Ireland, and describe the pre-1960s Irish engineering education system (see Figure 2-1, p. 34). Then, through consideration of a series of reports and related government policies, I chart the path to the establishment of the RTC (IoT) sector (Figure 2-2, p. 34).

2.4.1 Engineering and Technical Education in Ireland Prior to 1960

The early development of engineering education in Ireland followed a stratified approach, with university engineering education for the upper and middle classes, and on the other hand the Mechanics' Institutes, and, later, technical colleges, offering technical education for the artisan working classes to allow them to engage with the requirements of industry.

Dooge (2006) links the development of university engineering education in Ireland to that in the UK, where, as part of an expansion from a military engineering focus to encompass a civil one, in the 19th century engineering professorships were established in the UK universities, e.g. University College London (1841), Kings College London (1838), Glasgow (1840). The earlier professors were themselves trained under the previous apprentice-like system (Bucciarelli et al, 2009), leading to an emphasis on practical training.

In Ireland similar developments led to the initiation of engineering courses in 1850 in Queen's colleges, Cork, Galway and Belfast, with Trinity having established a school of civil engineering and architecture in 1841 (Dooge, 2006). Although the Catholic university, which was to become UCD in 1908 (UCD, 2011), was not successful in its plans for engineering programmes, the government run School of Science included a faculty of engineering on its foundation (Kelham, 1967). This later became the Royal College of Science of Ireland (RCSI), and was incorporated into UCD (2011) under the 1926 University act (Irish Statute Book, 1926).

The RCSI programme was illustrative of university engineering education of the times, with an initial theoretical basis leading to a more practical focus in later years, comparable to contemporary professional engineering education. The programme comprised a year of general study emphasising maths, followed by two years of more specialised study of a practical nature, leading to a Diploma of Associateship (Kelham, 1967). Similarly Trinity's initial two year engineering course emphasised earlier study of theoretical matters followed by a year of study of engineering practice (Dooge, 2006), with a similar structure as the programme duration extended to a Diploma in Engineering in 1845 and a Bachelor of Civil Engineering in 1872 (TCD, 2017a). The professional identity being formed through these courses, a theoretical foundation later contextualised in practical studies, was different to the earlier apprentice-like training for engineers (Bucciarelli et al, 2009; Dooge, 2006), and attracted debate as to its suitability (Adelman, 2006).

The establishment of engineering as a profession began with the "cultivation of a professional image by organised groups of engineers" (Adelman, 2006, p. *xxx*), leading to the formation of engineering professional bodies. The Institute of Civil Engineers of Ireland (ICEI), established in 1835 (Cox & Callanan, 2006), received its Royal Charter in 1877 (Cox & Dwyer, 2014), with engineering firmly regarded as a profession by the end of the 19th century (Adelman, 2006).

Whereas in Britain industrialisation created a demand and interest in scientific education, Ireland was less developed, with the principal exception of the Belfast region, where engineering industry was supported by a workforce with strong engineering skills (Malley, 1981). Engineering graduates were in demand throughout the UK and its empire for infrastructure development, with positions available in the civil service (Adelman, 2006). Nevertheless the overall level of industrialisation in Ireland led to engineering programmes experiencing difficulty attracting students. However, from 1899 onwards demand increased, although the level of industrialisation entailed that, for the case of the RCSI in particular, the majority of graduates took up work abroad (Kelham, 1967). Nevertheless, by the beginning, of the 20th century a university engineering education system for the training of professional engineers was established in Ireland, accessible, generally, to the middle and upper classes.

Dooge (2006) describes the parallel 19th century UK Mechanics' Institutes movement for the technical education of craftsmen. This was mirrored in Ireland with the establishment of such institutes in Dublin, Belfast, Cork, Limerick, Galway and others (Cooke, 1999). Patrons of the institutes were drawn from "the leadership of the nobility and landed classes" (Thomas, 1979,

p. 70) who lent them "their respectability, influence and values", although some "supporters of the institutes were interested in the general cause of education" (Thomas, 1979, p. 69).

However, the Mechanics' Institutes were more than just a means to provide industry with skilled workers, it is argued they were also an instrument of social control (Royle, 1971, Shapin & Barnes, 1977; Turner, 1980), making accessible to workers knowledge aligned with manufacturers' needs (Cooke, 1999; Thomas 1979). Engels (1845) identified the ruling capitalist classes influence in the Mechanics' Institutes, describing the class struggle to assert control. This ideological conflict was apparent in the Dublin Mechanics' Institute, resulting in a withdrawal of patronage, which, amongst other factors, led to it ceasing to function in the 1830s, although it was later revived and became more established (Cooke, 1999).

The success of the 1885 Irish Artisans' Exhibition led to the founding of Kevin Street College of Technology in 1887, aided by a grant from Dublin Corporation, to "provide education for the working classes of the city" (Duff et al, 2000), and effectively replacing the Dublin Mechanics' Institute (Cooke, 1999). Initial programmes encompassed technical subjects such as mechanics, mathematics, machining, chemistry, and electricity.

The Agriculture and Technical Instruction Act 1889 enabled local authorities to fund technical education. This led to the expansion of the Kevin Street college, growing to offer courses in science, technology, art and commerce, and the establishment of further technical schools in Dublin and other parts of the country (Duff et al, 2000). However, the majority of these training institutes were in Dublin and not readily accessible to those from the provinces, although Gleeson (1956) contends that the "training bearing on the possibilities of employment" (p. 3) they offered that was quite sought after.

There were to be further changes in engineering related education in the state, e.g., the 1926 Commission in Technical training led to the Vocational Training act (1930) (McCarthy, 1977) and the establishment of the City of Dublin Vocational Educational Committee (CDVEC). This assumed responsibility for the Dublin technical schools which were to later form the DIT (Duff et al, 2000), with the only other significant technical college situated in Cork (Walsh, 2018). These technical schools prepared students for either the examinations of relevant professional institutes, or alternatively the state technical examinations (Gleeson, 1956).

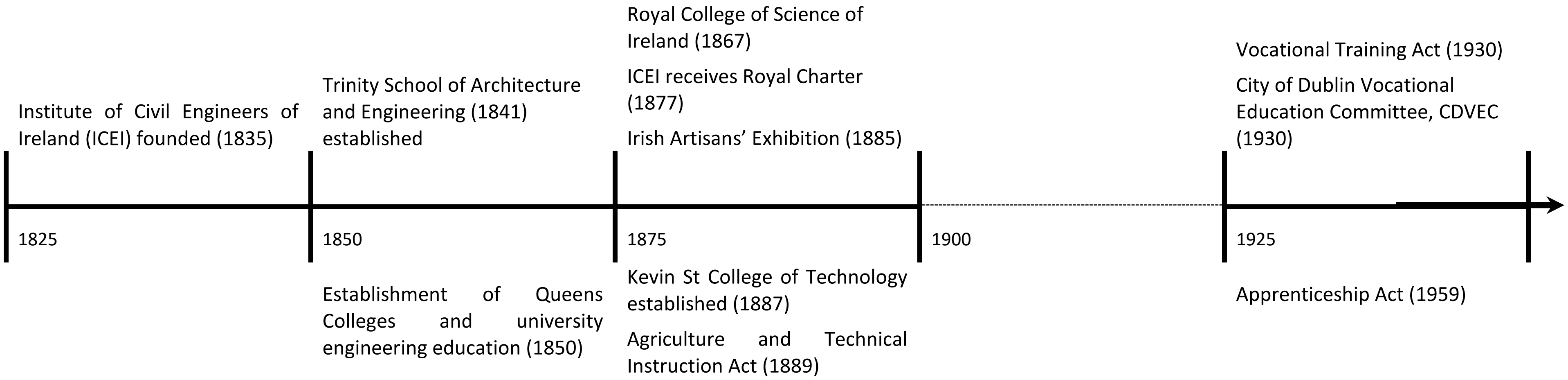

Figure 2-1 A Timeline of the Development of Engineering Education in Ireland Prior to 1950

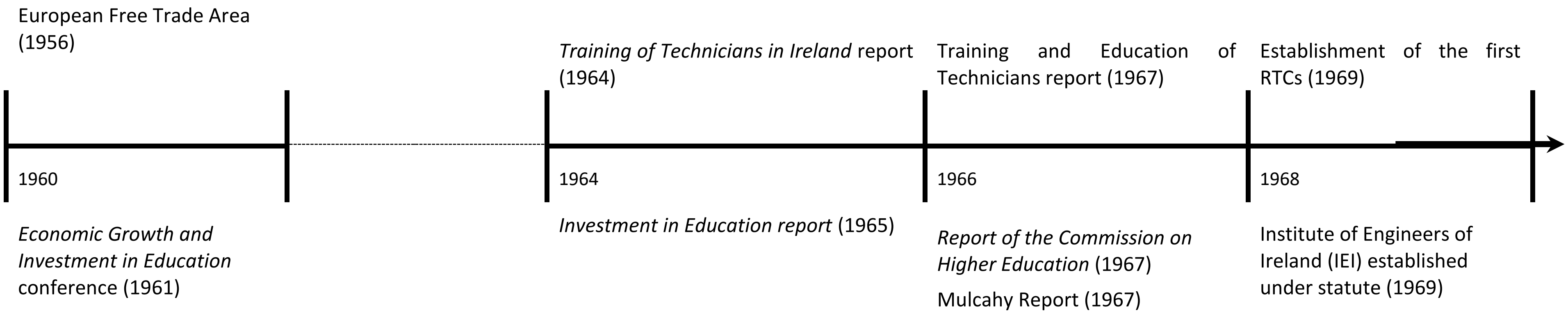

Figure 2-2 A Timeline leading to the Establishment of the RTC/IoT sector in the 1960s

The 1926 commission also led to the Apprenticeship act (1931), which "improved the situation in relation to apprenticeship" (McCarthy, 1977, p. 6). A further Apprenticeship Act (1959) established a National Apprenticeship Board, comprised of representatives from education, employers and employees. The apprenticeship board put in place a formal system of apprentice training, including the stipulation of the minimum educational requirements required to pursue an apprenticeship and a formal examination system, which had, hitherto, not been in place in all trades, and advanced proposals for specialist technical schools for the teaching of trades (OECD, 1964).

2.4.2 Training of Technicians in Ireland (1964)

In the late 1950s and early 1960s Irish government economic policy oriented "away from trade protection and towards export markets" (Barry, 2014, p. 214). This was partly motivated by the need to address the economic woes of the country. It was also influenced by the establishment of the European Free Trade Area (1960), the 1961 Washington conference on *Economic Growth and Investment in Education* (Hyland, 2014; O'Connor, 2014), and the UK's application for European Economic Community membership (1961), which threatened Ireland's preferential access to the UK market. This policy re-orientation (GoI, 1958, 1964; Hyland, 2014), supported by the Industrial Development Agency (IDA), to attract Foreign Direct Investment (FDI) led to a focus on the establishment of new industries.

It was apparent that these new industries required an educated, technically skilled, workforce (Barry, 2014), although what being a technician entailed was not clearly defined or understood in the Irish context (Latchford, 1962; Warren, 1961; White, 2001). Such technology oriented education as there was consisted of university engineering education, primarily accessible to the middle classes (Osborne, 1996)[5], and a parallel, rather small, disparate, Dublin-centric technician training system (GoI, 1965; OECD, 1964) which had not been the subject of coherent national planning (OECD, 1964). To illustrate the small numbers involved, during 1960-63 only 219 students passed the state technician examinations, with relatively small numbers also taking City and Guild technical examinations. In the comparable year 1964, engineering enrolments in the universities totalled 1005 (McGoldrick, 1992).

[5] The participation rate was relatively small however, less than 4% of the over-16 population in 1966 (CSO, 1970).

In order to understand the issues regarding technician education in Ireland, and answering the challenge that "one wonders if our higher educational authorities have the courage to admit that they simply don't know" (Warren, 1961, p. 22), the government, spearheaded by the interest and concern of the Minister for Education, Dr Hillery, commissioned an OECD survey of technician training in Ireland. A major theme of the resulting *Training of Technicians in Ireland* (OECD, 1964) report was that economic advance required a technically competent workforce, and the educational effort this required should be led by the state (White, 2001).

The report proposed that technician education should be "based on mathematics and the physical sciences" (OECD, 1964, p. 88), positioning this education towards engineering. In highlighting the paucity of information available regarding projected technician demand, the report encouraged the *Investment in Education* team (see below) to investigate this aspect.

In keeping with the economic drivers influencing government policy the report "strongly recommended that educational measures should be treated as a fundamental and essential part of economic development" (OECD, 1964, p. 101). A further recommendation, which likely influenced the later decision on the establishment of the RTCs, was that "steps should be taken to give people in western and southern Ireland access to technical education" (p. 106) as was already available in Dublin, where the bulk of existing technician oriented training was concentrated.

The report was received positively, with Dr Hillery remarking that it is "government's policy to make a substantial investment in education […] We intend to make changes, we shall welcome changes, and we are not only willing but eager to have advice on the form some of these changes might take" (OECD, 1964, p. 102). In further support of the report's findings, an influential speech from Dr Hillery announced the creation of the RTCs (Hillery, 1963), "in the belief that they would align technical education provision with manpower needs" (McManus, 2016, p. 278). Although the speech emphasised a post-primary second level role, the RTCs were to form part of a new third level sector, as anticipated in their creation (Dr Hillery, interviewed in Rigney (2009, p. 43)), where suitable candidates could undergo "further training […] for a post as a technician" (Hillery, 1963). The speech was notable for its emphasis on "equality of educational opportunity", which was a "duty of the state", and its view that courses (in business studies) should be "suitable for young women as well as young men". This speech influenced the Irish Government/OECD team preparing the follow-on

Investment in Education report to address the questions raised in the Training of Technicians report.

2.4.3 The Report on Training and Education of Technicians (1967) from the ICEI

The ICEI[6] was also taking an interest in technician education, and in 1967 their council approved the *Training and Education of Technicians* report (Dooge, 2006), which was issued to government to add to the national policy debate (Rafferty, 1968), and informed the later Mulcahy report (GOI, 1967).

Unfortunately it was not possible to locate a copy of the ICEI report itself[7]. However they clearly considered it significant, with a commentary on it constituting one of the cornerstones of the ICEI President's 1968 annual address (Rafferty, 1968), and from which the salient points are reconstructed. Referring to the report, the President echoed the economic considerations influencing national policy, stating that "the shortage of technicians has had the effect of slowing down economic growth" (p. *v*). This shortage entailed that engineers were performing technician work (OECD, 1964), described as "economically indefensible" (Rafferty, 1968, p. *v*), and intellectually draining on the professional engineer.

The ICEI, informed by the *Training of Technicians in Ireland* report, recognised the moves to establish a national certification authority for technicians, but in the meantime proposed to endorse technician awards from approved colleges of technology once ICEI academic standards were being met (Rafferty, 1968). This led to the creation of a new membership category for engineering technicians who met appropriate standards (Dooge, 2006). The ICEI prerogative as the professional body for engineering technicians in addition to engineers was enshrined in the act that provided the ICEI successor, the Institute of Engineers of Ireland (IEI), with its charter (Irish Statute Book, 1969). Thus the ICEI, quite likely influenced by earlier developments in the USA (NAE, 2017), the UK (Heywood, 2016) and elsewhere, adopted, in their capacity as the professional engineering body in Ireland, a stratified approach to engineering education, and this approach was enshrined in the legislation that governed them. Although the new technician education system in the RTCs was not yet established, the ICEI successfully positioned itself as an arbiter of standards for Irish engineering technician

[6] The ICEI amalgamated with Cumann na nInnealtóirí in 1969 to form the Institute of Engineers of Ireland (Cox & Callanan, 2006), and was to adopt the use of the name Engineers Ireland from 2005 (Cox, 2019).
[7] EI no longer have a copy, the DIT library, another potential source did not have one, and R. Cox, recommended by EI's registrar due to his personal archive of the history of engineering in Ireland, was unable to source a copy.

education. This positioning was later to play a pivotal role in the introduction of OBE in engineering education in Ireland.

2.4.4 The Investment in Education Report (1965)

In response to the lack of data revealed in the *Training of Technicians in Ireland* report (OECD, 1964), the government commissioned the *Investment in Education* report (GoI, 1965) as part of a pilot study for an OECD international *Education Investment and Planning Programme* (Walsh et al, 2014). In commissioning the report Dr Hillery explicitly linked economic development and education, noted the increased emphasis this was attracting internationally, and indicated the importance this would have in the European context.

This report has been regarded as marking a turning point (Hyland, 2014; O'Connor 2014) towards recognising Ireland's interdependence on the wider world, which "was being transformed through the continual advancement of knowledge" (O'Connor, 2014, p. 193). Re-orientation of the Irish economy was planned through a policy of rapid industrialisation using foreign direct investment, export driven, where education would be "a key facilitator in this transformation process" (Clancy, 2008, p. 123). The report considered the Irish education system through the dual lens of its capacity to meet future needs of industry, but also the societal need to improve access to education. The report was to supply "an adequate basis of relevant information" (GoI, 1965, p. *xxxiii*) to allow for "effective, decisions and policies".

Stark inequalities in Irish education were revealed. Students from semi- and un-skilled backgrounds constituted 25% of the population, but only 2% of university entrants (O'Connor, 2014). Furthermore, a deficit of qualified workers, particularly technicians, was projected for the planned industry expansion, leading to the conclusion of "the need for wider participation […] and for longer retention of pupils in the educational system" (GOI, 1965, p. 390).

Two possible strategies were suggested to achieve this, the first being to increase participation in education in those population groups that were already inclined to participate through "an expansion of the existing structure of education" (GOI, 1965, p. 391). An alternative approach was to re-shape the educational system to enable more equitable access. This would be costlier than the first approach of "expanding upon traditional lines", but would have the advantage of addressing the inequality in the educational system.

The report envisaged a doubling of the technician requirement by 1971 with "a total demand of 5,000 for the decade 1961-71" (GoI, 1965, p. 209). It was suggested this could be tackled based upon a model used in some parts of Europe where there "exist two grades of professional engineers, one with a university degree, the other with a professional qualification below university level". This signalled the intention to adopt a stratified engineering education system to meet industry requirements.

An analysis of programme completion rates, graduate emigration, and other factors, led to an annual entry cohort of 1000 students being proposed to meet projected technician requirements. However, based upon the technical education structures currently available, the report expected a deficit of as much as 75%. The requirement for the expansion of technician courses and places to meet this demand was expected to be met by the already announced RTCs (Hillery, 1963). However, the role of technical education in the state, and the structures and roles of the future RTCs, had not yet been fully developed. This was to be further examined and defined in the Mulcahy report (GoI, 1967).

2.4.5 The Report of the Commission on Higher Education (1967)

In parallel with these developments, the Commission on Higher Education had been deliberating since 1960 to review and make recommendations into "university, professional, technological" (White, 2001, p. 42) and other aspects of higher education. In contrast to the *Investment in Education* report, which has been described as "the foundation document of Irish Modern Education" (Clancy, 2008, p. 124), the commission's report, published in 1967 amid criticism for the delay (Dáil Éireann Debate, 1966; White, 2001), had little impact (Coolahan, 1981). Its focus on societal and personal developmental aspects of education, and the view that higher education should "be looked upon as a good in itself" (White, 2001, p. 44), was out of step with the economic drivers that were on the ascendancy (Clancy, 2008).

The commission considered universities unsuitable for technological education (Osborne, 1996), concerned the required expansion would affect their "essential nature and functions" (CoHE, 1967a, p. 27). This can be interpreted as the commission rejecting the instrumentalist view of education (Young, 2008) that had arisen in government, instead wishing to continue with a "neo-conservative traditionalism" (p. 19) in which the identity formation of students would be determined by a traditional approach to curriculum (White, 2001).

Whilst conceding that university engineering education was linked to technology, it considered the requirement that technician education be firmly linked to industry was not something that universities "should be asked to assume [...] and […] would not wish to assume" (CoHE, 1967b, p. 184). It was not that the commission did not recognise the growing importance of technical education and the importance of industry requirements, it was just that they considered it not for the universities (Osborne, 1996).

The government interpreted the report as positioning the universities as elitist organisations with little role in economic change (White, 2001, p. 50), and uninterested in providing technological education (Dr Hillery as interviewed in Rigney (2009)). Its proposals for technical education, the establishment of a Technological Authority and a new type of higher level institute, the New Colleges (Osborne, 1996) to focus on technical education (CoHE, 1967b; White, 2001), were rejected; instead the path to the already planned RTCs continued.

One important outcome from the commission was that it identified the lack of coordination and coherency in planning for 3rd level education in Ireland, and suggested in future there should be a unified approach to its development (Osborne, 1996). This led to its recommendation for the establishment of the Higher Education Authority (now part of the governance of the contemporary Irish higher education system).

2.4.6 The Mulcahy Report (1967) and the Creation of the RTCs

The steering group on technical education was established "to advise the Minister generally on technical education, and to provide the Department of Education Building Consortium with a brief for the technical colleges" (GoI, 1967, p. 5). In addressing this brief they were asked to "harmonise with any future thinking on third level technical education".

The report envisaged that the "long term function of the colleges will be to educate for trade and industry over a broad spectrum of occupations ranging from craft to professional, notable in engineering and science, but also in commercial, linguistic and other specialities" (GoI, 1967, p. 11). However, in the short term they would focus on "courses aimed at filling gaps … in the technician area". Technicians were regarded as an "intermediate position between the craftsman and professional" (p. 16), and some demand was envisaged from technicians and other graduates who may wish to further their education to gain professional qualifications.

The Mulcahy report took issue with the recommendations of the Commission on Higher Education regarding lower entry standards into, and restricting the classes of awards from, the new 3rd level institutions. The report stated that "we do not agree with the Commission's view" (GoI, 1967, p. 27), being concerned that it might create "an undesirable dichotomy".

The report's recommendations included: the establishment of the RTCs; the creation of the regional vocational educational committees; the establishment of the National Council for Educational Awards (NCEA) for the setting of standards, the approval of programmes, and the awarding of certificates and diplomas. These recommendations, which built upon prior ministerial announcements, the *Training of Technicians in Ireland* report and the *Investment in Education Report*, were "largely adopted" (White, 2001, p. 58) as government policy.

The government moved quickly to implement this policy, opening RTCs in 1969 in Athlone, Carlow, Dundalk and Waterford, albeit with low student numbers to begin with. By 1977 nine RTCs were in place, with the remainder following in the 1980s (Osborne, 1996) (with the exception of ITB, created in 1999). In parallel the Dublin Institute of Technology (DIT) was established in 1978 on an ad-hoc basis (formalised under legislation in 1993) from the merger of the CDVEC higher education colleges (Duff et al, 2000).

2.5 Engineering Education in the IoT Sector.

Moving forward past the national policy discussions, analysis and planning in the 1960s that led to the establishment of a binary higher education system and the development of the RTCs, what sort of engineering education resulted, and how has it developed?

The universities were left to one side in the expansion of higher education in the 1970s through the creation of the RTCs (White, 2001). However they were, from the late 1970s, to commit, through an alignment with "government's priorities in higher education", (Coolahan, 1990, p. 11), to technological education, with government recognition of this leading (White, 2001) to full-time engineering undergraduates in the universities rising from 2891 in 1981 to 4373 in 1991. I myself enrolled in 1983 on an electronic engineering course in UCG created in 1979 as part of that expansion (IEI Western Region, 2000). The universities offered bachelor degrees in engineering, as well as master's degrees and PhDs. The DIT spanned all levels of the engineering education spectrum, including technician, professional degree, and postgraduate engineering education. They were also the principal provider of apprentice training in higher education (Duff et al, 2000), a role shared with the RTCs.

The RTCs, through the Mulcahy report (GoI, 1967) were given the brief that, "to ensure their most effective contribution to the needs of society and the economy they must be capable of continuing adaption to social, economic and technological changes" (p. 11). It was acknowledged that the courses on offer would change over time to facilitate this adaptation, with the author's foreseeing "no final fixed pattern of courses in the Colleges" (p. 11). This brief was taken on board in the implementation of the RTC system, which has evolved from the earlier provision of pre- and post-leaving certificate courses and a largely vocational level of education (as proposed in GoI (1967)) to now offering apprenticeships, higher certificates, ordinary and honours degrees, master's, and PhD's (Kenny et al, 2015).

RTC engineering education focussed on technician programmes (McLaughlin, 1999) to meet industry requirements. Engineering students in the RTCs/IoTs during the NCEA era mainly pursued a ladder-based system of qualifications, consisting of two year national certificates, followed by a national diploma (a further year). Although through the 80s and 90s the RTCs encountered resistance from the department of education and others to overly expanding into degree provision (Thorn, 2018), for engineering diploma graduates two-year honours degrees became available (five years in total for an honours engineering degree) (McLaughlin, 1999). Provision of sub-honours degree offerings was particularly cost-effective, whilst strongly contributing to the needs of technology led industry as it expanded through FDI (Barry, 2005, 2007). Technicians were educated and trained for well-defined roles, being considered so important that a further higher education tier, the National Institutes of Higher Education, was established, partly with the purpose that technologist and technician roles should be "'status carrying in their own right" Clancy (1993) as cited in (Barry, 2005, p. 13).

Some of the RTCs adopted particular engineering specialisations, focussed around their remit of supporting their local region, e.g. polymer technology in Athlone, precision engineering in Sligo (McGoldrick, 1992), and aerospace engineering in Carlow. In the present day the main branches of engineering offered by the IoTs are in areas related to mechanical (eleven), electronics/computer engineering (eleven) and construction studies (ten)[8]. Additional

[8] Source the web-sites of the Institutes of Technology

specialisations include agricultural engineering (IT Tralee), chemical engineering (Cork Institute of Technology) and manufacturing (Cork Institute of Technology and IT Tralee).

State investment led to the number of engineering graduates increasing by 40% between 1978 and 1983 (Barry, 2007). Engineering students comprised 30% of new entrants to the RTC sector in 1980, and 25% in 1998, showing the engineering focus of the institutes. The 1980s and 1990s engineering enrolments showed that the RTC/IoT sector met government objectives of meeting industry demand for technicians (Clancy, 2008). As measured in 2016-17, the IoTs continue to contribute strongly to engineering education, where the 10217 full-time undergraduate enrolments represented 60% of national enrolments in engineering programmes (HEA, 2016). Furthermore, the IoT sector holds a dominant position in part time engineering provision, with 85% of all enrolments (HEA, 2016).

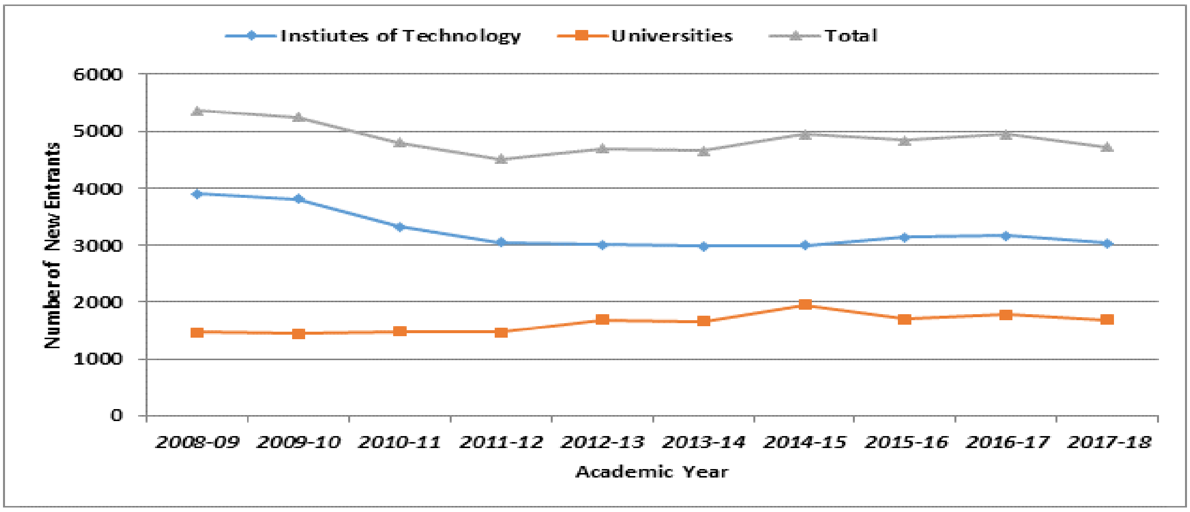

Figure 2-3 Number of Full-Time New Entrants to Higher Education in Engineering

An analysis of new entrants to engineering programmes over the decade 2008-2017 (*Figure 2-1)* based on HEA (2021) data, points towards somewhat of a failing in more recent government policy (DES, 2016) to increase the number of engineering graduates. There has been a decline in the overall number of new entrants to engineering programmes (to 87%) in higher education from 2008-2017, with new entrants to the IoTs declining to 78% of the 2008 figure.

This drop is accompanied by a significant change in the percentage of IoT students pursuing full-time level 6/7 (technician level engineering s) vs. level 8 (honours engineering) programmes. *Figure 2-2* shows enrolments in level 6/7 programmes represented 70% of the total in 2008-09, but only 45% in 2017-18, with honours degree enrolments increasing from

30% to 55% in that period. This shows a dramatic structural shift in full-time IoT engineering education, with level 8 programmes now having the most enrolments.

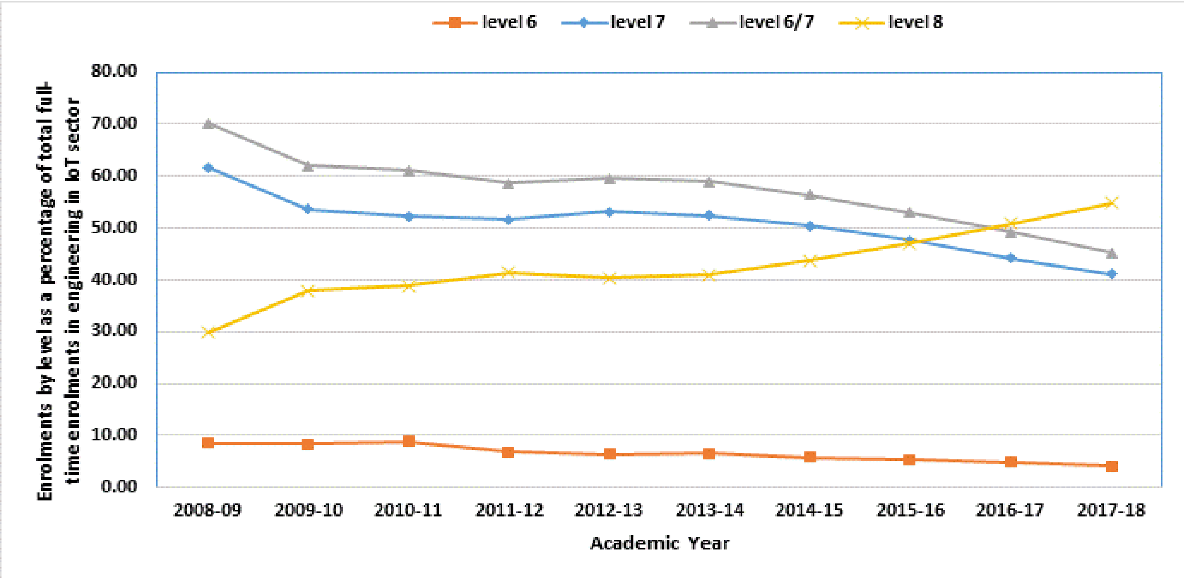

Figure 2-4 Full-Time Engineering Enrolments in the IoTs

A complementary perspective is provided by considering part-time enrolments (*Figure 2-3*), where level 7 programmes remain the most popular offering nationally, mirroring my personal experience as an engineering educator involved in part-time programme provision.

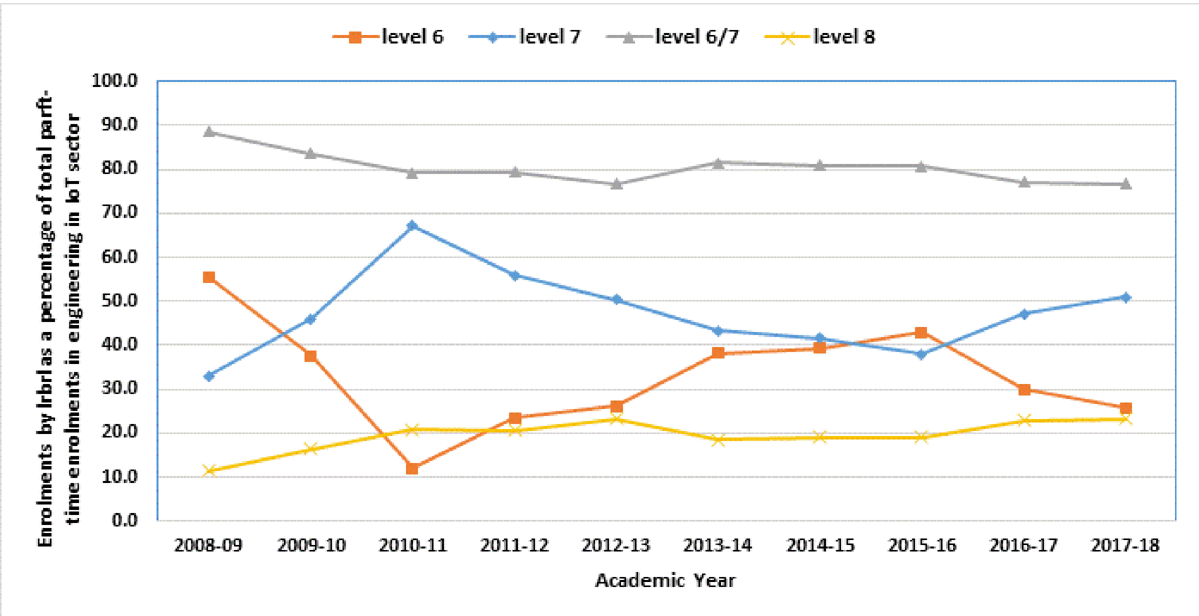

Figure 2-5 Part-Time Engineering Enrolments in the IoTs

This can be explained in that the majority of part-time engineering students are seeking to further their career, with industry funding and encouraging education for employees that furthers its business interests (Davies, 2008). Part-time level 8 honours degrees are important (some 413 enrolments in the IoTs in 2017-18) but to a lesser extent.

Barry (2007) suggests that Ireland's increasing affluence has promoted a preference for university programmes, which implies a corresponding increased interest in IoT honours degrees. It can also be argued that this is driven by the knowledge economy (OECD, 1996), where students see the benefits of engaging in longer programmes of study (Skilbeck, 2003). As will be shown later, it may also be partly an artefact of the NFQ concept of progression.

Notwithstanding the type of qualification that an IoT engineering graduate attains, as part of their education they will have received considerable practical training, in addition to having knowledge of engineering theory, and its application in practice. An IoT engineering graduate is expected to hit the ground running, whether in a technician role or in a professional engineering role. Indeed, Ireland's well-educated engineering workforce has helped attract inward investment, particularly in the electronics and software industries (Bruce, 1997), for which the IoTs can take considerable credit (McLaughlin, 2001). A comparable university graduate would have a more theoretical base, with less emphasis on engineering practice.

As I will explore later, do the structural changes discussed above reflect a shift from technician education to professional engineering education in the IoT sector, or is something more complex occurring? What are the implications for the stratification of engineering education and on the identity of the graduates being produced, who at level 8, would be expected to be more theoretically informed than in the past? How is this affecting the academic identity of the engineering faculty engaged with the development and delivery of these programmes?

2.6 The Role of Engineering Academics in the IoTs

A dichotomy of academic identity and profile amongst IoT lecturers was observed by O'Byrne (2009), focussing around the changes in the role of the IoTs towards adopting a research profile and beginning to teach higher level degrees, as formalised in the 1992 RCT act (Irish Statute Book, 1992). Those recruited pre-92 tended to have more industrial experience, be more concerned with teaching and imparting their experience to the students, have a pastoral care element to their professional identity, and had a relatively low level of interest in research. She found that they "feel that teaching must focus on the 'real' world in which the students will ultimately be expected to operate and be industry-led" (O'Byrne, 2009, p. 92.7).

Those recruited post-92 tended to have post-graduate qualifications, be more interested in research, and to lead and actively participate in course design. O'Byrne (2009) comments that:

> the relatively simple, predominantly teaching-based identity which was developed by lecturers who worked in the Regional Technical Colleges prior to the 1992 RTC Act seems to have been replaced by a more complex and multi-layered professional identity built around a combination of roles in teaching, research and administration (p. 92.4).

Edström (2017) reported a similar dichotomy of engineering academics to that observed by O'Byrne (2009), but also views that we need some academics who "can simultaneously defend both the academic and the professional values" (p. 84) of engineering.

The IoT lecturer role consists of ten duties (TUI, 2016a, 2016b), where, however, the "majority of existing academic staff within the IoT sector have been employed to teach", (Hazelkorn & Moynihan, 2010, p. 194). Indeed, the Senior Lecturer position is explicitly named 'SL (Teaching)'. Despite this emphasis, teaching qualifications are not required for IoT academics, and the majority do not hold one (Donnelly, 2008), although the desirability of holding postgraduate qualifications is recognised and linked to promotion (DES, 2005). I will return to this important point regarding training in pedagogy in the fieldwork and the discussion.

Although one of the duties of a lecturer is to engage in research and consultancy, not all lecturers are research active. Establishing research programmes in the IoT sector (O'Byrne, 2011) is not a straightforward process, with restrictions including funding, teaching hours, and "the lack of a reward structure for researchers", (p. 21) making becoming research active a difficult experience. Indeed, as a new IoT engineering academic I engaged in application focussed research (Carroll & Gallery, 2006; Gallery & Shakya, 2004; Gallery et al, 2009), graduating three research masters students. However, as research funding dried up in the post-Celtic tiger collapse, and my HoD duties became more demanding, I found it difficult to find time to be research active, prior to more recently commencing my doctoral studies.

Nevertheless, the institutes are increasing their research profile, and delivery of postgraduate programmes, with Moynihan (2015) identifying that engineering academics in particular felt increased pressure to carry out research. This increased research emphasis brings with it pressure to recruit new academic staff with PhD qualifications, and is gradually leading to a diminution of the level of industrial expertise of the academic staff of the IoTs. This may have longer term implications for the industrial relevance of IoT programmes (Hazelkorn &

Moynihan, 2010), which has always been a strength of the sector, with Beagon (2018) reporting that there is evidence to suggest that engineering academics with industrial experience place a higher value on professional skills, including technical skills.

On becoming an IoT engineering academic in 1999 I embraced this emphasis, seeking to relate the theory and practice I was teaching to my industry experience, to the benefit of my students. I noted previously that, on graduation, and as an early career academic in UCG in 1988, I had felt somewhat isolated from engineering practice. This prompted me to move from academia to Philips Research laboratories (Walling, 2005), where I gained the industry experience which firmly situated me as an engineering practitioner (Gallery, 1999a, 1999b; Gallery et al, 1992, 1999; Gallery & Ballesty, 1999; Gallery & Bliss, 2000; Gallery & De Bruyn, 2002; Gallery & Kuijpers, 2003; Gallery & Trew, 1992, 1994, 1997). In commencing lecturing as an IoT academic to our first year students, I distinctly recollect an epiphany as I related what I was teaching to how I had approached a problem in industry. In doing this I suddenly recalled my doubts regarding my ability to lecture on what I felt was real engineering in UCG post-graduation. I was now teaching my students with confidence about how, as a practicing engineer in industry, I had approached using the technology I was lecturing them about.

However, the conditions laid out for an IoT consortium to become a technological university (Irish Statute Book, 2018) include a requirement for a minimum percentage of postgraduate research students, further shifting the staffing emphasis from industrial experience to research. Other pressures on engineering academics (Kelly, 2009, 2010) include economic pressures, the changing needs of society (the drive towards more knowledge based business/industry), increased competition from universities, accreditation requirements, and increased QA requirements (including the use of LOs). Results of a survey (Kenny et al, 2015) indicated that academics felt pressure from being asked to perform more administrative work, which they considered non-productive in relation to their academic responsibilities.

A particular concern raised by Kelly (2005) was that lowering of academic standards may follow from increased access to education. Kelly proposed that this may lead to lecturers needing to change their pedagogic approach, particularly for mature students, who bring a "challenging dimension to the teaching experience" (p. 217), including "differences in learning styles, interests, attitudes and approaches to learning", all of which must be catered for.

A key contractual role for engineering lecturers is course development (McLaughlin, 1999). The IoTs pride themselves that in their programme development they "develop innovative responses to the needs of society in general and industry in particular" (p. 102). On the establishment of my own institute in 1999 (Irish Statute Book, 1999a) I participated in the development of technician and professional engineering programmes in computer engineering and mechatronics in response to industry and student demand. Later we expanded, under my leadership, into the provision of on-line mechatronics engineering programmes, specifically aimed at those working in industry. More recently the growth in pharmaceutical industry in our hinterland has led to my involvement in the establishment of related engineering programmes, and the demand for skills related to data centre operations has brought about an expansion into programme provision in that area (ITB, 2018).

This course design is now undertaken within the scope provided by the NFQ, and EI's LO based accreditation requirements, which I have earlier reflected on my role in promoting. The requirement that all higher education programmes be validated within the framework has been categorised as an aspect of quality assurance (Kelly, 2009; Kenny 2009), and a "diversion of academic time away from academic issues" (Kenny 2009, p. 38). Although I question the use of qualification frameworks, I argue strongly that such use is principally an academic rather than a QA issue, the implications of which go way beyond an added administrative overhead. Nevertheless, there is no disputing that the use of LOs brings additional workload:

> course leaders must adapt to this language of outputs and standards, must learn to work with the requirements of identifying learning outcomes and specifying course objectives, and in the process must produce seemingly endless new reams of documentation about their courses. (Barnett & Coate, 2005, p. 29).

However, we should expect more than just extra work-load from the use of OBE, which, as it shapes the pedagogic discourse (Bernstein, 2000), will have a consequent effect on academic identity. It is not just that there is more to do, staff will move to do things in a different way as their values and identity adapt to new pressures and requirements, as has been suggested happened during earlier changes in the role of the IoTs (O'Byrne, 2009, 2014). Kenny (2010) links the effect on curriculum and pedagogy, asking will "utilising a common language of 'learning outcomes' have any effect on pedagogical practice" (p. 45). This will be considered in more detail later in the literature review, and in the fieldwork.

2.7 Conclusion

I have described what is meant by engineering and differentiated professional and technical engineering and the associated education. In considering engineering from a philosophical perspective, I identified the multi-faceted nature of the epistemological influences. I advanced Bernstein’s characterisation of engineering as a region, inward facing to the knowledge and skills provided through academia, but outward facing to market demand, as a means through which engineering education can be conceptualised and considered.

I reviewed the field of EER, considering it from international, and national perspectives, and illustrated how my research into the impact of OBE on engineering educators and engineering education is positioned to contribute to this important aspect of the field.

I then outlined the creation of the engineering technician education system in the RTCs in the late 1960s, which was associated with the policy goal of increasing economic capacity through the development of a well-educated populace (Clancy, 2015; Garvin, 2004; Osborne, 1996). A further influence was a recognition of inequalities in the education system, and the need to improve access for those from working class backgrounds (Osborne, 1996).

The predominant focus of IoT engineering education since its creation was on the provision of two and three year technician programmes. In more recent years there has been a dramatic change, to where the majority of full-time enrolments are now on honours degree programmes. This structural change raises questions regarding the stratification of engineering education and the identity of the graduates being produced. It further raises a question as to the effect on the academic identity of IoT engineering educators, who experience pressures related to increased emphasis on research, the moves towards the creation of technological universities, increased administration and QA requirements, and in particular the introduction of OBE for engineering education in the IoTs.

In the next chapter I will consider the conception and aims of OBE, and how it has attained such a prominence internationally, in particular in engineering education. I will then discuss the aims, development and implementation of the NFQ, alongside the parallel adoption of an OBE approach for engineering accreditation by EI, in order to understand the contemporary context within which IoT engineering academics deliver an education to their students.

Chapter 3 Outcomes Based Engineering Education

In the world of engineering education [...] it is difficult to raise questions about the phenomenon of outcomes-based assessment.

Donald Woolston (2008, p. S4G1).

3.1 Introduction

The use of learning outcomes (LOs) is now firmly established in engineering education in Ireland. There are two pillars to this: our National Framework of Qualifications (NFQ) which mandates an outcomes based education approach (OBE) for higher education in Ireland; and the parallel adoption by Engineers Ireland (EI) of an OBE approach for accreditation.

In order to consider how this has arisen, I describe the origin and global rise in the use of OBE, and I discuss why National Qualification Frameworks (NQFs) are attractive to those developing and implementing government educational policy from an instrumental, industry focussed, economic viewpoint, but also from one in keeping with the concept of a learner centred education. I then describe how engineering education internationally has adopted OBE for accreditation, beginning with, and influenced by, the decision by ABET, the USA accreditation body, to fundamentally re-cast its accreditation approach as a LOs based one.

I then return to the national context, reviewing the policy basis (including European influences), development, structure, and implementation of the NFQ from an engineering education perspective, including a critique of its pedagogical basis. I discuss EI's parallel adoption of an OBE approach to accreditation, influenced by European developments and international accords. As a further manifestation of the influence of OBE on IoT engineering education, I show how the Bologna process to develop a European higher education area was interpreted by EI as requiring a change to the educational requirements for Chartered Engineer, resulting in structural changes in Irish engineering education.

3.2 The Development of the Learning Outcomes Concept

The conception of LOs can be traced through Taylor's time and motion studies (Allais, 2014) and the development of the scientific curriculum (Bobbit, 1918). The scientific curriculum was to be discovered, rather than developed, by the "curriculum-discoverer" (Bobbit, 1918, p. 11) through observing practitioners in the field, distilling the things that they do, the knowledge that they employ, the judgements that they make, the skills that they have etc. This allowed the establishment of educational objectives, or LOs, for carrying out these tasks. Education was to focus on "actual-life situations, a task distinctly different from the cloistral activities of the past" (Bobbit, 1918, p. 10). Tyler (1949) similarly proposed designing curriculum and instruction around assessment of educational objectives, emphasising studying real-life situations in curriculum design. Tyler proposed evaluation of educational objectives as a means of: curriculum planning and review; influencing what is to be learned; monitoring student performance and making consequential adjustments to what is taught; and evaluating the school.

Tyler assisted in the development of Bloom's (1956) taxonomy, where Bloom links curriculum development firmly to the ideas of Tyler, focussing on student achievement of learning objectives. Bloom's taxonomy orders cognitive skills in a hierarchy of 6 levels, from low level cognitive acts such as recall of knowledge, through increasingly more complex levels of mental ability, the highest being evaluation:

1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation (Bloom, 1956, p. 18)

Blooms taxonomy became very influential since its development in the 1950's, and is now considered part of "mainstream educational thinking" (Allais, 2014, P. 32). The widespread adoption of Bloom's taxonomy does not seem to have occurred due to deep engagement with his ideas, but rather, can be traced to the provision of substantial increased USA federal funding in the 1960s for childhood education. This led educational institutions in the USA to adopt the use of Bloom's taxonomy, in tandem with Tyler's concept of educational objectives, to design curriculum that could be used to meet government reporting requirements (Marzano & Kendall, 2006; Munzenmaier & Rubin, 2013).

3.3 The Rise of National Qualification Frameworks

Qualification frameworks incorporate the LOs approach in a hierarchical framework within which qualifications can be mapped, and compared. The UK NVQ framework, the first of the outcomes based NQFs (Young, 2008), incorporated a competencies and levels approach that was hugely influential as NQFs became a global phenomenon (Allais, 2014; Heywood, 2016), including for the European Qualification Framework (EQF) (Clarke & Winch, 2015).

Although developed for vocational education, Jessup (1991), one of the chief architects (Cort, 2010) of the UK NVQ framework, argued for the applicability of its outcomes based approach to all forms of learning (Heywood, 2016; Young, 2008). The NVQ incorporated the concept of a hierarchical arrangement of LOs across five levels (Jessup, 1991). Competencies to be achieved by the learner become more demanding as the level increases, with increased "breadth and range of competence; complexity and difficulty of competence; requirement for special skills; ability to undertake specialized activity;" (p. 20). The NVQ's primary purpose was "to facilitate transfer and progression" (p. 20), allowing awards to be grouped together at levels reflecting similar competency. Differentiating it from earlier LO models, including Bloom's, Jessup stated that: "a crucial aspect of the new model is that assessment is regarded as the collection of evidence from any relevant source" (p. 145). This concept that learning outside the classroom can be evaluated through a qualification framework, facilitating access (Young, 2003) was influential in the development of the NFQ (NQAI, 2003a).

Bloom's taxonomy is used to link the concept of educational objectives with that of the hierarchical structure of qualification frameworks (Allais, 2014), where it is commonly used as part of the design of LOs. In this approach 'verbs' from the taxonomy are used to provide the basis for LOs. Modules mapped to lower levels of a framework use verbs drawn from, for example, the *knowledge* and *comprehension* levels of Bloom's taxonomy, whereas verbs from *synthesis* and *evaluation* might provide the basis for LOs of final years of honours or master's degrees (Kennedy et al, 2006). However, different disciplines have their own logics and terminology (Young, 2008), and the taxonomy does not supply such context (Allais, 2014). As an engineering educator I find the application of the generic hierarchy of cognitive abilities from the taxonomy to engineering problematic, a concern shared by Heywood (2016), who considers the taxonomy may not be suitable for all aspects of engineering education. Furthermore, QQI (2013) sound a note of caution, stating that "taxonomies […] can help to express intended LOs. However, when such tools are inappropriately used or slavishly applied they can do more harm than good." (p. 16).

The development of various types of NQFs commenced in the 1990s, leading to the establishment of the Scottish Credit and Qualifications Framework in 2001, the South African

Qualification Framework (SAQA) in 1998, the New Zealand Qualifications Framework (NZQF) in 1992, and the Irish NFQ in 2003 (CEDEFOP, 2015b). The NZQF was "the first attempt to introduce a unified comprehensive national qualifications framework of 8 levels" (Allais, 2010a, p. 32). The proliferation of qualification frameworks since then is dramatic, as of 2015 over 150 countries implemented NQFs (CEDEFOP, 2015a).

The Irish NFQ is thus part of a transnational inter-related set of developments in which qualification frameworks of various sorts are being developed, established and implemented to influence, change and reconceptualise the delivery of education. In Europe a regional framework, the EQF (EC, 2008a, 2008b), allows national signatories to design and implement their own NQFs, aligned with the "EQF level descriptors (knowledge, skills and competence)" (CEDEFOP, 2015a, p. 10). Europe also has the parallel Bologna framework (ECA, 2020) (see Appendix E), which also promotes OBE. Although, as will be shown later, the Irish NFQ was developed in advance of, and contributed to the discussions that led both to the European Qualification Framework (EQF) and the Bologna framework, the development of the NFQ was in turn influenced by the New Zealand NZQF (Duff, 2011; NQAI, 2002a), which itself was guided by the structure of the NVQ (Priestly & Higham, 1999).

3.3.1 The Attractiveness of OBE as a Policy Instrument

The proliferation of NQFs is considered a consequence of neoliberal influenced educational policies, and the expansion of higher and further education (Young, 2003). An NQF can be attractive from a policy perspective (Young, 2008) for the following reasons: providing flexible qualification types in keeping with the needs of a modern economy; to facilitate learners to engage with life-long learning; and improving equity of access to education and ameliorating the effects of the stratification of knowledge in education systems by making it feasible for anyone to progress to the highest level of qualification. Further perceived advantages can be that the use of an NFQ may not disrupt "existing privileged routes to university" (p. 230) and provides employers an increased say in what was to be taught.

In support of these aims, OBE related policies garner support from what appear to be diametrically opposed viewpoints (Allais, 2014). Commercial interests seek skills-oriented, job ready, graduates (workers), painting subject based curriculum as "out of touch with the needs of industry" (p. 27) and "contributing to industrial decline". LOs are seen as facilitating a curriculum which, through mapping objectives to real-world tasks, ensures the job-readiness of graduates. However LOs are also associated with learner centred education, where a student's education proceeds at their own pace, choosing what they want to learn and when to learn it, building upon their knowledge of their everyday world (O'Neill & McMahon, 2005).

A learner centred education emphasises learning rather than teaching, with the teacher as a facilitator (Collins & O'Brien, 2011). Although this can be traced to various influences (O'Neill & McMahon, 2005, Allais, 2014), it is often associated with Dewey (1907), who proposed that the learner become "the centre around which" (section *51*) education is organised. This positioned a learner-centred approach as a progressive move to replace the medieval concept of learning as a passive act (Allais, 2014).

Learner centred education encompasses a continuum of teaching and learning possibilities, incorporating more student choice, involvement, and control over their own education (O'Neill & McMahon, 2005). Some advocates regard pedagogy as the learner-centred aspect, with curriculum defined through the knowledge associated with the discipline (Allais, 2014). However, others advocate a constructivist view (Attard et al, 2010; O'Neill & McMahon, 2005), where both the curriculum *and* associated knowledge are learner centred (Allais, 2014). Attard et al (2010) regard there to be two parameters to learner centred education: the use of innovative teaching approaches which focus on how best the student may learn; and the use of LOs, where the focus of education moves from the teacher to what the student can achieve (O'Neill & McMahon, 2005). This encompasses a shift in the power relationship from the teacher to the student (Hodge, 2010; O'Neill & McMahon, 2005).

It is noteworthy that the learner centred concept often appears alongside that of LOs in government policy (Allais, 2014), as in the development of the NFQ (GoI, 1992, 1995; NQAI, 2003a) where a skills agenda was driven alongside "the holistic development of the individual" (GoI, 1995, p. 5). As I discuss later, the presence of these disparate views of the purpose of education in a LOs system may create tensions, with consequent pedagogical implications (Muller, 1998).

Raffe (2009) proposed there are three types of NQF. A communications framework seeks to support an existing system of qualifications, providing "tools for change but does not try to drive change directly" (Raffe, 2013 , p. 148), e.g. the Scottish SCQF (SQA, 2017). A transformative framework can be used where a new system of qualifications is envisaged, e.g. the South African National Qualification Framework (SAQA, 2017), conceived in the post-apartheid state (Allais, 2014, p. xvi). A third type, a reforming framework, combines aspects of the communication and transformative frameworks. Similar to a communications framework, it starts with the existing education system, but will have “specific reform objectives” (Raffe, 2009, p. 5) (e.g. support for progression, quality assurance), and, consequently, will be supported by legislation and related statutory agencies e.g. the Irish NFQ.

Related policy objectives (Allais, 2010b; Bjornavold & Coles, 2010) include:

- comparison of different qualifications, nationally and internationally;
- consistency of qualifications across providers;
- transparency through programme LOs, as to what constitutes a qualification, for graduates and their employers;
- facilitating stakeholder engagement;
- formal certification of prior experiential learning through the mapping of a person’s work experience, training and general accumulation of knowledge onto the framework;
- promoting a student-centred learning approach;
- aligning a programme with labour market demands through LOs related to the role it is envisaged graduates will fulfil;
- facilitating transfer of students between educational institutions;
- serving as a basis for quality assurance (QA) of programmes;
- providing clear indication of progression opportunities for students;
- as a mechanism to implement policy initiatives and reforms.

Contradictions arising from NQF associated policies have been reported: Havnes and Prøitz (2016), in discussing OBE, regard “policy and pedagogy as potentially conflicting frames of reference” (p. 220); Fernie and Pilcher (2009) question whether “intended and unintended consequences” (p. 227) have been fully considered. A key contradictory aspect arises between the policy emphasis that educational programmes should meet the needs of the knowledge economy, vs. the emphasis on skills, and the consequent downgrading of knowledge that is associated with NQFs, leading to ”narrow qualifications without theoretical components” (Allais, 2010a, p. 12). In the case of the NFQ, as will be seen, many of the policy drivers discussed above are evident, sometimes with associated contradictory positions.

Young (2008), although quite critical of OBE, does not fully reject qualification frameworks from a policy perspective, but considers that they can only achieve a small part of the policy objectives with which they are associated, unless the larger problems they claim to be able to solve are addressed comprehensively. For example, the concept of allowing students to progress from one qualification level to the next only is meaningful if the higher value job or professional opportunities these higher level qualifications claim to lead to are put in place. As will become clearer later, this has particular ramifications for IoT engineering education, which I will explore through the fieldwork and in the discussion chapter.

3.3.2 Quality Assurance and National Qualification Frameworks

I believe that both HEI administrators and academics often lose track of what is meant by QA for higher education, which I consider should fundamentally be about supporting and enhancing academic programmes. However, this view is not universally shared (Fitzsimons, 2017a), for example from the perspective of someone concerned with managing a QA system, quality can be categorised as "the distinguishing characteristic guiding students and higher education institutions when receiving and providing higher education" (ESIB, 2002, p. 12). On the other hand, from an academic perspective, QA may be regarded as an administrative overhead (Kenny, 2010), whereas in fact it may be deeply effecting how and what we teach our students. A critical point is that one's view of what QA is for can lead to the fundamental question of "the purpose of higher education" (ESIB, 2002, p. 10).

In Europe QA is associated with the Bologna declaration (European Ministers of Education, 1999)[9] and the moves to create a qualification framework based European higher education area (Fitzsimons, 2017a). QA of higher education in Europe is based on European standards (ESG, 2015), which were explicitly created to support OBE. In considering QA's role in supporting NQFs, its origins in the marketplace (ESIB, 2002; Fitzsimons, 2017a) raises the likelihood of this taking an instrumentalist turn, rather than supporting the student centred approach promised by some advocates of LOs (Fitzsimons, 2017a). Indeed it is considered that a principal aspect of QA for qualification frameworks is "ensuring that intended LOs have been assessed and met when qualifications are being awarded" (Murray, 2013, p. 7). Thus QA in European higher education, measuring and reviewing compliance with the NQF approach, is a key aspect of supporting the economic focus of OBE (Fitzsimons, 2017a).

[9] See *Appendix E*

3.4 The Adoption of OBE based Accreditation for Engineering

In addition to the pressure experienced from the proliferation of NQFs, a further critical driver for the use of OBE in engineering education (Heywood, 2016, Matos et al, 2017) is the global move towards LOs based accreditation. This first arose in the USA, where their national engineering accreditation body, ABET (2018a), accredit both engineering technician (ABET, 2018b), and additionally professional engineering (ABET, 2018c) programmes.

Many USA employers in the 1990s considered engineering graduates lacking in design capability and manufacturing knowledge, and weak in innovation and teamwork (Prados et al, 2005). In response ABET's president, highlighting concerns of leading engineering educators (Prados, 1992), called for "fundamental change" (p. 1) in engineering education, to be supported by a new, radical, accreditation approach, realised through LOs.

ABET's subsequent review of their accreditation process, centred round a series of stakeholder workshops in 1994-95 (Prados et al, 2005), led to the recasting of ABET accreditation criteria around "a limited set of education objectives for any engineering program" (ABET, 1995, p. 6), devolving responsibility for details of these objectives, and curriculum content, to the educational institutions. Following pilot evaluations, EC2000 (ABET, 1998a), an OBE accreditation system, became mandatory (Prados et al, 2005). OBE accreditation criteria were also developed for USA technician programmes (ABET, 1998b), a sector where ABET are extremely influential, whilst not totally dominant (Frace et al, 2016).

ABET view OBE accreditation as a success, with a review in 2006 stating that "the implementation of the EC2000 accreditation criteria has had a positive, and sometimes substantial, impact on engineering programs, student experiences, and student learning" (ABET, 2006, p. 12). McCullough (2007), however, is critical of ABET's review for relying upon a (self-reporting) methodology which ABET themselves rejected as unsuitable for accreditation. The ABET report highlights graduates "better understanding of societal and global issues, their ability to apply engineering skills, group skills, and understanding of ethics and professional issues." (p. 13). An increase in interest in development of teaching and learning capability was identified in academics, which was thought to be partly driven by faculty seeking to better understand how to conduct assessment. Indeed, the engineering education literature contains a generally positive view of LOs (ABET, 2006; EI, 2014; Froyd et al, 2012; Owens, 2016a). Given ABET's role as a key professional engineering body for USA engineering, it would be expected to play a significant role in bringing about the acceptance by engineering educators of the use of LOs (Young, 2008). EI have a similar influence on Irish engineering educators, which I will explore in depth in the fieldwork.

ABET consider they provide "world leadership" (Milligan, 2014, p. 6) in engineering education, which alternatively has been described as a 'colonial' project spreading neoliberal views (Matos et al, 2017). ABET's influence is pronounced in international engineering accords (IEA, 2015a, 2015b), agreements of national engineering professional bodies. Signatories mutually recognise each other's accredited graduates, and agree to adopt a LOs approach which "categorise what graduates should know, the skills they should demonstrate and the attitudes they should possess" (IEA, 2015a, p. 14). The encapsulation of ABET's LO accreditation approach in these accords is considered a guiding influence in the adoption, internationally, by engineering professional bodies of LOs for accreditation (Augusti et al, 2011; Heywood, 2016; IEA, 2015b; Memon et al, 2009; Prados et al, 2005) including in Ireland (IEI, 2003).

EC2000, and more generally the use of OBE in engineering education, is not without criticism. Matos et al (2017) see neoliberal influences to the fore in engineering education. Neoliberal influences are also specifically recognised by Akera (2017) for EC2000, but also in terms of how he considers European engineering education is adapting to market pressures. The resultant use of LOs in accreditation can be characterised as reflecting a power struggle over the control of knowledge in engineering. This influences academics perception of knowledge, assessment and their academic identity (Matos et al, 2017), which matters, as my literature review progressed, became key considerations for my research.

Engineering student identity formation (Haase, 2014) can be considered as a series of epistemological transitions (Winberg et al, 2012), and I have a particular regard as an engineering educator for the importance of considering the journey alongside the destination in becoming an engineer. In OBE, the focus of curriculum and teaching is, inevitably, on assessment of whether specified outcomes have been achieved, and what I perceive as an over-focus on assessment, and over-emphasis on skills, concerns me. Of course student identity formation still takes place in such a process, and outcomes cannot be achieved without the journey towards them. However, Riley (2012) speaks of ABET's approach valuing "product over process in traditional engineering education" (p. 6) and Cheville (2016) critiques the OBE approach "which concerns itself primarily with efficiency of means but does not address or question the aims of education" (section *Conclusions*). In my own experience, and others (Adams & Forin, 2013; Socha et al, 2003), we learn much about engineering practice from reflecting on mistakes made as a student, engineering practitioner, and educator. As I will explore later in relation to my research, I fear that in an assessment focussed system this reflective aspect to education might be somewhat lost, although research such as Bowe and Duffy (2010) suggests this can be addressed through explicitly building reflection, alongside LOs, into the educational model.

Similarly, Woolston (2008) rejects the manufacturing input/output model to education resulting from LOs, and decries the increased administrative efforts resulting from EC2000. Indeed, Prados (2004) himself warned of the dangers of an increase in bureaucracy consequent to the new accreditation process, which resonates with earlier discussion of the increased administrative load pursuant from LOs experienced by IoT engineering academics.

A questioning voice confirms the influence the engineering professional bodies are having on engineering education: "the accrediting agencies are having a profound impact on what individual faculty and departments do. That is much time is spent, some would say an inordinate amount of time, by faculty showing how the programme outcomes dictated by the agencies are being met." (Heywood, 2016, p. 286).

3.5 *The Development of the NFQ*

Having reviewed the international context I now move forward to discuss the development of Ireland's NFQ, one of the two pillars of Ireland's OBE based engineering education.

Ireland saw increased state monitoring and intervention in higher education since the 1980s, as government policy sought to reorient it to a more economic focus, under neoliberal influences (Mercille & Murphy, 2015). For example, the *National Development Plan 1994-1999,* which emanated from the National Economic and Social Forum, was tasked with developing "economic and social policy initiatives" (NESF, 1993, p. 29). The 1992 Green Paper on education (GoI, 1992) put forward the view that education was to fulfil the "need to develop students for life as well as work, in a social and economic environment that is rapidly changing" (p. 3), and that it should "prepare young people adequately for work".

The linking of the social and economic good continued in the 1995 White Paper on education

(GoI, 1995), which took the philosophical position that education policy should comprise:

> the articulation, nationally, of a statement of broad educational aims, which focus on nurturing the holistic development of the individual and promoting the social and economic welfare of society, including the provision and renewal of the skills and competencies necessary for the development of our economy and society (p. 5).

This led directly to the development of an NQF to assist with the implementation of a skills focussed educational system.

3.5.1 Teastas, the NQAI, HETAC and FETAC, and the Path to the NFQ

The path to the NFQ was associated in legislative and policy development terms with the moves, reflected in the discussion and announcements in the 1992 Green Paper and the 1995 White Paper, towards replacing the National Council for Educational Awards (NCEA) with Teastas, a new national certification body.

The Green Paper (GoI, 1992) proposed significant changes in higher education, including the establishment of a Council for Educational and Vocational Awards (CEVA), incorporating the NCEA and the National Council for Vocational Awards (NCVA). The NCEA had been created on an ad-hoc basis in 1972 (OECD, 2006) in response to the Mulcahy report (GoI, 1967), to oversee qualifications, being later established on a statutory footing (Irish Statute Book, 1979). The NCEA developed a formal QA system of awards, including processes for examination boards (NCEA, 2001), and periodic programmatic reviews of academic schools and departments (White, 2001). The QA processes associated with the NCEA have been characterised as “important in giving public assurance as to the quality of the work in these new institutions and helped to build their successful public profile” (OECD, 2006, p. 243). The NCVA had been created more recently in 1991 with responsibility for awards in the further education sector (Trant, 2002) and to provide certification of vocational training.

The Green Paper proposed that higher education adopt modularisation and a credit transfer system, which it was expected would facilitate mature students entering third level education, and play a significant role in workplace up-skilling (GoI, 1992). The Green Paper used language strongly suggestive of qualification frameworks. Awards were to be “modular, *graded by levels*[10], and standards based” (p. 116), with “courses at lower levels […] being

[10] My emphasis.

reorganised into potential stepping stones to higher levels" (p. 114) consistent with an NQF approach incorporating levels and progression. The Green Paper also made reference to "accreditation of levels of knowledge, skills and competences" (p. 113), which language was to be retained in the development and implementation of the NFQ.

The concept of an overarching national body with responsibility for awards in higher and further education was further developed in the 1995 White Paper (GoI, 1995), where the Report on the National Education Convention (Coolahan, 1994) was referenced as supporting a "unified National Awards framework" (GoI, 1995, p. 88) of certification. One of the proposed functions of Teastas (previously CEVA) was to be "responsible for the establishment, direction, supervision and regulation of a national qualifications framework" (GoI, 1995, p. 89). The creation of an NQF was revealed as official government policy.

The White Paper also continued the theme of encouraging a modular approach to higher education, which it assumed would "enable mature and part-time students to study for qualifications while remaining in full-time employment" (GoI, 1995, p. 101). Although modularisation is not intrinsic to the use of LOs, it is often linked with them (Adam, 2004), and in Ireland, modularisation, qualification frameworks and LOs all came to the fore in the same time-frame and in the context of the same policy discussions.

Following on from this, Teastas was established first as ad-hoc body (1995) and later on a statutory basis by the Qualifications Act (Irish Statute Book, 1999b). This act created the National Qualifications Authority of Ireland (NQAI) (Teastas renamed again), the Higher Education and Training Awards Council, HETAC (which subsumed the NCEA) and the Further Education and Training Awards Council, FETAC (which subsumed the NCVA) (OECD, 2006). A consultation process regarding the establishment of the NFQ was initiated, with the Minister for Education remarking upon the active role of "the technological sector of higher education" (Dáil Éireann Debate, 26 March 1998). HETAC, FETAC and the NQAI were all later to be subsumed into Quality and Qualifications Ireland (QQI) in 2012, which took on their collective responsibilities (Minister for Education and Skills, 2012).

HETAC now took on responsibility for conferring awards at third level, replacing the NCEA. It had a more overseeing role, with the act allowing the devolution of awarding powers to specified higher education institutes[11]. The replacement of the NCEA by HETAC can be considered through the concept of "community of trust" (Young, 2008, p. 134). It takes time for qualifications to be trusted by society, including by those who seek to attain a qualification, and those who employ or otherwise interact with those who hold them. The replacement of an awarding body by another can damage trust in the old awards and create a difficult starting point for the building of trust in the new awards, a concern raised with regard to HETAC (Granville, 2003; White, 2001). However, the NCEA itself did not have the fulsome support of the RTC sector (Coolahan, 1994; Cullen, 1996; Walsh, 1999). Although the IoTs/RTCs were, by this point, principally concerned with third level programme provision, apprentice programmes they also delivered would fall within the remit of FETAC.

The act created the statutory basis for the NFQ, mandating the NQAI to "establish and maintain a framework [...] for the development, recognition and award of qualifications […] based on standards of knowledge, skill or competence to be acquired by learners" (Irish Statute Book, 1999b, section 7). The NQAI was required to promote standards of higher and further education, and "promote and facilitate access, transfer and progression".

3.5.2 Policy Developments

The decision to develop the NFQ had an immediate influence on government educational policies. Indeed from the vantage of 2005, it appeared to the OECD that "in Ireland the introduction of a national framework of qualifications is the central concept in a comprehensive reform of the qualifications system" (OECD, 2005, p. 35).

A Green Paper on adult education and lifelong learning (DES, 1998) explored the role an NQF would have. Deficits were identified in the recognition of prior learning, and learning in the workplace. The NCVA was praised for its pioneering work in OBE, with modular structures, and transparency through module descriptors, being particularly highlighted. The proposed NFQ legislation was discussed, and described as "a major development for adult education" (p. 103). Amongst advantages it proposed would follow were the facilitation of transparency and the use of standards of educational achievement. A further advantage would be that it would support the use of LOs, which would in turn facilitate the recognition of work-based and experiential learning. A further perceived advantage was that the NFQ would allow

[11] I had a lead role in delegation of awarding authority to Institute of Technology Blanchardstown's (ITB, 2006).

learners from different educational backgrounds to join programmes at levels appropriate to their prior achievement and would allow for multiple modes of assessment.

The follow-on White Paper on adult education, entitled *Learning for Life* (DES, 2000), further discussed the role an NQF would have in regard to adult education. Adult education was seen as a key component of lifelong learning, where citizens of the state were expected to engage in “a continuum of education from the cradle to the grave” (DES, 2000, p. 32). The NFQ was to be “a fundamental ingredient in a comprehensive system of lifelong learning” (p. 155). In particular, the NFQ would facilitate the recognition of informal, experiential and work based learning through the “development of mechanisms” (p. 62) for accreditation of same. The White Paper viewed that “participation by disadvantaged groups in third-level education” (p. 142) would be facilitated by the promotion of access, transfer and progression by the NFQ.

The continuing interest in Irish government policy considerations in lifelong learning, and the role the NFQ could play, is reflected in a contemporary OECD study of the role of national qualification systems in Europe in promoting lifelong learning (OECD, 2005). Themes included the use of NQFs to reform and manage education systems, QA, and recognition of experiential learning. As part of this activity an OECD (2003) report praised the impact they anticipated the NFQ would have on lifelong learning in Ireland, particularly in introducing coherency and flexibility to Irish qualifications, with clear lines of progression. The report noted that the open nature of Ireland’s economy created a requirement for Ireland’s qualification system to reflect international developments, and for there to be “comparability and compatibility” (p. 65) with European qualifications.

3.5.3 European and International Influences.

The influence of European matters on Irish education policy was quite pronounced. In the 1992 Green Paper there was a European dimension to the proposed adoption of modularisation and a credit transfer system, which would facilitate “mutual recognition by different educational institutions of each other’s academic courses standards” (GoI, 1992, p. 187), enhancing student mobility. Duff (2011) links the Green Paper’s discussion on the European context directly to the provisions of the Maastricht Treaty (European Communities, 1992) “encouraging mobility through the recognition of qualifications” (Duff, 2011, p. 4). Duff further regards the treaty as placing obligations on Ireland of “utilitarianism in education, certification and *qualifications framework arrangements*[12]; […] and quality assurance" (p. 5).

European influence was also apparent in the 1995 White Paper (GoI, 1995), which, although it quoted from the Maastricht Treaty that cooperation on European initiatives would fully respect member states control over their education systems[13] also committed the state to participate fully in all European education initiatives;.

Dáil records reveal this European influence continued in the development of the NFQ: in a 1998 debate (Dáil Éireann Debate, 12 Feb 1998), the Minister for Education, Deputy Martin, made clear that on-going significant contacts with the European Commission, reflected a "mutually supportive position" regarding the establishment of the NFQ.

Although it is clear that the EC were aware of and supportive of the development of the NFQ, Ireland's efforts were in advance of overall European developments. The overarching EQF was not proposed till 2005 (Tuck, 2007), by which time the NFQ had already been established and implemented. Ireland was the first country to reference its NQF to the EQF (NQAI, 2009). Indeed, QQI view that "Irish experience of the NFQ has been a strong influence on the evolution of the EQF and Irish experts have been active contributors to a great many policy discussions and peer learning events in Europe" (Coles, 2016, p. 22): see Bergan (2003). Ireland was also a key contributor to the parallel Bologna process to develop a European higher education area (see *Appendix E*), which Duff (2011) considered committed Ireland to adoption of a system of comparable degrees implemented using the NQF approach.

As part of the development process, and in line with OECD recommendations, the NQAI considered international developments. A working paper (NQAI, 2002a) discussed the significance of the Bologna declaration, which, with its concept of first and second cycle degree's (bachelor's and master's) constituted "a partial framework for Higher Education in Europe" (p. 5). It also reviewed NQFs in the UK, Australia, South Africa and New Zealand, the latter being particularly interesting to Ireland due to the comparable size of the countries (Duff, 2011). Of further interest, however, was that the NZQF acted as a "tightly structured

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[12] My emphasis

[13] Vocational training, which OBE was developed to support (Jessup, 1991, Allais, 2014; Heywood, 2016), was an area in which the Maastricht treaty's provisions respecting member states control over their education systems was less strictly adhered to, e.g. a 1995 European Commission White Paper (CEC, 1995) called for "generalising vocational training and strengthening cohesion in the European Union". (p. 21).

system of regulation […] where a single central authority has statutory responsibility for all qualifications, except those of universities" (NQAI, 2002a, p. 2), paralleling the later Irish experience (NQAI, 2003a). This signalled that state control over qualifications was an important factor for the NFQ, as it was previously for the NCEA (Seanad Éireann Debate, 1979).

3.5.4 The Consultation Process

The consultation process leading to the establishment of the NFQ now intensified (Granville, 2003), with the NQAI publishing *Towards a National Framework of Qualifications: A Discussion Document* (NQAI, 2001b), to guide the discussions (NQAI, 2003a). This described how the Qualifications Act (Irish Statute Book, 1999b) would support lifelong learning, the statutory bodies created under the act (NQAI, HETAC and FETAC), and their responsibilities. The principles that would underpin the NFQ were set out, "transparency, simplicity, equality, relevance, comprehensiveness and flexibility" (NQAI, 2001b, p. 9). The document further discussed the processes, policies and criteria that were under consideration for the NFQ.

The document is notable for a lack of specific discussion with regard to the philosophy of education that was being proposed through the NFQ, although the focus on LOs implied both instrumentalist and student-centred approaches. The NFQ would need to "cater for all types of learning and for all learners in a comprehensive way." (NQAI, 2001b, p. 23). However, there was almost no discussion on how this learning might be achieved (as opposed to how it was to be assessed): with the document making over 400 references to 'learning' or 'learners', but only one to 'teaching', where it was anticipated it would be necessary to "adapt curricula and teaching methodologies" (p. 52). The manner in which educational institutions might need to adapt in order to implement OBE was also not addressed in a comprehensive manner, although there was an acknowledgement that the way they provided learning might change.

The importance of professional bodies was considered, particularly their role in setting standards. It was proposed that, where an award certified a recipient to carry out a particular occupation, it should be possible to clearly identify its correspondence with the appropriate professional standards. However, it was proposed this would be done through liaison with the providers of such awards rather than in consultation with the relevant professional body.

Signalling a significant issue that was to arise during the implementation of the NFQ, the document pointed out disquiet regarding the meaning of awards such as certificate and diploma, and highlighted the need to reconsider their naming. The role of employers was discussed, who were expected to have “a large part to play in developing and maintaining the framework” (p. 59), and it was suggested that the framework, through “setting standards for knowledge skills and competence” would have a significant economic influence.

This discussion document, and submissions relating to it made to the NQAI by interested parties (88 published submissions (NQAI, 2001a)), were used as the basis for a public forum in February 2002, hosted by the NQAI, affording the 300 attendees the opportunity to address the issues raised in the discussion document (NQAI, 2001b).

A presentation for the forum summarised the issues raised in the submissions (NQAI, 2002c). This focussed on the principles of the framework (e.g. whether accessibility and progression should be additional principles), and guidelines for its use. However, broader and somewhat contentious issues also came to the fore, e.g. conflicting views on the balance between “the economic and instrumental objectives of education and training” and “broader humanistic ideals of human learning” (NQAI, 2002c, p. 53). This was reflected in views that “employability represents only one aspect of learning” (p. 34) and those that considered “employability vital for framework relevance”. There was also a concern that past awards should not be devalued by the introduction of the framework, which was certainly influenced by the submissions from the Institute of Engineers of Ireland (IEI) and the Heads of School of Engineering of the IoTs.

The IEI (2001a) submission, although generally supportive, expressed concern that the award titles of National Certificate and National Diploma might be replaced, potentially devaluing the contribution holders of such awards made to the economy and multinational companies in particular. They also drew attention to the knock on effect on international agreements that IEI had with regard to such qualifications. The IEI accepted the principles of OBE, explaining that this mapped on to the manner in which it already described the competences of Chartered Engineers, and accepted that these competences could be achieved by a variety of routes. However, their submission raised concern regarding the National Certificate, which it was concerned might get re-classified into further education. The IEI stated that adequate staffing and facilities were essential if academic standards were to be maintained, i.e. outcomes based programmes still required capable educational institutions (Allais, 2014).

The submission of the Heads of Engineering of the IoTs (CoHE IoT, 2001) stressed the importance of maintaining linkages to professional bodies and their requirements. They also advocated the retention of the awards of National Certificate and National Diploma. They further advocated for “a clear description of each standard in terms of knowledge, skill and competence for each level of award so that course designers have a defined learning outcome to target when designing a course” (CoHE IoT, 2001). This is significant in that this approach was later adopted at both generic (QQI, 2014a) and discipline specific level (QQI, 2014c).

An analysis of the submissions (NQAI, 2001a) to the forum reveals almost a complete lack of comment on the pedagogical implications of the framework, or for staff training that might be required. Although only a few submissions commented on pedagogy (4 out of 88), those that did were quite insightful and questioning. These addressed the fundamental issue that the framework was not just a mechanism for implementing awards, but had the potential for significant impact on teaching and learning, and the educational philosophy and the associated pedagogy needed to be thought through. For example, “the learner-centred focus is welcome. It is envisaged that this will have implications for the adult education pedagogical approach” (Connolly, 2001), and “the pedagogic principle set to underpin the overall framework ought to be articulated from the outset” (ITT, 2001). Perhaps the most articulate was a recommendation that “the epistemological and pedagogical positions underpinning the Discussion Document be fully articulated so that there is convergence of understanding before mechanisms for implementation are further developed” (APEL, 2001). These submissions showed an appreciation of the influence the NFQ would have on the pedagogic discourse (Bernstein, 2000), and that this did not appear to have been taken into account. HETAC (2001), in differentiating its role from FETAC’s, suggested that differences in pedagogy between vocational and academic programmes should be considered (Young, 2008).

However, the vast majority of the submissions were silent regarding pedagogy, focussing on the structures of the NFQ, the implications as they saw them for themselves, and for lifelong learning, without considering how the framework might influence the means of education (other than to recognise a focus on assessment). Reports from the forum discussion groups (NQAI, 2002d), and the submission summary (NQAI, 2002c), were similarly silent regarding pedagogy. Collins et al (2009) report that Irish academics felt that the timeframe within which the NFQ was developed limited consideration of pedagogical matters, and that subsequent attempts to debate the pedagogical basis of the NFQ were perceived as resistance rather than constructive dialogue. However, my research has shown that there was indeed adequate time, it was just not regarded as an issue requiring discussion by most stakeholders.

This consultation process was followed by the publication of the proposed policies and criteria that would govern the NFQ (NQAI, 2002b). This also set out the underpinning values and principles, and defined the concepts of standards of knowledge, skills and competences as this related to the framework. An outline of the framework was given, based upon levels (without defining how many), with awards-types mapped into the different levels. The discussion regarding award names was re-visited, making it clear that change was coming, without reaching a conclusion. Despite identifying the confusion that existed regarding exactly what was meant by a certificate award, the document did not address the issue that further confusion might be created by introducing new award names to replace old ones.

3.6 The NFQ Revealed

The consultation process culminated in the publication of the *Outline National Framework of Qualifications* (NQAI, 2003b), which revealed the NFQ as a 10 level framework, and where there had been some renaming of award types, as had been anticipated. The NFQ was formally established by NQAI in 2003 (NQAI, 2003a), under The Qualifications (Education and Training) Act (Irish Statute Book, 1999b), to “control access to the market for education and training qualifications” (QQI, 2017, p. 8).

Awards are mapped to the 10 levels of the NFQ (see *Figure 1-1*) through level indicators (NQAI, 2009), which are generic statements, for each level of the NFQ, of the standards of knowledge, skills and competence represented by generic awards mapped to that. Level indicators are available from QQI in grid-form (NQAI, 2011), and are included in *Appendix A* for levels 6-10. As can be seen, knowledge, skills and competence have been expanded into:

- Knowledge Breadth and Knowledge Kind;
- Know-How & Skill Range and Know-How and Skills Selectivity;
- Competence Context, Role, Learning to Learn and Insight.

Level descriptors provide sets of generic LOs which must be met for an award to be mapped to a level of the framework, consistent with the approach taken in most NQFs (Coles, 2016).

3.6.1 Values

An exploration of the founding values of the NFQ (NQAI, 2003a) provides context for the vision that was in place at its establishment, and how this has matured (Coles, 2016; QQI, 2013, 2016a). In doing so I highlight those aspects particularly germane to my research.

3.6.1.1 Equality and Accessibility

Equality of access (NQAI, 2003a) refers to allowing disadvantaged groups access to all levels of education, but also to the recognition of prior learning, whether achieved in an educational establishment or through life/work experience. This latter aspect assumes that it is possible to fully equate knowledge gained outside of education with knowledge gained in education. This goes straight to the heart of a LOs approach, in that it focuses on whether LOs have been met, as opposed to what and how someone has learned (Jessup, 1991). On the other hand critics of LOs deny the equivalency of experiential learning and all academic knowledge, and argue for the essential role of academic institutions in providing an academic education (Allais, 2014; Young, 2008; Young & Muller, 2014).

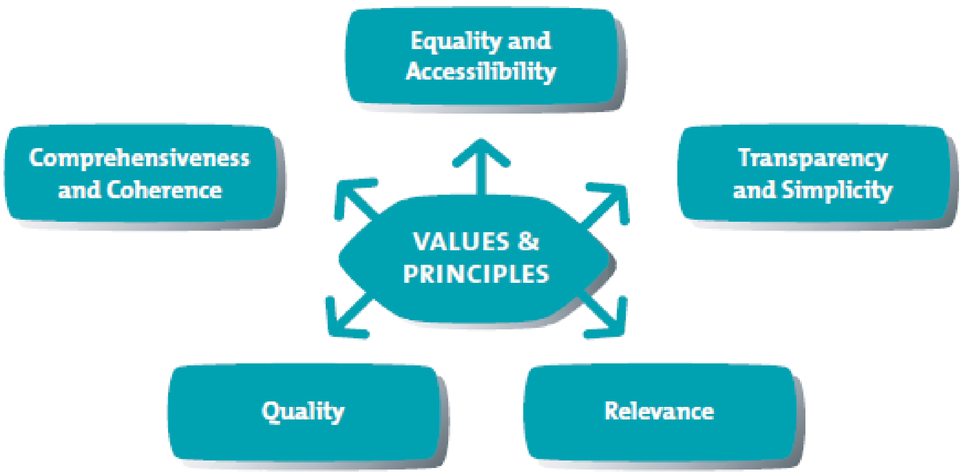

Figure 3-1 Values of the Framework (NQAI, 2003a, p. 11)

In my own experience, experiential learning can be used effectively for advanced entry, where the new entrant must subsequently undertake formal academic learning and assessment to gain an award. However, assessment of prior learning can be difficult (FIN, 2011), and although I have helped develop ad-hoc approaches for particular situations that have been quite effective, I consider it of limited applicability, albeit important for those who benefit.

3.6.1.2 Comprehensiveness and Coherence

The framework is designed to support awards reflecting "personal and cultural development" (p. 12). However, the NFQ is particularly tasked with facilitating awards that represent new types of employment, and that reflect the effects of the rapid change in technology and roles in existing employment areas. The relationship between different awards in the framework should be apparent, which is designed to facilitate progression opportunities for learners (NQAI, 2003a), as enshrined in the enabling act (Irish Statute Book, 1999b).

There are some issues with the comprehensiveness of the NFQ. Confusion arises with the difference between an Advanced Craft Certificate (trade) as compared to a Higher Certificate, both placed at level 6 (Collins et al, 2009). For example a level 6 Higher Certificate award is generally sufficient for progression into an add-on level 7 programme, whereas a level 6 Advanced Craft Certificate is not. Further confusion arises in that whilst level 5 and 6 awards from the further education and training (FET) sector are accepted for entry to first year of some higher education programmes, entry to second year (QQI, 2016c) may be allowed for holders of some FET level 6 awards. SOLAS (2014) acknowledge this confusion, and the need to build upon the NFQ to “deliver more seamless progression pathways” (p. 170) to higher education, in order to meet progression targets from FET.

Although an NQF composed of levels can be regarded as representing a vertical stratification (Triventi, 2010) of educational qualifications (Adelman, 2009; DHET, 2014; Teustsch, 2010), progression pathways seek to counter the elitism that can be associated with this segmentation (Singh, 2017; Young, 2008). Pre-NFQ, the IoTs had all taken steps to introduce degree programmes, often allowing progression for national diploma graduates to honours degree. The NFQ formalised the situation, aiming “to facilitate all learners to receive recognition and facilitate progression” (NQAI, 2003a, p. 10). A qualification at any particular NFQ level thus represents a graduate’s current educational achievement, as opposed to a limits on what they have been able, or allowed, to achieve. Given the marked shift in engineering enrolments in the IoTs from level 6 and 7 technician programmes towards level 8 engineering degrees noted earlier in *Chapter 2*, this signposted the need to consider, in the fieldwork, the effects the concept of progression might be having.

3.6.1.3 Transparency and Simplicity

Transparency means it should be clear to all stakeholders, staff, students, employers, etc., what an award on the framework is, what someone should be able to do on completing an award, and what they are required to have done to commence studying on a programme (NQAI, 2003a). This is to be achieved through the use of module and programme outcomes.

I consider the concept of transparency problematic. It may be a useful attribute if regarded in a limited fashion, e.g. to allow academics to compare the standard of one programme against another. Although transparency can be regarded as contributing to the student centred facet of an NQF (Attard et al, 2010), that potential students can understand programmes LOs specified by domain experts is disputed: ”what you should know as someone who is qualified cannot be explained to any unqualified person by giving them a list of LOs” (Young, 2011, p. 97). Cort (2010), in analysing the efficacy of the EQF in achieving its policy goals of transparency, comparability and portability of qualifications, suggests that qualifications specified in terms of LOs are “an opaque language of qualifications” (p. 309) for both educators and students.

Heywood (2016) questions, in the case of engineering education, whether LOs are readily understandable by all faculty, and considers they may not be interpreted to have the same meaning by those who develop them as by those teaching or learning them. He reports on a study (Squires & Cloutier, 2011) which identified differing perceptions by instructors and students of competencies taught and assessed in engineering. Their findings questions whether students and academic staff share mutual understanding of LOs, which they speculate may be due to “differences in perceptions” (p. 237.41.13) regarding knowledge. Indeed the assumption that engineering students could fully understand LOs written by experts is not consistent with their education being a process of graduate identity formation (Haase, 2014) involving a series of epistemological transitions (Winberg et al, 2012).

However, despite these criticisms, the value of transparency has become more important in the NFQ over time, e.g. Coles (2016) where the “aim of the NFQ structure is to enhance transparency and trust in qualifications.” (p. 7)[14]. These are said to be important “so that qualifications can better support economic and social policies such as skills supply to the labour market, lifelong learning and social inclusion”, (Coles, 2016, p. 7). In line with other qualification frameworks, trust and transparency are achieved in the NFQ by three factors:

1. the classification of awards by type and level, thus allowing the qualification system to be communicated to all stakeholders;
2. the specification of the QA procedures to be used to validate awards;
3. through acting as a point of contact between those involved with national

[14] The Qualifications Act (Irish Statute Book, 1999b) calls for a framework focussed around knowledge, skills and competence. Recasting this as being aimed at transparency and trust seems to obfuscate this.

qualifications and those who have international qualifications.

Simplicity refers to restricting the names allowed for awards in the NFQ. However, the replacing of national diplomas by ordinary degrees provides scope for confusion between what exactly a degree is (i.e. honours or ordinary). The IEI moved from their earlier position arguing for the retention of the National Diploma title, advocating for its replacement with Bachelor of Engineering Technology awards (IEI, 2004), and they continued to object to the decision that the IoTs should use title of Bachelor of Engineering for a level 7 qualification (IEI, 2005b). However, their representations to HETAC and the NQAI did not lead to change. The DIT could choose their own award titles, and instead selected the title of Bachelor of Engineering Technology. I myself consider this more appropriate, and I was involved in an unsuccessful attempt to initiate a national discussion on this issue in 2012, along with HETAC, IoT Ireland (the representative body for the IoTs), and other colleagues from the sector.

3.6.1.4 Quality

The importance of QA was highlighted during the policy development leading to the NFQ (Fitzsimons, 2017b). QA processes are a "central issue" (NQAI, 2003a, p. 13) underpinning the NFQ, and are intended to "permeate all aspects of learning and awards", including in institutional review, programme design and validation, module design, programmatic review, external examining, exam paper production and monitoring of student progress (QQI, 2016b).

Under the NFQ QA has become a pervasive aspect of academic life in the IoTs. QQI recognise the significant impact of LOs on QA processes (Coles, 2016) and that the use of LOs is not without criticism. However, Coles goes on to argue that there are clear benefits (in terms of objectivity and transparency) from QA, and, as an open question, asked "should the NFQ do more to encourage the use of LOs in curriculum specification, qualification specification and quality assurance processes?" (p. 11).

Kenny, however, (2009) argues that the quality previously achieved through the excellence of specialist academic institutions has been displaced from its central role in higher education through the introduction of OBE, echoing arguments made by Allais (2014). Fitzsimons (2017b), in recognising the tension between the learner centred aspect of the NFQ, and its employability focus, considers that, although "QA has the capacity to support divergent philosophies" (p. 28), what she terms the "employability discourse" is dominant. I have participated in QA as an academic, a head of department, external examiner, and a registrar. In these roles I have being involved with exams, programmatic reviews, EI accreditation, and institute reviews for QQI. On reflection, I can certainly identify times when student centeredness came to the fore, in exam appeals procedures, in student representation at course boards, and in ensuring the student voice is heard in reviews. However, in terms of QA of how and what we teach, by far the dominant factor has been a procedural approach in which the use of LOs is a principal consideration.

3.6.1.5 Relevance

The NFQ is intended to be relevant to all stakeholders: students; teachers/lecturers; employers; and to provide support for awards that encourage an active participation in society (NQAI, 2003a). It is also intended to prepare students for employment, and where appropriate, to certify their competency to engage in professional practice. Such awards should demonstrate a clear mapping to "occupational or professional standards" (p. 14). Moving forward from the introduction of the NFQ, QQI (2013) regards the primary objective of a qualification system as "to prioritise the support of human development" (p. 22). However, they give significant weight to the "employability objective" (p. 23), emphasising learning to learn skills to cope with rapidly changing workplace requirements.

3.6.2 The Engineering Standards

A set of supplementary standards were developed, including the award standards for engineering (QQI, 2014c), which effectively create an engineering-specific sub-framework (Coles, 2016). They further subdivide each aspect of the generic standards level descriptors of Knowledge and Know-How and Skills-Range, on the basis of Mathematics, Science, Information Technology, Design and Development, Business Context and Engineering Practice. The standards can be regarded as a language of learning (Biesta, 2005) associated with the NFQ (Kenny, 2006), emphasising process (stipulating outcomes) (Cheville, 2016; Riley; 2012; Woolston, 2008) rather than knowledge (Allais, 2014).

As an embedded systems engineer, I find these engineering specific LO based standards in turn quite generic, lacking disciplinary context (Wolff, 2015). For example, in *Table 3-1* the engineering standards for Knowledge-Breadth for level 7 and 8 are shown. The *design and development* descriptors state what is obvious to an engineering educator, that a graduate of a level 8 programme should be knowledgeable and be able to apply appropriate design techniques as they might require them in the solving of engineering problems. The standards could thus be considered to be of little value to curriculum design other than ensuring it follows a LOs approach, aligned with the levels of the NFQ. However, they are more than just a QA mechanism to map a lecturer's expertise into a curriculum. The control over knowledge these standards represent, the skills focus they enforce, and the emphasis on process (Biesta, 2005) act to influence us as academics in relationship to the curriculum and instruction. This is an aspect of OBE I was to consider in the fieldwork.

Table 3-1 Engineering Standards (QQI, 2014c)

	Level 7	***Level 8***
Knowledge-Breadth	**Specialised knowledge across a variety of areas**	**An understanding of the theory, concepts and methods pertaining to a field (or fields) of learning**
Mathematics	Has knowledge of the underlying theory essential to the mathematics used for common engineering problems in the particular sub-field of engineering	Has knowledge and understanding of a range of mathematical methods and the underlying theory relevant in the particular sub-field of engineering.
Science	Has knowledge of the fundamental principles of science appropriate to the particular sub-field of engineering.	Has comprehensive understanding of the fundamental principles of appropriate scientific knowledge and the extent of their applicability to engineering problems.
Information Technology	Has knowledge and understanding of the role of ICT for engineering. Has sufficient knowledge and understanding of ICT to adopt it to solve common engineering problems.	Has knowledge and understanding of the role of ICT and its application to the particular sub-field of engineering. Has sufficient knowledge and understanding of ICT to adopt it to solve complex engineering problems.
Design and Development	Has knowledge of the essential elements of the design process and design methodologies relevant to common engineering problems in the particular subfield of engineering.	Has knowledge and understanding of the essential elements of the design process and methodologies relevant to complex engineering problems in their particular subfield of engineering.
Business-Context	Has basic knowledge and understanding of management and business in the context of common industrial practice.	Has knowledge of management and business in the context of complex industrial practices and in the context of technological innovations and change. Understands the different operational and managerial structures in companies and the context of employment legislation, trade unions and public and private bodies.
Engineering Practice	Has knowledge of specific codes of practice in common engineering problems, including the role of design factors. Has knowledge of the codes of practice relating to hazards and operational safety. Understands the need for operational safety by design and good working practices.	Has knowledge of current engineering practice at project and management levels.

3.7 The NFQ as a Policy Tool to Emphasis the Teaching of Skills

The use of LOs can lead to radical forms of social constructivism (Young, 2008), reducing curriculum to a question of who is in control (employers or educators/students) of particular parts of it. For example, in post-Apartheid South Africa where, in the interests of promoting access to education, curriculum was replaced entirely by LOs promoting generic skills, the development of the citizenry, the integration of school and everyday learning and knowledge selected based upon the views of the educator and the local culture of the students[15] (Hoadley, 2015). On the other hand, if industry is allowed too much influence an instrumental viewpoint may prevail (Young, 2008). Rather than education being based upon cognitive interests, curriculum is side-lined and replaced by skill-oriented LOs constructed to reflect employers' views on what constitutes appropriate knowledge for the workforce.

Although the NFQ was developed with the dual aims of supporting student centred learning, and promoting a skills focus in education to support the economy, it appears the latter is the key motivation (Allais, 2017). Lynch (2006) argues that the massification of higher education in Western countries, which has resulted in significantly higher standards of living, requires major, and ongoing, state investment to support it. This results in the marketization of higher education, in which "the values of the commercial sector can be encoded in the hearts of the university systems and processes almost without reflection" (Lynch, 2006, p. 6). The NFQ can be considered an aspect of this, inculcating a pronounced skills focus in education, with knowledge relegated to a secondary role (Allais, 2014; Corbell, 2014; Young, 2008; Young & Muller, 2010). Kenny (2010), in considering the Irish context in relation to international educational policy developments, states that "NQFs provide for a human capital accumulation currency mechanism. Human capital can be quantified into units of knowledge, skills and competency, mediated by 'learning outcomes' and placed on the hierarchical currency table of national frameworks" (p. 72)

This human capital focus leads to a clear emphasis on skills at a national policy level, even our Minister for Education is, in fact, a Minister for Education *and Skills*. National strategy for higher education considers that "a high proportion of the skills that we need now in the workforce are high-order knowledge-based skills" (HESG, 2011, p. 4), equating knowledge and skills. An Irish government key advisory body on industry requirements is the Expert Group on Future *Skills* Needs (Skills Ireland, 2017). Ireland's national skills strategy closely links skills with economic success, the personal development of individuals and society (DES, 2016).

Ireland's national strategy for higher education (HESG, 2011) emphasises its role in providing the skilled graduates needed for the knowledge economy. The concept of lifelong learning is

[15] Young, who was involved in this as a consultant, relates that "the teachers were underqualified. Expected to create knowledge themselves, they didn't know what to do. It was a disaster", as interviewed in Wilby (2018).

an inherent aspect of the knowledge economy[16], which is "characterised by the need for continuous learning" (OECD, 1996, p. 13). Indeed, this learning is seen to be of the highest importance "in determining the fate of individuals, firms and national economies." (p. 23). Shannon (2019) contends that Irish policy makers embraced the lifelong learning concept "to develop common strategies for employment and education policy" (p. 100), and I have shown it was a key concept during the development of the NFQ. However, it is a particular type of learning that is considered to be of most value (Shannon, 2019), that of "learning new skills and applying them" (OECD, 1996, p. 23)[17]. It is contended that this skills emphasis is motivated by the neoliberal belief that employers' requirements should drive the curriculum and it is the role of the state to support learners in meeting these (Allais, 2014).

The focus on skills in programmes implemented using LOs establishes that someone can competently carry out specific tasks, which is normally equated with vocational education. However, this is problematic for other types of education, particularly more advanced studies, where specifying curriculum using LOs downgrades the knowledge that may be required to achieve the specified competencies, and curtails the role of those teaching (Young, 2008).

I applied the keyword analysis approach of Corbell[18] to the policies and criteria related to the establishment of the NFQ (NQAI, 2003a), which constitutes a key node in the policy discourse (Corbell, 2014). I examined the document's use of the word 'knowledge', finding that of 133 occurrences, 95 are associated with the word 'skills' e.g. 'knowledge and skills'. Thus knowledge is quite bound with skills in the NFQ, consistent with the knowledge economy perspective outlined above. Although NFQ LOs encompass knowledge, skills and competence, in fact knowledge is somewhat side-lined through its equation with skills. Indeed, Corbell suggests that the phrase 'learning outcomes' is a proxy term for 'knowledge and skills', part of the skills discourse of Irish government educational policy for lifelong learning (Shannon, 2019). The NFQ is thus a key enabler for the knowledge economy, through its promotion of knowledge and skills *together,* as part of life-long learning. A finding is that the NFQ is one of

[16] In a knowledge economy "knowledge is now recognised as the driver of productivity and economic growth, leading to a new focus on the role of information, technology and learning in economic performance" (OECD, 1996, p. 3)

[17] Regarded by some as a key player in the promotion of neoliberalism (McPhail, 2008; Mahon, 2010), the OECD's prominent role in the development of Irish technician education, and support for the NFQ, has already been discussed. McPhail (2008) describes the OECD transition to a neoliberal organisation in the 1970's, regarding it as asserting that "society's well-being rests upon economic imperatives" (p. 43), promoting state intervention to support this. Savage (2017) regards the OECD as having a leading role in reforming education "for the sake of increasingly economic productivity" (p. 152).

[18] See section 5.4.1.

the principal tools to promote the government skills emphasis in higher education.

The emphasis on skills is concerning from an engineering perspective, where a balance of disciplinary knowledge and skills is required (Winberg et al, 2012; Wolff, 2015). This provides the student with the capability to engage with professional practice, rather than providing them with "short-term, utilitarian and instrumental ideas of education, geared only to the minimal preparation of practitioners" (Winberg et al, 2012, p. 20).

These concerns have particular relevance to the IoT sector, with its traditional emphasis on engineering practice supported by theory. Young (2008) contends that attempting to describe both work-based learning and theoretical learning using the same OBE approach masks the critical epistemological differences between the two types of learning. There is a distinction between academic and vocational education (Shay, 2012), which is formed from both codified disciplinary knowledge and "implicit and sometimes tacit knowledge acquired in workplace" (Young, 2008, p. 144). The skills focus leads to "a steady weakening of boundaries, a de-differentiation of knowledge and institutions" (p. 18) as the boundaries between vocational and academic qualifications are weakened. This leads to a concern (Allais, 2014) that vocational programmes can become pathways to education rather than employment, and provides a perspective from which to consider the NFQ concept of progression between higher certificate, ordinary degree and honours degree programmes.

3.8 EI Accreditation: The adoption of LOs, and the Influence of Bologna

I now move on to discuss the second pillar of Ireland's OBE engineering education system, EI's accreditation requirements, which is now LOs based. This is an important factor to consider in understanding the impact of OBE on engineering education in the IoTs. In addition, EI's interpretation of Bologna, and resultant further change in accreditation requirements, was significant for the structure of Irish engineering education.

EI is the sole body in the state licenced to award the title of Chartered Engineer (Irish Statute Book, 1969), and may also admit engineering technicians as associate members, in line with the earlier positioning of the ICEI (Rafferty, 1968). EI consider its remit is to "establish and maintain standards of professional engineering and engineering education" and "act as the authoritative voice of the engineering profession in Ireland" (EI, 2017b).

EI (then the IEI) decided, in the early 1980s, to accredit programmes itself, where previously this had been conducted by UK engineering institutions, and commenced to accredit programmes in the universities and the RTCs (Cox & Callanan, 2006, Cox, 2019). This activity was regarded as having "greatly enhanced the image and status of the organisation" (Cox & Callanan, 2006, p. 75) and facilitated it having an "influential voice in subsequent negotiations about the equivalence of qualifications in Europe and elsewhere". The IEI also began to move beyond the traditional links to the UK, with increased international contacts, particularly with the USA. This was to lead to the IEI being one of the initial signatories in 1989 of what was to become known as the Washington Accord, along with the USA, Australia and New Zealand, with the UK and Canada signing at a later date (Cox, 2019).

EI accredit programmes as suitable for the titles of Engineering Technician, Associate Engineer, and Chartered Engineer. EI stipulate input standards for each title, being particularly concerned that, generally, those admitted to programmes suitable for the path to Chartered Engineer should have an honour in Leaving Certificate maths[19]. Becoming a Chartered Engineer typically requires gaining appropriate accredited qualifications, acting as a practicing engineering for a number of years, followed by an interview to assess suitability.

EI developed revised LOs based accreditation criteria in 2003, in which they acknowledged the influence of other engineering bodies, and the Washington Accord (IEI, 2003). EI is also a signatory to the Dublin and Sydney Accords, agreements on the equivalency of accredited programmes for engineering technician and technologist respectively (IEA, 2016). Influenced by ABET's accreditation requirements, these accords all developed requirements for signatories to undertake accreditation visits (IEA, 2016) to evaluate programmes for accreditation, and that criteria for accreditation should be programme outcome based.

These international agreements required EI to move from its earlier position of considering NCEA approval of certificate and diplomas as sufficient for accreditation (IEI, 2001b). Instead, from 2006, accreditation would be based upon evidence of meeting programme outcomes as evaluated by a visiting panel of experts (IEI, 2004). It was, however, presented to the IoT Heads of School of Engineering as consequential to a lowering of standards in their

[19]Given the basis of the learning *outcome*s approach, it is difficult, in my opinion, to justify the honours maths rule at *input* to a programme, although I agree that proficiency at maths is essential for engineers.

programmes following the introduction of new progression opportunities for students (McNutt, ITB, personal communication, October 2003). In any case it marks EI moving to establish firm control over standards in technician education through their accreditation process (Matos et al, 2017), and was to reinforce the use of LOs in IoT engineering education.

EI also participates, through the ENAEE (overarching European engineering professional body) (ENAEE , 2015) in Eur-Ace (Augusti, 2009), a European project to establish a badge of quality for engineering programmes. ENAEE also stipulates the use of LOs to determine the capability of engineering graduates and the accreditation of programmes, as influenced by ABET (Augusti et al, 2011; ENAEE, 2017), and within the context of compatibility with the Bologna framework. As a member of the ENAEE, EI, in their accreditation requirements, has "based its approach firmly on the basis of programme outcomes" (EI, 2014, p. 3).

3.8.1 The Bologna Process and the Impact on Irish Engineering Education

The Bologna Process led to the establishment of the European Higher Education Area (EHEA), which, alongside the EQF, reinforces the OBE approach in Europe. The development of the Bologna framework is described in *Appendix E*, where the important Irish contribution culminated in the Dublin descriptors that enshrined the use of LOs (Feeny & Horan, 2016).

Implementation of the Bologna '3+2' structure (three year bachelor degree followed by two year master's degree) has impacted in different ways on European engineering education. In Germany it is associated with concerns including the loss of well-regarded degree titles, graduate work-readiness, and continued retention issues (Schuster & Hees, 2010). It has been argued that Bologna has had little impact in France (Orivel, 2005), where under the Bologna process engineering schools have continued to offer their old programmes, with the old five year diplomas renamed as master's degrees (Campus France, 2016): "the majority of university departments have simply changed the names of their diplomas, but not their content" (Orivel, 2005, p. 13).

EI's interpretation of Bologna, in addition to supporting the adoption of a LOs approach to accreditation, had an impact on the structure of Irish engineering education. A 2001 submission to government (IEI, 2001d) set out options for awards suitable for accreditation for Chartered Engineer that would be compatible with Bologna. These included retaining the status quo, and changing the accreditation requirement to master's degree. EI expressed a particular concern that Ireland's bachelor degree route to accreditation should align with developments in Europe to change the accreditation benchmark to that of master's degree. This attracted some criticism, with Kelly (2001) arguing "the existing 4 year university engineering degree is fully (100%) in compliance with Bologna and there's no reason to change it"[20] (p. 25). Professor Kelly later made it clear he considered this move by EI unrelated to Bologna, but, rather, an attempt to restructure Irish engineering education (SEFI, 2002).

However, ultimately EI interpreted the Bologna framework as requiring that a professional engineering degree, suitable for accreditation purposes, should be at master's level (EI, 2012), and recommended this be implemented using the Bologna 3+2 structure. Consequently universities (and some of the IoTs) established taught master's programmes for many of their engineering bachelor degree graduates in order to satisfy EI's qualification requirements for Chartered Engineer (EI, 2017a). However, despite the prediction by EI's Registrar that the 3+2 structure would "become the norm", (Bucciarelli et al, 2009, p. 6), with the exception of UCD those universities and IoTs that offer accredited engineering degrees have retained their four year Bachelor degrees and added a one year add-on master's (EI, 2017a).

The accreditation changes have had a significant effect in the IoT sector. Previously IoTs could seek accreditation for five year honours degree programmes, graduates of which would be eligible for chartered status. Such degrees were structured as three years of technician education and training, followed by a more theoretical final two years of education to professional engineering standard. The additional requirement of at least a year to gain a master's degree made the route to chartered status through such five-year programmes seem over-long. Consequently, many such programmes in the IoTs were discontinued, as predicted by McLaughlin (2001), and supplanted by four year honours degree engineering programmes. Such programmes do not generally form part of the accreditation route for receiving the title of Chartered Engineer, instead being suitable for the EI title of Associate Engineer. Thus EI's interpretation of Bologna acted to curtail the teaching of programmes leading to chartered status in the IoTs, reinforcing the stratification of engineering education.

[20] I participated in this event as a rather novice IoT academic, which is how I located the reference. I distinctly recall Professor Kelly's intervention, which in my recollection, was the only real challenge to the proposal.

3.9 *Implications for the Design of Engineering Curriculum*

IoT engineering educators have to consider, when designing curricula, two separate, but related, LOs based, standards, the Engineering Standards (QQI, 2014c) backed by the legislative basis of the NFQ and the professional standards influence brought to bear by EI (2014). EI's accreditation procedure evaluates a programme's suitability for accreditation, and in itself, is not strictly speaking a curriculum design guide. However, in practice anyone designing a new engineering curriculum, or updating an old one, must consider the implications of the EI accreditation criteria. For example, see Forero et al (2011), where EI programme outcomes are discussed seamlessly in the context of the design of module LOs.

The accreditation guidelines, sitting alongside the HETAC standards for engineering, define programme outcomes to be addressed in accreditation, including: science and mathematics; discipline-specific technology; software and information systems; design and development; engineering technology practice; and social and business context. Each programme area will have a subset of modules associated with it, with the modules LOs forming conglomerate programme outcomes which are assessed to demonstrate "the engineering technology graduate's achievement of the stated Programme Outcomes" (EI, 2014, p. 13).

As an example of EI generic programme outcomes, consider Associate Engineer (EI, 2014, pp. 11-14). These, which map to the NFQ level 7 outcomes, include knowledge of relevant maths, engineering science and technology alongside capability to: identify and solve engineering problems; contribute to the design of engineering solutions; work as an individual or a team in multi-disciplinary settings and undertake lifelong learning; and be able to communicate regarding engineering activities to engineers and others. Additionally, associate engineers should have awareness of related ethical issues.

The two, inter-related, LOs based standards are reinforced through separate review process. The first, programmatic review, is a periodic five yearly review required of programmes stipulated by QQI, an intensive effort by academics to revitalise their programmes for the next cycle e.g. see ITB (2017). The second is EI accreditation, which, also, has a five yearly cycle.

This discussion on curriculum leads into consideration of the pedagogical approaches that IoT engineering academics use to deliver such curriculum, with Barnett and Coate (2005) regarding the two as "intertwined", (p. 79), asking "where does the development of the curriculum end and pedagogical strategies begin?".

3.10 Engineering Pedagogy and OBE

In considering the effect that OBE might have on our pedagogy as engineering educators, in the Irish engineering education context in which my research is situated I have shown that little attention was given to pedagogy in the development of the NFQ. However, it has received some attention in more recent years at European, and Irish, policy level. CEDEFOP (2009) places LOs above and in control of both pedagogy and curriculum, with equal gravitas to the mission of the host institute. EC (2010) expects that educators should "adapt pedagogy and training and assessment methods, to align them more clearly to LOs." (p. 23). In Ireland, higher education strategy (HESG, 2011) expects that "in the design of courses and programmes, HEIs should ensure alignment and balance between learning outcomes, pedagogy and assessment" (p. 62).

The proposal that pedagogy should be aligned with LOs is suggestive of the concept of 'constructive alignment' (Biggs & Tang, 1999), an OBE approach which seeks to provide a cohesive approach to teaching, learning and curriculum. In constructive alignment, which follows from the ideas of Tyler (Biggs, 2014), LOs, and in particular the 'verb' used to describe them, are used to drive the selection of pedagogical approaches that "address the verb" (Biggs & Tang, 1999, p. 100) on the basis that this will align pedagogy with LO. Assessment tasks should also make use of the 'verb', focussing the student, and assessors, attention to the criteria implicit in the LO. Teaching activities, and what students do, are "aimed at achieving the outcomes by meeting the assessment criteria" (UCD, 2021).

Constructive alignment has been applied as an approach for engineering pedagogy in OBE (Biggs, 2014; Turunen & Byers, 2012; Marusik, et al., 2019), although not without criticism as to its effectiveness (Nightingale et al., 2007). Within Irish engineering and technology education, there is some direct evidence in the literature of the application of constructive alignment in particular engineering education contexts. For example: Murphy et al. (2019) consider the presence of constructive alignment in an engineering programme can be used as a measure of whether it is meeting its educational goals; Keenahan and McCrum (2021) describe its effectiveness as the basis for the design of a first year module taught to engineering and architecture students; and Buckley et al. (2020) propose it as a suitable approach for the teaching of design in second-level technology courses.

However, Bowe and Duffy (2010), fellow IoT engineering educators, present constructive alignment as an implicit, mainstream, aspect of the practice of engineering education. In considering the validity of this perspective, it must be acknowledged that IoT engineering academics have had some exposure to the concept, given that constructive alignment features as an approach to linking pedagogy and curriculum in guides to the use of OBE developed for higher education (Lahiff, 2006; DIT, 2009; LIT, 2018). Of particular significance during the introduction of OBE in Ireland was Kennedy (2007), highlighted in Collins et al (2009) as a reference point in Irish higher education for the use of LOs and, in particular, for introducing the concept of constructive alignment.

Kennedy (2007), which was quite influential in my own IoT engineering department, describes a three-step process of constructive alignment in which you approach curriculum, pedagogy and assessment through:

1. Clearly defining the learning outcomes.
2. Selecting teaching and learning methods that are likely to ensure that the learning outcomes are achieved.
3. Assessing the student learning outcomes and checking to see how well they match with what was intended. (Kennedy et al, 2006, p. 68).

Rather than the deepening of our approach to consideration of curriculum, pedagogy and student achievement that was claimed would result through this approach, my own experience as a HoD leading the transition to OBE was that, given the imperative to redesign curriculum, our emphasis was, instead, on an instrumentalist approach that focussed on adapting to the use of verbs in writing LOs (Kennedy, 2007). The contemporary 2006 ITB engineering department programmatic review (ITB, 2006) panel report confirms the pressure we experienced at the time to re-write syllabi using LOs and the emphasis this was engendering in us in how to assess these LOs. Furthermore, in retrospect it is notable that it did not report on a reflection from my department on how OBE was going to affect our approach to teaching engineering.

Moving forward to where OBE is now firmly established in IoT engineering education, a sample of programmatic review documents from engineering departments, schools and faculties from across the sector (ITB, 2015; LIT, 2017; IT Sligo, 2019; GMIT, 2019; CIT, 2021) reveals that, although there is some discussion of pedagogy (often in the context of assessment of LOs, e.g. the number and timing of assessment events linked to LOs (ITB, 2015)), there is no mention of constructive alignment. It is perhaps telling that, now that OBE is quite firmly established in IoT engineering education, a programmatic review panel report for Limerick IT Electrical and Electronic Department recommended that “the verbs used in the Learning Outcomes in a number of the level 8 modules need attention” (LIT, 2017, p. 9).

The concept of constructive alignment has further influence in Irish engineering education through the Conceive-Design-Implement-Operate (CDIO, 2021) initiative. CDIO is a model for engineering education (Andrews et al, 2011; CDIO, 2021; Heywood, 2016) developed contemporaneously with ABET’s EC2000 in which constructive alignment is implicit (Edström & Malmqvist, 2010). CDIO makes use of the OBE concept but looks beyond this in incorporating “the full lifecycle of product, process and system development and deployment” (Edström, 2018, p. 52). As examples of the use of CDIO in Irish engineering education: Coyle & Rebow (2009) describe CDIO’s application in the development of a Masters programme concerned with sustainability and energy systems, and were influential in a contemporary decision by the Dublin Institute of Technology to join the CDIO initiative; Hyland et al. (2018) apply CDIO in engineering design courses; and IT Sligo Faculty of Engineering describe it as feature of their approach to mechanical engineering education (IT Sligo, 2019), but do not propose it to have wider applicability within their engineering faculty.

UK and Ireland CDIO activity is sufficient to sustain an annual conference to share ideas and experiences, where, in 2020, workshops considered engineering ethics and the technician role (CDIO, 2020). However, only two Republic of Ireland Universities, with 11% of Irish engineering students in 2019-20 (HEA, 2021) and no IOTs, are currently members of the CDIO initiative (CDIO, 2021). Given this excludes TU Dublin, Munster Technological University and UCD, who between them had 45% of Irish engineering education enrolments in 2019-20 (HEA, 2021), it appears that CDIO is not an overarching influence on Irish engineering education. In comparison, as discussed earlier, all Irish Universities and IoTs engage with Engineers Ireland accreditation.

More generally, and as discussed earlier[21], engineering education research is generally accepting of the OBE approach to curriculum and pedagogy. A wide range of pedagogic techniques are described in the literature for use with OBE engineering education, including: problem based learning (Mitchell et al, 2019), action research (Bhat et al, 2019), agile methods (Myers, 2016), didactic approaches (Sedelmaier & Landes, 2014), service learning (Ropers-Huilman et al, 2007), and approaches designed to improve students' reflective capacity (Bowe & Duffy, 2010). IGIP (2021), the International Society for Engineering Pedagogy, offers certification as an engineering pedagogue. IGIP advance a perspective of engineering pedagogy as fundamentally oriented around a goal-oriented approach based on taxonomies such as Bloom's (Rüütmann, 2017), where the "teacher's main didactic task is to find an optimal teaching method" (p. 3) to "achieve a given instructional objective".

In considering this I ask myself as an engineering educator whether I feel that what and how I teach my students should be defined by the alignment of teaching with objectives. Surely it is the body of knowledge and practice associated with a subject, my own experience and knowledge of it, and the reflective capacity in this regard that I have developed as an engineering practitioner and educator that should inform my teaching approach. Similarly, Wolff (2015), who is critical of OBE, argues that engineering curriculum structures should instead reflect the organising structures of the disciplines from which the region is formed, with clearly defined pedagogic practice required to develop the problem-solving characteristics of each engineering qualification. Indeed IGIP concede the role of the subject matter under consideration in the selection of a teaching methodology (Rüütmann, 2017). Rather than this discipline-oriented approach being evident in the IoTs consequent to the NFQ, Kenny (2009), a fellow engineering educator, argues that "teaching is reconstructed to meet the defined LOs" (p. 24).

In suggesting alignment of pedagogy with LOs, HESG (2011) proposes that "academic staff should make full use of the range of pedagogical methodologies […] and be qualified as teachers as well as in their chosen discipline." (p. 11). However, if alignment of pedagogy with LOs is a requirement then the range of teaching approaches available may be somewhat restricted. As Finnegan (2016) writes "neoliberalism and the linked phenomenon of outcomes

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[21] P. 28

based assessment have narrowed the educational imagination" (p. 55). For example, consider the DIT *Postgraduate Diploma in Third Level Learning and Teaching* (DIT, 2017), designed for new academic staff. The indicative syllabus covers a range of models for curriculum design and assessment. Given that module design and delivery in the DIT was firmly LOs based, the LOs oriented aspects appear most likely to influence academics taking the programme.

I am concerned that the pedagogic basis of the NFQ, so firmly linked to assessment, like other NQFs (Deacon & Parker, 1999) is quite limiting. Pedagogy is not dictated by EI's accreditation criteria, which is "left to the HEIs" (EI, 2014, p. 6). However, given the LOs focus, it would be expected to reinforce the influence of the NFQ. Whereas Kenny (2010) questions whether LOs might "have any effect on pedagogical practice" (p. 45) I considered, given the lack of attention to pedagogy in the drivers for OBE in Irish engineering education, that, as suggested in the literature (Finnegan, 2016), there may be significant implications. I was to explore this with my research participants in order to understand their views and experience of how our pedagogy as engineering educators has been affected by the NFQ.

3.11 Conclusion

The NFQ and EI are revealed as dual pressures on IoT engineering academics to engage with OBE. A skills agenda, reflecting international and European developments, dominates national policy for higher education, for which the NFQ is a key enabler. EI, similarly influenced by international developments, adopted an OBE approach for accreditation of engineering programmes, and, through their interpretation of Bologna, introduced new accreditation requirements leading to structural change in IoT engineering education.

It is important not just to acknowledge, but to consider the implications of these dual pressures on IoT engineering education. How are the regulatory nature of the NFQ, and the influence that EI have as an engineering professional body, perceived by engineering educators, and what impact do they have? The NFQ concept of progression, alongside the skills focus of OBE, raises concerns regarding the weakening of boundaries between the level 6, 7, and 8 programmes, which traditionally represent a ladder from more vocationally focussed programmes to more academic focussed ones. What impact have the structural changes resulting from EI's interpretation of the Bologna framework had? And what of the student journey of identify formation as they progress from one level to the next?

The literature review also highlighted the need to consider the effect the NFQ, alongside EI's accreditation requirements, may be having on curriculum design, and whether engineering educators' view of knowledge has been affected. Neither the NFQ nor EI's make stipulations regarding pedagogy, but the literature suggests the assessment focus has implications. I show the NFQ value of transparency to be a problematic concept, given that LOs may not be interpreted with the same meaning by either educators or students. Above all else, these considerations suggest that the NFQ and OBE based accreditation requirements do more than introduce additional workload through increased QA, they would be expected to have tangible effects on our academic identity, and on the education we offer.

In the next chapter I will discuss the conceptual framework that my literature review, and my consideration of my own role in the implementation of OBE, led me to develop to assist in contextualising these complex, inter-related, aspects of our engineering education system, in order to explore them in the fieldwork.

Chapter 4 A Conceptual Framework from which to consider IoT Engineering Education

"I'm an Engineer," he said simply, as if it would explain everything.

April Adams (2011, Kindle Edition, "Two 8", para. 30).

4.1 Introduction

My review of the development of Institute of Technology (IoT) engineering education, and the dual pillars of its outcomes based education (OBE) approach, highlighted the international and national policy influences and other interests that act within this arena. In order to develop a fuller understanding of this complex field I was researching I sought to develop a conceptual framework which reflected my own experience as an engineering educator, and allowed me to analyse and learn from it. Although I initially struggled to find an adequate theoretical grounding for my research, I was later drawn to Bernstein's (2000) characterisation of engineering as a region, as described earlier, inwards facing towards academic, and outward facing to the market, mediated by the engineering professional bodies, to assist in conceptualising what I was reading and observing. This social realist perspective foregrounds the importance of the consideration of the power relationships between both internal and external forces, and the historical conditions within which they arise, in developing understanding of education systems (Muller, 2004b; Young, 2008), as has been proposed for engineering education (Akera, 2017, Edström, 2018).

In my conceptual framework I draw selectively on social realism's contribution to the sociology of knowledge, particularly the concepts and research of Basil Bernstein (1971, 1999a, 1999b, 2000, 2001) and Michael Young (1971, 2002, 2003, 2005, 2008, 2010, 2011, 2014; Young & Muller, 2010, 2014). This influence emphasises the importance of knowledge and the curriculum in education. In recognising the social construction of knowledge, it foregrounds consideration of the social and political issues and structures within which our knowledge as engineering educators is constituted and framed (Barrett & Rata, 2014a), issues which are very much to the fore in the use of OBE (Allais, 2014, Matos et al, 2017; Young, 2011). Alongside social realism's acknowledgement of the manner in which pedagogic discourse acts to shape academic and student identity (Bernstein, 2000), this provides a framework, building upon my own experience as an engineering educator, from which the impact of OBE on engineering educators and education can be regarded and critiqued.

4.2 Drawing on Social Realism

Matos et al (2017) speak of the importance of considering power relationships in understanding the structure of engineering education, and identify that "accreditation maintains a continuing power struggle over the control for regulatory power of knowledge" (section *Governance and Accreditation*). They regard LOs based accreditation as promoting a "neoliberal turn" (section *Relationship of ABET to Engineering and Engineering Education*) in international engineering education, raising questions regarding the control of access to knowledge, the identity formation of graduates, and academic identity, including approaches to assessment. In considering the role of qualification frameworks, Young (2008) regards the introduction of OBE as attempts by government to exert increased control over education, and to break with past practices, which have been identified as some of the drivers for the introduction of the Irish National Framework of Qualifications (NFQ) (Allais, 2017).

My conceptual framework allows engineering education to be critiqued from this perspective, drawing on the educational sociology lens provided by social realism, which has been applied in research into a number of aspects of engineering education (Case, 2015; Nudelman, 2018; Shay, 2012; Smit, 2016; Wolff, 2015). My principal social realist influences are Michael Young (1971, 2002, 2003, 2005, 2008, 2010, 2011, 2014; Young & Muller, 2010, 2014) and Basil Bernstein (1971, 1999a, 1999b, 2000, 2001), two key proponents. In order to contextualise their influence I first discuss social realism from an historical perspective charting the changing viewpoints over time of Michael Young (1971, 2002, 2008).

I then describe important theoretical aspects, with a particular emphasis on how I make selective use of the ideas of Bernstein, who made significant contributions to the educational sociology of curriculum and pedagogy through: his understanding of how communication is affected by power relationships: how this influences pedagogy and the curriculum; and how this acts to shape the identity of those teaching and those being taught. Young looked to Bernstein as a principal theorist, identifying his key contribution that "you cannot have a curriculum theory without a theory of knowledge" (Young, 2014, section *Introduction*). Young (2014) proposes that research into curriculum theory should investigate the processes associated with Bernstein's concept of recontextualisation[22], where competing pedagogic

[22] See p. 10 and p. 93

and official recontextualising discourses highlight the tension between educators and government and other official agencies in shaping the curriculum.

4.3 From The New Sociology of Education to Social Realism

In order to understand contemporary social realism, it is necessary to consider the intellectual journey that led to it, commencing with the new sociology of education, which emerged from Young's earlier research. This stressed the importance of considering the curriculum and pedagogy in research into the sociology of education, and of understanding the competing power relationships between different groups involved in the specification of the curriculum.

The publication of *Knowledge and Control* (Young, 1971), which included contributions by Young (1971) from an anti-positivist perspective, and Bernstein (1971) and Bourdieu (1971) from structuralist perspectives (Hoadley, 2015; Young, 2002), marked the founding of the "new sociology of education" (Young, 2008, p. 3). This asserted that curriculum and pedagogy should be the focus of a re-orientation of the sociology of education (Young, 2002). Young advocated a social constructivist perspective in which power relations within what he terms the "dominant institutional order" (Young, 1971, p. 34), consisting of "economic, political, bureaucratic, cultural and educational" groups, were conceived as central to the selection of the curriculum content. The stratification of knowledge which follows from this leads to a view of the curriculum as being constructed to reflect the knowledge of the powerful, and thus a source of unequal access to education. Indeed, Young (1971) questioned whether the very basis of academic curriculum, "bookish learning" (p. 38), was anything other than a manifestation of "the values and beliefs of dominant groups" (p. 38).

The new sociology of knowledge sustained considerable criticism from conservative advocates of traditional educational approaches, where in proposing that the curriculum was inherently socially biased it was seen as "challenging something almost sacred" (Young, 2002, p. 40). The new sociology of education was also criticised for its characterisation of teachers as the principal agents of change, divorced from policy makers and policy implementation (Young, 2002).

Young (2008) was to later acknowledge criticisms of the theoretical limitations of the new sociology of education (Moore & Muller, 1999) as a form of voice discourse which eschews the "epistemological grounding of knowledge" (Young, 2008, p. 3) in favour of the "standpoints of [...] dominant social groups". Legitimation of knowledge claims moves from "what is known (and how) to who knows it" (Moore & Muller, 1999, p. 200). Thus a principal theoretical problem was that the new sociology of education ignored the fact that although the knowledge in the curriculum may reflect the vested interests of controlling groups, it may also be a source of "real understandings" (Young, 2002, p. 44): 'powerful knowledge' as opposed to 'knowledge of the powerful' (Young & Muller, 2010).

Having later engaged in a considerable body of work on policy related matters (Hoadley, 2015), Young was also to accept criticism (Moore & Muller, 1999) that the theoretical weakness of the new sociology of education was compounded by the insulation of those proposing it (university academics) from "both policy and practice" (Young, 2002, p. 47). For example, the new sociology of education provided "no criteria for developing and assessing curricula alternatives" (Young, 2002, p. 45). Indeed, taken to an extreme it could be used to argue for a curriculum totally based on experience, or indeed none at all, i.e. "deschooling", (p. 44). In reflecting on his earlier questioning of the traditional classroom based curriculum, Young also began to see a value beyond the social stratification that may have led to it: recognising the role that formal schooling can provide in inculcating knowledge that students can make use of in the wider-world (Wilby, 2018; Young, 2002).

However, despite its relatively short life (Young, 2002), and theoretical limitations (Moore & Muller, 1999; Young, 2002, 2008), the new sociology of education was important (Hoadley, 2015) in contributing to a debate as to what counted as educational knowledge, and seeking to move the focus of the sociology of education to curriculum and pedagogy. It also made a distinctive contribution (Young, 2002, 2008) in identifying the considerable influence power relations had on knowledge in the curriculum. Bernstein (2001) contends that though the approach of the new sociology of education may have been flawed, the problems it identified continue to require attention, and I consider them important for the research in this thesis.

Building upon his earlier writings, the criticism it attracted, his subsequent experience in educational policy (Hoadley, 2015), and the research of Bernstein (1999a, 2000), Young (2008) set out a vision of social realism as a sociology of education with knowledge at its heart, whilst fully acknowledging and considering the social circumstances that leads to its creation. The subsequent perspective on knowledge can be viewed in terms of the epistemological dilemma, where knowledge is regarded from either a positivist viewpoint, where it is absolute, and "located outside of society" (Young, 2008, p. 25) or a relativist standpoint, which, in "privileging the exclusivity of particular experiences" denies the "possibility of knowledge that goes beyond […] experience". Social realism transcends this dilemma through acknowledging that, although all knowledge is created in a social context, it is not reducible "to the activities and interests of those who produce or transmit it", (Young, 2008, p. 94), and some knowledge will have a truth and value outside of the context of its creation.

4.4 Knowledge

My personal ontological and epistemological positioning, which is shaped through my education and experience by the engineering view of the utility of knowledge (de Vries, 2006; Montfort et al, 2014), is a key aspect of my conceptual framework. Drawing usefully upon social realism, which emphasises the importance of knowledge and the curriculum in education (a key consideration in my research) entails my engineering worldview of what constitutes knowledge should be commensurate with the social realist perspective.

As a professional engineer and engineering educator (Winberg et al, 2012), I regard knowledge, to a significant extent, as that engineering knowledge, of technology, engineering science, practice etc., which we will teach our students on their path to becoming engineers. However, an engineer also requires the ability to operate successfully within and outside organisational structures, using the tacit knowledge that Heywood (2016) characterises as *know-how*, but which also involves *know-who*. Thus as an engineering educator knowledge is also my understanding of how to get things done, and who with, which has inculcated within me a consciousness of the organizational structures and power relations within our sector, and the ability to navigate within these to achieve ends.

Social realism borrows from the critical realism (Archer et al, 1998) position on knowledge, developed through consideration of ontological realism, epistemological relativism and judgemental rationality (Maton & Moore, 2009; Moore, 2014). The key idea of the new sociology of education, the importance of power relations in the selection of knowledge for the curriculum, is maintained, but knowledge no longer reduces to "statements about knowers" (Moore & Muller, 1999, p. 190).

Ontological realism, the principle that there is a "reality beyond the symbolic realm" (Maton & Moore, 2009, p. 4), is a recognition that, although socially constructed, our knowledge of the world reflects, although is not identical to, our experiences and beliefs regarding a reality that exists (Smit, 2016). Engineering is concerned with the production of artefacts (Lipton, 2010) through which we interact with that reality (Lawlor, 2016), relationships within which the assumption of ontological realism can be considered implicit (Hector et al, 2018; Zelic & Stahl, 2005).

Epistemological relativism views knowledge as “not necessarily universal, invariant, essential Truth – we can ‘know’ the world only in terms of socially produced knowledges which change over time and across socio-cultural contexts” (Maton & Moore, 2009, p. 4). As science, technology, and their application move forward new engineering knowledge displaces the old in professional practice through its dissemination by engineering practitioners, professional engineering bodies, engineering educators and others, an epistemological relativism.

Judgemental rationality completes the framework within which social realism regards knowledge, asserting that decisions as to what constitutes knowledge are made on a rational basis. Archer et al (2016) describe this in terms of “we are able to, and required to, adjudicate between rival or competing accounts, and there are often relatively objective reasons for affirming one model over another”. Sayer (1992) suggests practical adequacy as providing a rational basis for such decisions. i.e. “to be practically adequate, knowledge must generate expectations about the world and about the results of our actions which are actually realized” (p. 69). Arguably this is the implicit model used by many engineering practitioners, who will select one technique, technology or piece of science over another on the basis of practical adequacy (Tilley, 2016), through their own experience or that of their fellow-professionals, and, may regard some things as not useful at all, and thence not engineering knowledge.

Judgemental rationality has profound implications for education, in that it follows firstly that there is a body of “established powerful knowledge” (Moore, 2014, p. 37) to be taught. This is the means through which engineering education introduces students to the body of engineering knowledge (Heywood, 2016) they require in their identity formation (Haase, 2014). Secondly, the principles that led to the production of this knowledge need themselves to be taught through their embedding in pedagogy in the classroom (Moore, 2014). Frezza and Nordquest (2015) speak eloquently of what this can mean for engineering education:

> an engineer’s education and practical experience will make him or her familiar with an abundance of patterns of data and of relations of causality and dependence – and these

patterns can be brought to bear both in achieving insights and in establishing the conditions that must be met for something really to be so (section *Patterns of Knowing*).

4.5 The Engineering Professional Bodies, Cognitive Interests, and Knowledge Structures

Social realism highlights the role of the engineering professional bodies as communities of trust (Young, 2008) for engineering as a region (Bernstein, 2000), and this is important for the analysis offered in this thesis. I explore this through social realism's contention that there are two types of social interest that regulate the production and dissemination of knowledge. The first are ‘external’ interests associated with wider societal developments, for example economic and political pressures. The second are ‘internal’ cognitive interests associated with the creation and acquisition of particular knowledge, for example academic disciplines and professional bodies, and which form a contested intellectual field. Social realism see’s specific value in understanding the historical events that influence, help form, and contribute to change in these social interests. This leads to complementary aims, on the one hand to understand how external interests may exert power to influence the curriculum, and on the other hand to understand the influence that the social organisations that correspond to the cognitive interests will in turn have in shaping wider society (Young, 2008l; EI, 2017c). An implication for my research into the consequence of OBE for engineering educators and education is that I must be cognisant of the shaping of engineering by society but also that of society by engineering (Heywood, 2017, Pawley, 2019).

The social organisations that form cognitive interests can be considered through the ideas of Bernstein (1999a), who distinguishes between two types of knowledge discourse, the first of which are horizontal discourses, which reflect the common-sense, experiential knowledge that people will acquire as they go about their every-day social activities. The second are vertical discourses, which contain the coherent knowledge base of an academic discipline, organised through “specialised symbolic structures of explicit knowledge” (Bernstein, 2000, p. 160). These knowledge structures are typically acquired in academic settings in accordance with pedagogy and recontextualisation of knowledge associated with the academic discipline (Young, 2008). Critically, this means that the coherency of an engineering curriculum relates not only to the knowledge and skills selected for the curriculum, but also to the “associated pedagogic practice“ (Wolff, 2015, p. 5).

Bernstein's describes academic disciplines as singulars, intellectual fields with their own "texts, practices, rules-of entry, examinations, licences to practice […] etc." (Bernstein, 2000, p. 52). For some singulars, e.g. the humanities, knowledge is horizontally organised through "a series of specialised languages with specialised modes of interrogation and specialised criteria" (p. 161). In others, e.g. the sciences, knowledge is hierarchically organised, with increasing abstractions at higher levels incorporating concepts from lower ones (Wolff, 2013).

Concern has been raised regarding the impact of OBE on hierarchically organised knowledge (Allais, 2014, Wolff, 2015). Whilst acknowledging that the EQF explicitly includes knowledge as one of the headings under which LOs are specified, Allais (2014) proposes that it is information rather than knowledge that is being assessed through such LOs. Knowledge "is viewed as information or facts—something that can be broken into little bits which can be selected and combined at will." (Allais, 2014, p. xx), not taking into account the hierarchical nature of knowledge in many disciplines.

Regions comprise groups of singulars, and "face inward" (Bernstein, 2000, p. 55) to academic disciplines, and "outward" to the field of practice (e.g. engineering). Engineering knowledge is comprised of the disciplinary knowledge of its constituent singulars, but also has its own knowledge, particularly in engineering practice. The concept of design (of artefacts) epitomises engineering practice, which integrates knowledge from across the singulars that constitute the engineering region. However, design also builds upon the experience of engineers, and the application domain of the artefact, in doing so making substantive use of social skills (Wolmarans, 2017). Consequently, although some engineering knowledge is hierarchically organised, e.g. design of systems, other knowledge, although part of a vertical discourse, will be horizontally organised (Wolff, 2013; Wolmarans, 2017), and some engineering knowledge will even be part of a horizontal discourse (Wolmarans, 2017).

Regions may include 'communities of trust' with associated powers of accreditation and standard setting, of which the engineering professional bodies are a particular example. These provide an objectivity to the knowledge associated with a region and a measure of the standard of those admitted to the discipline as they move from being students to graduates (Young, 2008). Furthermore, they have a role in the establishment of professional identity (Wolmarans, 2017). Singulars and regions, and their associated knowledge, may well have elitist origins, but the cognitive interests intrinsic to them have a real value in the production of knowledge and its recontextualisation in the curriculum (Young, 2008). This highlights the influence of the engineering professional bodies on the curriculum through their adoption of OBE for accreditation. My conceptual framework reflects that I consider the curriculum not just a source of education and knowledge about engineering (Heywood, 2016), but, as do others (Matos et al, 2017, Pawley, 2019), a site of "ideology and power" (Edström, 2017, p. 15). This recognises that engineering cognitive interests have an associated emancipatory potential, a critical consideration given the manner in which society is shaped by engineering (Homan, 2020).

4.6 Curriculum

Introducing students to engineering knowledge is a key curriculum objective of engineering education (Heywood, 2016; Wolff, 2015). This position of the importance of knowledge in the curriculum is shared with social realism (Young, 2008), with Allais (2014) considering that "knowledge should be the starting point of curriculum design" (p. *xv*). However, whether for technician or professional engineering education, the application of that knowledge in engineering practice through skills is critical (Edström, 2017; McLaughlin, 1999; NAE, 2001, 2017). It is argued that at times engineering education struggles to find the appropriate balance between knowledge and skills (Dempsey, 2017; Dooge, 2006; Edström, 2018; Heywood, 2016; Johnston et al, 1996; Prados, 1992; Seeley, 1999). Debate on this matter has led directly to the adoption of OBE for accreditation of contemporary engineering education, with the pendulum between the analytic and practice orientations which Edström (2018) identifies currently ascended towards the skills maxima.

The needs of the market have been shown to be, historically, a strong influence on engineering education (Heywood, 2016; Akera, 2018). However, Young (2008), in reference to Bernstein (2000), raises a concern regarding regions: the "readiness on the part of professionals and […] scholars to respond to whatever the exigencies of the markets require in the shaping of their intellectual fields" (p. 155), which influences include OBE. One could argue that the fact that market oriented neoliberal influences lead to OBE and its skills emphasis (Barnett & Coate, 2005; Allais, 2014) is just another manifestation of this influence from a curriculum perspective. Certainly OBE, despite concerns as to its reinforcement of the neoliberal agenda (Allais, 2014, Matos et al, 2017; Pawley, 2019), is largely regarded, as I have shown, as a positive influence on engineering curriculum (ABET, 2006; EI, 2014; Froyd et al, 2012; Froyd & Lohmann, 2014; Owens, 2016a).

However, engineering, in providing us with the artefacts required for, and enabling the infrastructure of, our modern society (Lawlor, 2016), is a human endeavour (ASEE, 2020) in which we must strive for “morality in our actions” (Einstein, as quoted in Dukas & Hoffmann (2013, p. 95). It has been argued that the neoliberal influence “abdicates engineering’s moral choices to the market” (Pawley, 2019, p. 452), preventing engineers from engaging fully with important debate on “the purpose of engineering education, and who should decide”.

Pawley (2019) sought to provoke discussion regarding the effect of the neoliberal influence on engineering education, rather than offering solutions, and addressing this fully within this thesis is not feasible. Through my research I can offer some insight to contribute to the debate, in seeking to understand, for a sample of IoT engineering academics, whether they consider the skills emphasis of OBE leads to an appropriate, balanced, curriculum approach, suitable for the education of engineers in our modern Irish society. A particular concern is whether OBE has led to the de-emphasis of knowledge identified by the social realists (Allais, 2014; Young, 2008). Furthermore, is there a diminution in the discipline specific cognitive and pedagogic elements of the production and teaching of engineering knowledge (Wolff, 2015)?

4.7 Recontextualisation of Knowledge and the Pedagogic Device

Bernstein (2000) regarded pedagogy as the transformation of knowledge into a discourse associated with teaching that knowledge, and also the teaching, or pedagogic practice, itself. This transmission of knowledge is influenced by power relations between vested interests associated with the pedagogic discourse, and encompasses: who the knowledge is to be transmitted to and where; alongside what is to be transmitted and how. Bernstein (2000) considered pedagogic discourse embeds two associated discourses, an instructional discourse related to disciplinary knowledge and skills, and a regulative discourse related to social order.

The concepts of ‘classification’ and ‘framing’ model power and control relationships within the pedagogic discourse (Bernstein, 2000). Classification is used to describe the degree of insularity between academic disciplines. A more traditional academically oriented discipline in which strong boundaries exist between subjects, and where the academic discipline is clearly defined, is said to be strongly classified. The degree of classification, strong or weak, is associated with power relationships within and external to the discipline. Framing refers to the degree of control within the discipline regarding pedagogy. Where there is strong control by dominant actors within the field over what is taught, how it is taught, and when it is taught there can be said to be strong framing.

Bernstein (2000) conceptualised the pedagogic device to address whether there are "general principles underlying the translation of knowledge into pedagogic communication" (p. 25), and in which the concepts of classification and framing are situated. It models the knowledge practices associated with pedagogy. The field of production is the site where new knowledge is produced, for example universities. The field of recontextualising is where disciplinary knowledge is selected and sequenced, based upon intrinsic and extrinsic interests, to become pedagogic discourse, and to form the curriculum. However, recontextualisation refers not just to what to teach, but also to the selection of the theory of instruction. The field of reproduction is the site where pedagogic practice occurs, i.e. where the curriculum, in tandem with pedagogy, is used by educators to teach students.

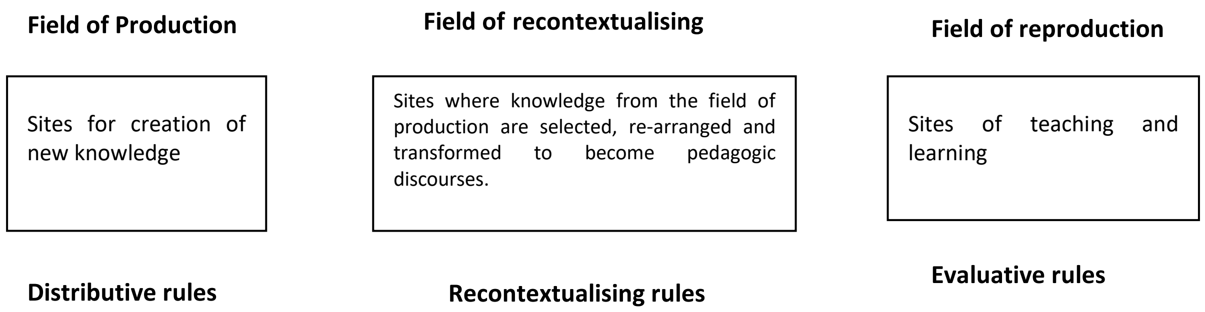

Figure 4-1 Arena Created by the Pedagogic Device(Maton, 2014, p. 48)

The pedagogic device acts as an arena (Bernstein, 2000, Maton, 2014) within which the classification and framing of knowledge are mediated through a hierarchical set of rules: distributive rules define the power relationship between different social groups in terms of access to knowledge, practice, and consciousness, and regulate "who may transmit what to whom and under what circumstance" (Bernstein, 2000, p. 31); recontextualisation rules regulate the transformation of disciplinary knowledge into pedagogic discourse: evaluation rules constitute the pedagogic practice itself, and act to influence the consciousness of those who acquire the knowledge (e.g. the identity formation of engineering students).

The recontextualisation rules lead to a pedagogic discourse encapsulating an instructional discourse (what knowledge is available to be taught) and a regulative discourse (what *should* be taught). The recontextualising field is formed from two sub-fields, the first being the official recontextualising field (ORF), corresponding to the educational apparatus and influence of the state, and which, for engineering education, has been extended to include the professional bodies (Klassen, 2018; Moodley, 2014). Bernstein uses the phrase “Official Knowledge” (p. 65) in relation to this field, as that which is expected to construct moral and motivational dispositions in academics and students, leading to “particular performances and practices”. The second field is the pedagogic recontextualising field (PRF), corresponding to those engaged and concerned with pedagogy. Bernstein views the ORF as typically dominant, as the state and its agents attempt to exert control over “the pedagogic discourse and its social contexts” (p. 33), curtailing debate over “pedagogic discourse and its practices”. This shapes both academic and student identities, and influences academics’ pedagogic practice.

However, the PRF, and its associated cognitive interests, also contribute to the pedagogic discourse. For example, Bell and Stevenson (2006) acknowledge the central role of the state in defining educational policy, but that though academics may be influenced by policy, they also, through “personal characteristics, expertise […] and opportunity” (p. 21) influence its formation and implementation. Similarly, in considering the effect of policy on educators, Coffield et al (2007) write that “policy makers are not writing upon a blank slate, but on a page already taken up with 'ecologies of practice', past and present initiatives and specific local factors”(p. 728). Thus the pedagogic discourse (Bernstein, 2000) that arises through OBE is being shaped not just by official knowledge of the ORF, but also by the academic staff.

I argue for the applicability of this model to engineering education through considering Heywood (2016) who emphasises the importance of knowledge in the curriculum. He speaks of “the curriculum process” (Heywood, 2005, p. 3), to which both “learning and instruction” are central, corresponding to the field of reproduction. Heywood (2005) acknowledges: the social nature of what he terms the curriculum process; the interdependence of engineering academics; the potential for conflict between competing internal, cognitive, interests (the instructional discourse which leads to the PRF); and the importance of regulatory influences such as government funding priorities and the engineering accreditation bodies (the ORF).

The emphasis on what is to be taught to new generations of students is decided through the distributive rules of the field of production, which is largely at the direction of the state with a view to meeting the needs of industry. The ORF is constituted through both the influence and direction of the state, but also is influenced, for engineering, by our professional bodies (Klassen, 2018; Moodley, 2014). Together these act to influence: what knowledge is selected; why that knowledge is selected, and how that knowledge is recontextualised in pedagogy; and to influence the identity formation of both academics and students.

Tyler (2004) proposes Bernstein's ideas relating to pedagogic discourse provide a means to analyse market-driven educational policies, their implementation and impact, and Klassen (2019) has shown how it can be extended to consider higher education and the professions. Thus the pedagogic device provides a framework through which OBE, and the competing interests involved in influencing and controlling IoT engineering education, can be considered. Sitting alongside the insight provided through Young's deep interest in policy and its implications, this provides me with a means to analyse the role of the various influencers and regulators concerned with OBE in Ireland's IoT engineering education system.

4.8 Pedagogy and Identity Formation

Bernstein (2000) defines pedagogic identity as "the result of embedding a career in a collective base" (p. 66), and as being shaped by educational reform. Pedagogic identity emerges from the pedagogic practices resultant from the interaction of dominant social interests in both the ORF and PRF.

Bernstein (2000) contrasts different types of pedagogic practice that may emerge within the pedagogic device, influencing the pedagogic identity of the teacher and student. The first of these is termed competenc*e* or therapeutic, associated with learners having control over the pace, selection and sequencing of their learning. In a competency model highly trained teacher/facilitators assist students in moving towards their personal goals. It is assumed that all may become competent, that there is a "democracy of acquisition" (p. 43), and that learners actively participate in the construction of their own individually-oriented knowledge. However, in a performance model, strongly classified, emphasising assessment and grading, students have little control over what, when, where, or the pace at which, they learn. Performance models reflect pedagogic practices in knowledge fields with strong classification where grading, and relative performance of learners, is a key aspect. Bernstein regards performance modes/models as associated, primarily, with singulars and regions.

Bernstein (2000) cautions of the tendency for regions to be dominated by market pressures, which can cause regionalisation to become “a crucial recontextualising procedure” (p. 60), and Heywood (2016) identifies and challenges the utilitarian model of engineering education that has dominated post-ww2. Bernstein (2000) concludes that regionalisation, and its susceptibility to market pressures, leads to an erosion of the “inner commitments and dedications” (p. 62) of introjected identities associated with the disciplinary discourse to be replaced with “state-promoted instrumentality” (p. 61).

I earlier discussed the changes in academic identity as the Regional Technical Colleges (RTCs) expanded from their initial role (Hazelkorn & Moynihan, 2010; Moynihan, 2015; O’Byrne, 2009, 2011, 2014). A finding is that these changes are consistent with Bernstein’s concept of pedagogic identity changing under the influence of a changing pedagogic discourse. The introduction of OBE, constituted as part of the ORF of IoT engineering education, would be expected to have a significant effect, above and beyond being a workload and quality assurance (QA) matter, on the pedagogic discourse, and pedagogic identity.

4.9 IoT Engineering Education Viewed as a Pedagogic Device

Knowledge is “socially produced and acquired in particular historical contexts, and in a world characterized by competing interests and power struggles” (Young, 2008, p. 88). Through my research I have shown that an understanding of the socio-historical context of IoT engineering education’s adoption of OBE encompasses: the development of the engineering technician education system in the RTCs and its subsequent evolution into contemporary IoT engineering education; a review and critique of the development globally of OBE; a discussion of the skills focus that arose in Irish government education policy and that led to the development of Ireland’s NFQ; and the concurrent adoption by EI of an OBE accreditation approach influenced by international developments in engineering accreditation, and also by the Bologna process.

The policy debate and formation which led to this can be regarded as the struggle over, and the establishment of, the distributive rules of the pedagogic device of IoT engineering education. Control of this is associated with the official knowledge of government policy and associated organisation and legislative structures. This includes Quality and Qualifications Ireland (QQI), the NFQ, the Higher Education Authority (HEA), the Department of Education and Skills (and the skills emphasis in government educational policy), the various RTC and IoT acts and other legislation, and the governance structures of the IoTs. Official knowledge is also formed from the influence of EI, through their accreditation requirements. The IoT engineering education system, can be represented, as per Klassen (2019), as a pedagogic device, *Figure 4-2.*

The distributive rules governing the structure of this education (Kwok, 2017; Lim, 2014) include the NFQ, which is used as a key policy tool in the government's skills agenda for higher education, i.e. who is taught what. EI, through their accreditation requirements, and the affect that their interpretation of Bologna has had on the structure of engineering education, also form part of the distributive rules, i.e. where things are taught.

The discourse of the ORF, where factors related to the use of OBE compete to exert control over the pedagogic discourse in the field of recontextualisation, is formed, *inter alia*, from the influence and prescription of the NFQ and EI, particularly over course design and course structures. Key aspects are set out below.

- The government skills agenda for higher education, which is enabled through OBE, and which is linked to the concept of lifelong learning.
- The NFQ value of *transparency*, through which the use of LOs is mandated, is a key factor in course design and programme review (Kenny, 2006).
- The nomenclature of the NFQ, and the QQI Engineering Standards form a language of learning (Biesta, 2005), influencing academics' engagement with LO's. However, I will show that the voices of the interviewees reveals this goes deeper, in their use of a language of levels (Raffe, 2011) to engage with policy *and also* academic practice.
- The structure of the NFQ, and the foregrounding of progression.
- EI's accreditation requirements reinforce the use of OBE (Forero et al, 2011; Kenny, 2006), and additionally influence the structure of engineering education.
- EI also have a further, complementary, influencing role as the professional body of the community of practice of engineering.

In examining this struggle over the pedagogic discourse (Bernstein, 2000) I regard the NFQ and EI, alongside government policies and economic imperatives, as having both an implicit influencing aspect and an explicit prescriptive aspect (Ingram, 2016; Slough-Kuss, 2015) on engineering education and educators. This dual aspect of control over Irish education is recognised by Kenny (2006), who views policy implementers as seeking to "*influence*[23] and *direct*[23] the higher education environment" (p. 311) and the work of academics.

[23] My italics

Field of Production

Sites for Creation of New Knowledge

Distributive rules: The selection of skills and competencies as what is to be taught to new generations of students can be seen as a consequence of the dominant influence over the distributive rules by neo-liberal oriented economic interests.

The NFQ promotes the teaching of skills in higher education, in line with government policy.

EI's accreditation requirements increase vertical stratification in engineering education.

Field of Recontextualisation

IoT Engineering Education as a site where knowledge and skills from the field of production are selected, re-arranged and transformed to become pedagogic discourses. This includes programme and module design.

Recontextualising rules

The Discourse of the Official Pedagogic Field

The ***ORF*** is formed from the influence and the control of the NFQ, QQI, HEA, and also EI's accreditation requirement, i.e. by Official Knowledge

Aspects of this discourse include:

Government Policy, in particular the skills driven knowledge economy and related economic imperatives

Transparency, a key under-pinning of the NFQ, manifests as use of learning outcomes, leading to new course design requirements

The nomenclature of the NFQ, helping to communicate policy and shape implementation, including the level descriptors and the engineering standards

Progression is foregrounded

Skills being emphasised

Engineers Ireland require OBE approach for accreditation

The Bologna declaration

The Discourse of the Pedagogic Recontextualising Field

The ***PRF*** incorporates the cognitive interests of academics

The NFQ would be expected to influence the pedagogic discourse

Pedagogic identities of academics are being re-shaped by the **ORF**

Field of reproduction

The IoT Engineering sector as sites of teaching and learning

Evaluative rules

OBE approach to teaching and learning.

Identity of new graduates is being formed.

How is the technician identity being affected?

Figure 4-2 The Pedagogic Device of IoT Engineering Education, as Shaped by the NFQ and EI, alongside other Policy Drivers, adapted from Bernstein (2000)

In Collins et al (2009), the framework is described as “embedded in academic policies” (p. 10), reflecting an explicit prescriptive aspect. In constituting part of the dominant, regulative, discourse of the ORF, the NFQ exerts explicit control over the pedagogic discourse through defining new course structures and validation requirements which *must* be followed. Similarly, EI’s use of LOs within their accreditation processes is quite prescriptive. Slough-Kuss (2015) characterises this as the ORF describing what education “should be” (p. 19).

On the other hand the influencing nature of the framework is suggested where understanding of the framework is said to depend upon “the level of engagement of individuals" (Collins et al, 2009, p. 16), and the “the *insinuation*[23] of the Framework into the daily processes of teaching and learning” (p. 49). The more inclusive engagement referred to by Collins et al seeks to connect educational policy with academics as “social actors” (Slough-Kuss, 2015, p. 23), *influencing* lecturers in how they approach course design, pedagogy, knowledge acquisition and recontextualisation of knowledge.

The resultant pedagogic discourse acts to re-shape the pedagogic identity of academics: in their attitudes to knowledge (Allais, 2014; Barrett & Rata, 2014b; Young, 2008), curriculum and pedagogy (Bernstein, 2000; Muller, 1998), and may impact on the stratification of engineering education itself. This will have consequences for the education we teach, and in turn the identity formation of our engineering students. The pedagogic device provides a model within which the fieldwork can be conceptualised, allowing consideration of the pedagogic discourse that has arisen (Bernstein, 2000).

4.10 Conclusion

I have shown how my conceptual framework draws selectively on social realism, alongside my experience as an engineering educator. This foregrounds the influence of power relationships on the structure of that education and the selection of knowledge in the curriculum. Engineering is regarded using Bernstein’s concept of a region, which highlights the influences of the professional bodies and the market in engineering education.

Key to my conceptual framework is the use of the pedagogic device to model the discourse of IoT engineering education. In order to establish the “rules” (p. 27) which regulate the behaviour of the pedagogic device of contemporary IoT engineering education, I drew on the socio-historic accounts I developed earlier, and the understanding of the power-relationships in this contested field these accounts, and my own experience, engendered.

The distributive rules of this pedagogic device are determined by official knowledge of the state, EI, and market influences. Alongside the cognitive interests of engineering academics, these additionally contest the field of recontextualisation. The field of evaluation consists of the sites of teaching and learning for IoT engineering education, and is where the identity formation our engineering students takes place. This pedagogic device will be used to frame the analysis of the fieldwork, and to situate critique of OBE, as I examine its impact on my interviewees and the engineering education system they work within.

This provides a conceptual framework from which the political and socio-economic considerations that lead to the use of OBE, including EI's role as the engineering professional body, can be regarded and critiqued. It acknowledges the stratification inherent in engineering education and the power relations at play, foregrounding related issues, such as progression and student identity formation. It allows consideration of our identity formation as engineering academics, in terms of the discourse we engage in as pedagogues, and with regard to how we view knowledge, skills, and their recontextualisation in the curriculum.

Chapter 5 Research Methodology

> *Beware of first- hand ideas!' exclaimed one of the most advanced of them. 'First-hand ideas do not really exist. They are but the physical impressions produced by love and fear, and on this gross foundation who could erect a philosophy? Let your ideas be second-hand, and if possible tenth-hand, for then they will be far removed from that disturbing element - direct observation.*
> E. M. Forester (1909, part III, para. 3).

5.1 Introduction

I designed the research methodology to allow me to examine how engineering academics in the Institute of Technology (IoT) sector perceive the impact of outcomes based education (OBE), on themselves and their colleagues, on the education they teach, and on the identity formation of their students. Given my training as an engineering educator, with strong positivist and rationalist influences, following a quantitative approach might have seemed more natural (McNutt, 2010; Nudelman, 2018). However, as I was introduced to the concepts and possibilities of qualitative research, the rich understandings it enables, including for engineering research (Kelly & Bowe, 2011), offered a powerful approach to gaining insight from my engineering academic colleagues at the "front line" (NAE, 2001, p. 23) of OBE. Furthermore, I have, through my time as an engineering, and academic, manager, seen the value in gaining an "individual's point of view" (Denzin & Lincoln, 2011, p. 9) in order to develop understanding of shared issues, a strength of qualitative research. I concluded that it would be very difficult to understand the field I was researching without using a qualitative approach to gain access to the ideas, impressions and actions of my colleagues and peers in the sector: quantitative methods, such as surveys, would just not provide the rich data I needed for my research to progress.

As is not uncommon in qualitative research (Hewlett, 2013), my research had not been fully planned, and, as it progressed I struggled with a theoretical framing which would allow me to make sense of the complex field my literature review, and the fieldwork, began to reveal. My literature review grew from being an analysis of the National Framework of Qualifications (NFQ) as it related to IoT engineering education to encompassing a number of inter-related socio-historical accounts: of the genesis of engineering education in Ireland; of the development of the RTC/IoT sector in response to government policy that saw education as playing a key role in improving the life of the citizenry through economic advancement; the later development of the NFQ as part of a skills-focussed reorientation of higher education; and the reasons for, and consequences of, the adoption of OBE for engineering accreditation, internationally and in Ireland. As I read further into the literature, and began to analyse data from the fieldwork and grappled with how to interpret it, Bernstein's (2000) concept of engineering as a region, alongside social realist critique of OBE, offered explanations which resonated with what I was reading and observing. This led me to develop the conceptual framework described in *Chapter 4*.

My conceptual framework reinforced the importance of following a qualitative methodology. This research approach allows us to seek understanding regarding what it is about the social structures in which effects are observed that have caused them to come about (Sayer, 1992), and offered an approach to accessing the knowledge of practitioners in the discourse (Sayer, 2000) of IoT engineering education. Van et al (2008), from an engineering perspective, regard a qualitative approach as ideal for research that explores the thought processes and dispositions of teachers and students, allowing for the generation of descriptions and understanding of their actions in context. Hewlett (2013), from a social realist viewpoint, highlights the relevance of a qualitative approach in research challenging the dominant viewpoint of curriculum. This has a particular resonance with my research, which examines issues related to the privileging of the dominant discourse (Tilley, 2019) of learning outcomes (LOs) in engineering education. These arguments gave me confidence that my research methodology would connect my theoretical paradigm to "strategies of inquiry" (Denzin & Lincoln, 2011, p. 14) and "methods for collecting empirical material", through working with my research participants to generate the understanding I sought.

Representing the engineering education system in the IoTs as a 'pedagogic device' provided a focus for my lines of inquiry. My fieldwork was particularly concerned with the role played by the NFQ (QQI, 2014b) and EI's accreditation requirements as 'official knowledge' (Klassen, 2018; Moodley, 2014), although other government policy, legislation and associated organisational structures also contributed. I used the framing provided by the pedagogic device to examine how these influences on the pedagogic discourse act to re-shape the pedagogic identity of academics, on their attitudes to knowledge, curriculum, pedagogy, the identity formation of students, and on the stratification of engineering education itself.

This chapter discusses the choices I made in designing the fieldwork and analysis phases of the research methodology, describes the implementation of the associated research methods and concludes with a discussion of ethical issues.

5.2 The Research Question

The research question is "what effect has the use of OBE had, and is having, on engineering educators and engineering education in the IoT sector in Ireland". A serious of related sub-questions emerged from the research process which I explored with my research participants, taking cognisance of the claims of proponents and critics of OBE.

To begin with I expanded the research question to consider aspects such as:

- how do engineering academics perceive the influence of the NFQ and EI?
- what other policy driven changes to engineering education are at play in the sector?
- what acceptance has there been by academic staff to the use of OBE, and how is this manifest?
- are any of the problems that were suggested in the literature evident?
- how are the NFQ principles of transparency and progression seen to have impacted on engineering education?

However, as the literature review progressed (*chapters 2-4*), and my conceptual framework began to solidify, deeper, more reflective, questions emerged:

- how are these factors affecting the pedagogic identity of the engineering faculty?
- what effect has OBE had on: pedagogy; curriculum design; and knowledge building?
- what changes are seen to have occurred to the structure of engineering education in the IoT sector since the implementation of the NFQ?
- do these changes reflect a shift from technician education to professional engineering education in the IoT sector, or is something more complex occurring?
- what are the implications for the stratification of engineering education and the identity of the graduates being produced?

The questions I posed in the interviews were also influenced by aspects of IoT engineering education highlighted by my research participants. In particular, the emphasis, in the first interview, by Bill on the concept of progression caused me to foreground my inquiries in that regard. A further notable interview topic that emerged from the analysis of the earlier interviews was to ascertain my research participants views of the 'language of levels' that was to become apparent in the analysis. This not only confirmed my interviewees were cognisant of its use, but, in one case (George) led to discussion as to whether it was appropriate for representing graduate identity. As the interviews progressed, the importance of Engineers

Ireland (EI) influence also became even more apparent than it had through the literature review, ensuring I gave my interviewees adequate space to share their view of this with me.

5.3 Selection of Research Participants

Having chosen avenues of inquiry, my selection of interviewees was guided with a view to allowing the areas of inquiry that I had identified to be investigated (Denzin & Lincoln, 2011; Sayer, 1992). To achieve this I used my knowledge of the field to address a number of crucial issues, including ensuring that those I recruited would be in a position to contribute effectively to my research (Denscombe, 2003), and that I would be able to recruit a sufficient number.

Engineering lecturers are experts in particular facets of engineering and engineering education, but, also, they share common roles, aims and means of enacting those. I decided that research participants should be my colleagues in the sector, practitioners in the field, from whom I hoped to gain access to the insight and understanding I sought. My research participants would have either or both of the following roles:

- engineering academics, from whom I would seek to understand their experience of the effect of OBE.
- academic management/leaders who would be able to provide a complementary viewpoint of their experience of helping to lead the implementation of OBE.

I considered whether probability or non-probability sampling was appropriate (Saunders, 2012) for the selection of research participants, and in addition what constituted the sampling frame I should use (Denscombe, 2003). Given the nature of the research, the resources available, and the research question, the rich understandings offered by non-probability sampling, see *Table 5-1,* seemed most suitable in the search for answers to the research question. This offered an approach in which I could gain a new perspective on the use of OBE in engineering education, revealing and illuminating key themes, and which would support theoretical generalisations (Saunders, 2012).

In non-probability sampling the choice of potential research participants is "based on the researcher's judgement regarding those of the population's characteristics that are important in relation to the data required to address the research aim" (Saunders, 2012, p. 39). All of my prospective research participants, i.e. lecturers, heads of school, heads of department, had lecturing duties, were involved with course design and delivery, and with knowledge building associated with that, i.e. they helped form the 'pedagogic recontextualising field' (PRF). Management would bring an additional perspective on managing the change to OBE, where they act as an interface between the 'official recontextualising field' (ORF) and the PRF. However, the predominant viewpoint that I sought was that of lecturers' perception of the change in engineering education, and how they perceived this impacted them. Consequently, I chose a ⅔ to ⅓ split in sampling between lecturers and academic management.

Table 5-1 Differences between Non-Probability and Probability Sampling (Saunders, 2012, p. 39)

Difference	Non-Probability	Probability
Specification of Population	Not Necessary	Essential as is a sampling frame
Basis of sample choice/selection	Researcher's judgement	Random
Basis of generalising from sample	If undertaken theoretically findings may be transferrable	Statistical representation
Nature of aim usually addressed	Exploratory, answered using rich understandings	Explanatory, answered using statistical inferences
Sample size	**Relatively small (other than for quota sampling)**	**Relatively large**

The sampling frame consisted of a relatively homogenous group (Morgan D. , 2008), for which a sample size of twelve has been suggested as sufficient (Ando et al, 2014; Boddy, 2016; Fugard & Potts, 2016; Saunders, 2012), particularly where the research is seeking to understand, and develop themes, related to their shared experience (Guest et al, 2006), as was the case with my own research. I decided to aim for fourteen research participants in total, falling into one or more of the inter related categories of lecturers, heads of department, and heads of school involved with engineering programmes in the IoTs. The decision to aim slightly above the minimum sample size allowed for a situation to arise, where, post-interview, a research participant might withdraw from the process.

There is a significant gender disparity in engineering in Ireland (Fingleton et al, 2014), with females representing 20% of undergraduate students, but, only 9% of those who attain Chartered Engineering status. In my selection of research participants I endeavoured to ensure I had a female voice, representative of the sector, with three of the fifteen interviewees (20%) being female, which included one in an academic management position.

I did not set out to select academics by discipline, as, in terms of the conditions under which we serve as IoT engineering academics, and the pressures we experience as educators from the NFQ, and EI, we appear to me a relatively homogeneous group. Take up of the invitations was by academics involved in the delivery of either electronic or mechanical related engineering programmes, or with one of these as their original engineering specialism, and civil/structural engineering academics were not represented in my fieldwork. This reflected the academic profile of my own department, and it is apparent, that, in leveraging my knowledge of the sector to identify potential interviewees, I favoured these disciplines.

This is significant in that, although EI accreditation is particularly relevant for employment as a civil/structural engineer, it is less so for electronic or mechanical engineering graduates. To illustrate this consider EI (2019a), a list of those companies that EI accredit for continuing professional development for their employees, which is dominated by civil engineering oriented employers. In my own experience as an electronic engineering graduate the issue of EI accreditation has never been raised in any job interview I have participated in, either as an employer, or potential employee. Although, as will become clear from the fieldwork, the pressures of EI accreditation on engineering education are very important for my interviewees, it would be expected that the relevance to employment would be raised. This leads to a limitation for my research findings, discussed, below.

The physical environment, the people with which an interaction takes place, and the objects with which someone interacts in the gaining of an experience, are intertwined. Situating the fieldwork in a physical location related to a research study helps to stimulate memories of the conditions of the experience in order to help the interviews flow. On this basis I decided the fieldwork should be situated in each participant's IoT.

I used an informal approach, using my contacts in the field, to identify potential research participants. However, conscious of power issues associated with my position as an academic manager in the IoT sector, I followed a two stage process to invite and discuss participation with potential research subjects, as discussed below in section 5.9 on ethical considerations.

5.4 The Role of Document Analysis in my Research Process

In considering curriculum, Young (2008) stresses "its fundamentally social and historical basis" (p. 19). Documentation proved an important source of historical data, providing insight into the genesis of Irish engineering education, the state of play of this education pre-1960s, and the subsequent development of the RTC/IoT sector. I also used documentation in my consideration of how the ideas that led to OBE had evolved over time, and in examining the factors leading to the global proliferation of national qualification frameworks (NQFs). Historical records further illuminated: the policy development that led to the NFQ; international influences; the consultative process that was followed; and the structure and values of the NFQ as it became a statutory instrument. In considering the pedagogical basis of the NFQ, available evidence indicated this was afforded little discussion, even though my research suggested it was important. In investigating the implementation of OBE in IoT engineering curriculum I made use of programme schedules mapped to the NFQ, e.g. ITB (2016). I further used documentation to assist in developing an understanding of the global move towards LOs based accreditation in engineering education, and EI's adoption of same for Irish engineering education. This historical data also illuminated the social pressures that influenced the policy formation and implementation that the records describe.

I also applied two document analysis techniques in my research. I used Corbell's (2014) keyword analysis methodology to examine the co-occurrence of the terms "knowledge" and "skills" in NQAI (2003a) to support and develop an argument regarding the NFQ as a policy tool in promoting a skills agenda in higher education. I made use of readability analysis (Reck & Reck, 2007), as applied to curriculum LOs, to support an argument that the NFQ concept of transparency (of LOs) was not a valid concept in consideration of the accessibility of their meaning to prospective students, or students in the early years of study on a programme.

5.4.1 Keyword Analysis for *Knowledge* and *Skills*

Corbell's (2014) keyword analysis methodology is concerned with "issues and problems" (p. 110) relating to knowledge, which are "significant for the development and social distribution of knowledge through the vocational curriculum" (p. 110).

Corbell's premise is that the co-occurrence of the words 'knowledge' and 'skills' in a text representative of a particular policy discourse is indicative that the individual meanings of the words may have been superseded, for that policy discourse, as the words occur *together* as a *binomial*[24]*,* with a new joint meaning. In order to establish what meaning this binomial might have, Corbell (2014) notes the change in dictionary (Oxford University Press, 1992, 2012)

[24] A "commonly occurring pair of words linked by a conjunction which works within a sentence as […] a single word" (Corbell, 2014, p. 115)

definitions of knowledge from 1992 to 2012, where in the latter version one of the associated definitions includes 'skill', and a further definition frames knowledge squarely in the context of the knowledge economy; on the other hand a more abstract definition of knowledge as representing that which is known has been dropped when compared with the 1992 edition. Corbell draws the conclusion that this is indicative that the phrase 'knowledge and skills', is in fact, a proxy for 'skills'.

To investigate the significance, keyword analysis searching for the co-occurrence of the words of interest is applied to documentation associated with the policy discourse. Corbell proposes this can be facilitated through the identification of what he terms a nodal text (a key policy document) associated with the policy discourse, to which keyword analysis is then applied to quantify the degree to which the conflated term is present, and to allow consideration of the contexts within which it is used. Corbell demonstrates the effectiveness of the technique through the analysis of a nodal text associated with the policy discourse on education and the knowledge economy in Australia, finding an overwhelming use of the words 'knowledge' and 'skills' together. This juxtaposition of knowledge and skills in policy documentation implies an associated dilution of the more abstract meaning that can be associated with knowledge (in line with the changes in dictionary definitions). Corbell (2014) concludes that "the voice of knowledge is being silenced in through its conflation with skills in the lexical item knowledge and skills" (p. 118), which he particularly associates with the use of NQFs.

In my research I had a concern, that, regardless of the lifelong learning and student-centred policy aspirations associated with the introduction of the NFQ, and although NFQ LOs should encompass knowledge, skills and competence (NQAI, 2002b), the primary driver was to increase the skills focus of Irish education. Corbell's keyword analysis as applied to the use of 'knowledge' and 'skills' together offered an approach to investigate this. In line with Corbell's methodology I identified NFQ (2003), a compendium of the policies and criteria related to the establishment of the NFQ, as a suitable nodal text, and applied keyword analysis, as described in *section 3.7*, to support the argument that a skills agenda was the primary focus of the NFQ.

Although I have made use of keyword analysis in a similar policy context to Corbell, I note that it has the potential for wider applicability. In order to utilise it in the analysis of other policy discourses the following steps are suggested: the co-occurrence of keywords of significance in the policy discourse under consideration should be identified; their meaning, separately and as a binomial, established; the significance of the meaning of the binomial in the policy discourse determined; and appropriate nodal documentation identified to allow the significance of the usage to be considered.

5.4.2 Readability Analysis

One of the claims associated with LOs is that they promote transparency (one of the values of the NFQ) with regard to qualifications (Cort, 2010), for all stakeholders, including students and prospective students. However, as discussed earlier (*section 3.6.1.3*), there are compelling arguments in the literature as to why transparency of LOs is not achievable for non-domain experts (Cort, 2010, Young, 2011, Heywood, 2016), for whom the language of levels and learning provided by NQFs through LOs would be largely opaque. In the fieldwork I was to discuss the validity, importance and application of transparency with my research participants.

Readability analysis (Reck & Reck, 2007) offered a further route to explore this through providing an analytical tool to measure the readability of programme LOs from curriculum documents. This allows their readability, and hence transparency, to be quantified, and thus the accessibility of LOs to non-experts to be ascertained. Alongside investigating transparency in the fieldwork and literature, I was to make use of this technique to examine particular claims for transparency: that prospective students should be able to understand LOs sufficiently well to make an informed decision regarding entering a programme of study (Kennedy, 2007; Lindholm, 2009) and additionally that LOs should be easily comprehensible by a student in the earlier years of study on a programme (Kennedy, 2007; QQI, 2018).

In considering prospective students, Lindholm (2009) links LOs directly to the marketing of a University's programmes: "learning outcomes communicate to prospective students, their parents, and the public what is valuable about (an) academic program." (p. 9). Armstrong & Lumsden (1999), in investigating the impact of a university's marketing material on prospective students, suggest that "most of all, the materials need to speak the (prospective) students' language" (p. 90). Similarly, QQI (2018) propose that LOs should be comprehensible to students, although I counter argue that, for students in earlier years of study, their epistemological journey has not yet progressed sufficiently for them to be fully familiar with the terminology of their academic discipline as will be used in the specification of the LOs.

In order to demonstrate the complexities of programme LOs for qualifications mapped onto NQFs a readability analysis of the programme LOs of a number of such programmes is presented in *Appendix C*. Such programme level LOs are readily available for IoT programmes mapped to the NFQ, e.g. ITB (2016), MTU (2021), DKIT (2021), from which a critical point related to the value of readability analysis for my research emerges. On the one hand, in keeping with the NFQ value of transparency the IoTs make their LOs based programme curricula readily available through open-access web interfaces. On the other hand, this only has value for non-expert readers if the programme LOs are, indeed, easily comprehensible, or transparent, to them.

To carry out the readability analysis I used an on-line utility (Readability Calculator, 2017), which takes as input the text of the programme LOs I was considering. Through the use of a number of readability algorithms, Coleman-Liau, Flesch Kincaid Grade Level, Simple Measure of Goggledygook (SMOG), Gunning Fog Index, and the Automated Readability Index, the utility provides indices representing the readability of the input text in terms of the number of years of formal education needed to easily understand the text (Reck & Reck, 2007). A note of caution is sounded in the literature, in that "domain specific attributes such as complex terminology or language can direct readability scores towards higher values than the actual complexity of the text warrants" (Reck & Reck, 2007, section *Introduction*). However, I argue that in my research into the transparency of LOs, which may well contain such complex terminology, a useful measure of readability is precisely one in which the presence of such domain specific attributes is taken into account.

Detail of readability analysis of a selection of programme LOs is provided in *Appendix C.* For the sample I considered, readability analysis indicated that, rather than the meaning of the programme LOs being accessible to prospective students with a pre-university education, or indeed to students in the earlier years of study of a programme, a much higher level of education (at least to graduate level) would be required to easily understand them. I make use of this in the discussion in *section 11.3* in relation to claims by QQI (2018) for the transparency of LOs.

5.5 Selection of Data Gathering Methods

As I briefly began to discuss earlier, in selecting a research methodology a "social researcher is faced with a variety of options and alternatives and has to make strategic decisions about which to choose" (Denscombe, 2003, p. 3). In developing my research methodology, I had to consider the research questions (Ryan, 2006), the type of data that would most suitably lead to answers to these questions, and approaches to gathering this data (LeCompte et al, 1993). In my research I needed to select methods that would allow academics' views to be gathered and analysed. Having considered possible approaches to generating the qualitative data required for the research, I chose a semi-structured interview approach, followed by the use of a focus group.

5.5.1 Interviews

Interviews, in which the researcher works with research participants to generate accounts related to the research issues, are the predominant data collection tool for qualitative research (Peräkylä & Ruusovouri, 2011), and have been usefully applied in the field of engineering education research (EER) (Kelly & Bowe, 2011; Lauritsen, 2012; Karwat et al 2014; Sheppard et al, 2006; Van et al, 2008). Denscombe (2003) points towards the attractiveness of interviews for data gathering, given that it uses the conversational skill of the researcher and the interviewee. However, he distinguishes a conversation from an interview, where the research subject has consented to take part and have their participation on the record, and the agenda is set by the researcher. Interviews can be used to gain in-depth information on a topic, often from a relatively small number of participants, and are suitable in situations where the researcher requires information on "emotions, experiences and feelings", "sensitive issues" (Denscombe, 2003, p. 165) or where the information would be "based on privileged information" held by key individuals. In my research key individuals, engineering lecturers and management, hold privileged information with regard to how they, and the engineering education system they work within, have been affected by OBE. This strongly suggested interviews as a data-gathering technique for my research.

In considering what type of interview technique to use, structured (Firmin, 2001b), semi-structured (Denscombe, 2003, Adams, 2010), or un-structured (Firmin, 2001a). I reflected on my aims. Most importantly, I wanted to ensure that my research participants' experience was the "focus of the interview" (Adams, 2010, p.20). It was key that the interviews would go into sufficient depth to get to the detail of the various ways my research participants might have perceived engineering education has changed under the influence of OBE. Additionally, I anticipated that they would have views and experience with regard to OBE that I had not considered, and it was essential that I provide them with the opportunity to discuss these.

On this basis I chose to use semi-structured interviews, which consist of a defined list of questions to addresses a pre-determined list of topics (Denscombe, 2003), but the interviewer uses their discretion with regard to what is asked. Open questions encourage the interviewee to expound on topics raised, and allow the interview conversation to flow and develop. Semi-structured interviews should be used “in research questions where the concepts and relationships among them are relatively well understood” (Ayres, 2001, p. 811), which was to an extent true of the research proposed in this project. Ayres (2001) further states that “the development of rich, relevant data rests on the interviewer’s ability to understand, interpret, and respond to the verbal and nonverbal information provided by the informant” (p. 811), where, given I was working in the field, I was well-positioned to do.

5.5.2 Focus Groups

In a focus group research participants are collectively interviewed and group conversations are enabled (Kamberlis & Dimitriadis, 2011). Focus groups also allow pedagogical interaction with the participants, and furthermore, can have a political dimension, where they can be used to raise group consciousness regarding a topic (Liamputtong, 2011) towards enacting change. Kamberlis and Dimitriadis (2011) propose that focus groups work best when all three facets are in play, where the synergy of the research, pedagogy and politics are exploited to produce data and effects that cannot be realised through individual interviews.

A focus group would provide the opportunity for a collective voice to emerge with regard to the impact of OBE. This could reveal more, or something different, than interviewing individuals, which could only be ascertained by utilising them in conjunction. Additionally, I considered that focus groups could be used in reviewing and expanding the initial findings of my research, after individual interviews had been undertaken and analysed (Morgan, 1998).

I also considered the political and consciousness raising facets of focus groups. As a former registrar in ITB and currently HoD in TU Dublin, I had to respect the power and political relationships between myself and other academics, and also other registrars and IoTs. A focus group concerned with the impact of OBE on engineering education and educators could be seen as a political statement within the sector, and as something I was trying to drive change in. Similar issues existed for McNutt (2010), a Head of School of Informatics and Engineering, who used focus groups in his research into the habitus of educational technologists. McNutt regarded this political dimension positively for his participants, which could “contribute to local initiatives designed to consolidate the status of the individuals as practitioners within the field.” (p. 86). Similarly, Fitzsimons (2015) reported that the focus groups used in her research had a strong political and pedagogising element for some participants, and provided them with a “feeling of empowerment and energy” (p. 356).

Having considered the political dimension to focus groups, and having reviewed the positive view discussed above, my concerns were mitigated. I realised that, in the same way that a focus group has a political facet to it, so do my studies, readings and research towards a doctorate (Ryan & Walshe, 2014). Indeed, as my fieldwork progressed, and I began to draw conclusions with regard to my research, I found that I actively sought out conversations with my colleagues related to these issues, on the basis that these were important topics for us to consider, and I welcomed the opportunity to run a focus group when it arose.

As discussed below in the section on ethics, the use of focus groups also has a power relation dimension to it, where “focus groups can (and often do) mitigate or inhibit the authority of the observer, allowing participants to ‘take over’ or ‘own’ the interview space” (Kamberlis & Dimitriadis, 2014, p. 324). This further supported their use, given my concerns about power relationships with the research participants.

I decided to use a focus group as a means for reviewing and expanding the initial findings of the research, inviting those I had already interviewed to take part.

5.6 Conducting the Interviews

I commenced each interview by seeking to establish with the research participants how they came to be an engineering academic in an IoT, what they currently do as an academic, and seeking to elicit from them what they thought had changed consequent to the introduction of OBE. Prompts I used to ensure important aspects were covered included:

- what did they see as their role, e.g. course design, assessment, delivery, and research? (“how did they become a lecturer” was an opening line in each interview);
- how did they relate to the use of theory and practice together? This concerned both the pedagogical use of theory and practice together to aid learning, and also with the use of theory and practice together in the teaching of engineering practice;

- what impact has OBE had, in terms of how they approach course design, delivery assessment, pedagogy, and their own approach to knowledge building;
- how do they see what they do now to be different to before the NFQ, and how do they relate to any perceived change;
- how they keep to the forefront of developments in their technical fields?
- understanding how technologies, techniques and theories can be combined together and applied to achieve practical effects, often in the development of engineering systems to achieve particular desired effects;
- their research interests;
- what influence have EI had?

In preparing for interviews, Plummer (2001) advises being concerned with the practicalities of the interview location, arriving on time, ensuring the functionality of the recording device, and planning in advance how to conduct the interview. He stresses being an empathic and good listener: considering aspects of the interview that you as an interviewee would struggle to answer; and reflecting on why these may provide that tension and how to move through it. Plummer suggests showing alertness and interest, and considering how to deal with resistance to addressing particular topics. Denscombe (2003) on the other hand believes “the good interviewer is able to tolerate silences during the talk” (p. 177). This was all useful advice which I considered in advance of the interviews taking place. In particular I felt the most important thing to do to avoid silences and tensions was to build a rapport with each research participant at the beginning of the interview, as discussed below, and, in general, to use our shared experiences to move through times in the interview where the conversation faltered. Although the interviews flowed quite freely for the most part, I did find that, on occasion, with no discernible pattern, a topic I raised did not elicit a strong response. In such cases I tried, often successfully, to bring the conversation to life through speaking with them on our shared experience of the topic, and where that was not successful I moved on to the next question. I was, however, conscious that I was there to get their perspective, rather than share my own, and I was careful to try and maintain my role as interviewer.

I conducted fifteen interviews in total between June and November 2016, of which four were academic management, one former academic management, and the other ten lecturing staff. I had an uptake of approximately 50% on interview invitations, which I issued in groups of 4-7 in order to pace the interview schedule. I noticed that a positive response to an interview invitation was more likely from those with which I was personally acquainted, although a number (six) were not known to me previously. Furthermore, in considering those who responded positively, I note the majority (fourteen) had been involved in engineering research of one form or another. The interviewees came from six of the IoTs, with participants from individual IoTs numbering five, four, two, two, one and one respectively. Of the fifteen research participants, nine had experience as IoT engineering academics prior to the transition to OBE, five had joined whilst that transition was ongoing (i.e. before a complete cycle of programme renewal through programmatic review and/or accreditation), with only one having joined the IoT sector when the use of OBE was more fully established. All interviewees signed the consent form as per the agreed ethical protocol.

Equipment failure resulted in the audio recording for one interview (Grace) being lost. Taking heed of Denscombe's (2003) advice I checked that the equipment was working prior to the interview commencing. However, the malfunction occurred and the data was lost. After that I used two recorders. The interview still yielded interesting data, in the form of a memo of the interview agreed as part of the process of informing the interviewee that the data had been lost, the salient point of this memo having been captured in my fieldwork journal. The net result was that I had fourteen interviews fully transcribed, and one additional interview which, although not transcribed, still contributed valuable data.

The interviews were transcribed using a professional service. Upon receipt of the transcripts they were anonymised, but otherwise unchanged, and forwarded to the interviewees for comment, as agreed in advance. This gave each participant the opportunity to review the interview transcript, and, ultimately, they could ask for this not to be used in the thesis. The transcripts describe aspects of a research participant's life, and their views related to their profession, and there was a possibility that an interviewee would later disagree with the use of their transcript. However, I received no requests to amend or withdraw the interviews, although one asked that I be cognisant of where they might have spoken on sensitive matters, and be judicious with regard to how I used their words, but left it to my discretion.

Research subjects were anonymised using the first names of famous engineers, Bill (Gates), Gordon (Moore), Ayah (Bdier), Vitruvius (Marcus Vitruvius Pollio), Rudolf (Diesel), Isambard (Brunel), John (Logie Baird), Kees (Bulthuis), Grace (Hopper), Henry (Ford), Thomas (Edison), Edwin (Armstrong), Edith (Clarke), George (Stephenson), Alan (Oppenheim). In suggesting that the issue of pseudonym selection should be of primary concern, Clarke (2006) considers that the choice of pseudonym can have connotation of “class” (p. 6). In choosing names for the interviewees that equated them with a class of famous engineers I showed that I was regarding the opinion of them all equally. Additionally, the choice of pseudonyms reflected that I wanted to “select names that would at least in some way resonate with them” (Saunders et al, 2015, p. 621), and that choosing *important* names for them would draw attention to the significance with which I regarded their contribution. I received feedback from two of the interviewees on this, who expressed sentiments of being proud to be associated with the engineers in question. I preserved gender in the anonymisation, on the basis that it had been observed that from the perspective of research participants a minimal desirable attribute for an anonymising reference appeared to be gender (Clarke, 2006).

I had the interviews transcribed verbatim, (Cavendish, 2011), which preserved the emotion and meaning implicit in the language of the interviewees. This did not affect the readability of the transcript texts themselves, rather the meaning that the interviewees were trying to impart was often easier to discern, for example as they developed a theme by repetition of points (Corden & Sainsbury, 2006). Indeed, in reference to the repetition of words by speakers, in itself a type of filler word, Clark and Wasow (1998) suggest that it solves the dual problems of “how to speak in a timely fashion and yet how to speak smoothly. Repeating a word deserves our respect as an efficient and effective way of dealing with these problems.” (p. 239). This implies that the use by the interview subjects of repeated words as fillers helped them to develop the cogency of their responses to my questions.

The interviews largely followed the points laid out above, many of which were raised organically through the interviews, as the topics were quite inter related and did not always need to be specifically addressed. However, as anticipated some prompting was required to steer the interviews to ensure we covered all topics I had identified, and in each interview there were some points I had to specifically raise towards the end. In keeping with the framing of the interviews I commenced by discussing with each interviewee their motivation for becoming a lecturer. This made it clear to them that: the interview was about *their* personal views; it established a rapport with them, in that we often had shared/similar experiences; and it seamlessly brought us into discussion directly relevant to the research. Andrews et al (2019), remark on the difficult task of getting their colleagues in engineering education to engage in reflective discussion regarding their pedagogy, and the importance of framing the discussion to encourage this. I believe my fieldwork achieved a similarly rich approach to data gathering to that which they reported.

As the interviews progressed, and I carried out the coding of the initial interviews, some topics emerged which I had not anticipated, but which seemed, on reflection, germane to the research. Consequently, later interviews covered some additional topics, in particular the use by lecturers of the 'language of levels' that has come about due to the NFQ.

5.7 Coding and Analysis

The aim of coding is to identify concepts that will help explain complex social phenomena (Denscombe, 2003, p. 20) under consideration in the research. Lichtman (2014) describes the application of generic, or open (Saldaña, 2009), coding as applied to data gleaned from interviews with research subjects. In this approach, an interview is read and analysed in order to identify categories and codes that represent data within those categories. The codes themselves are either words or phrases, arrived at through a careful reading of the first (and usually several more) interviews.

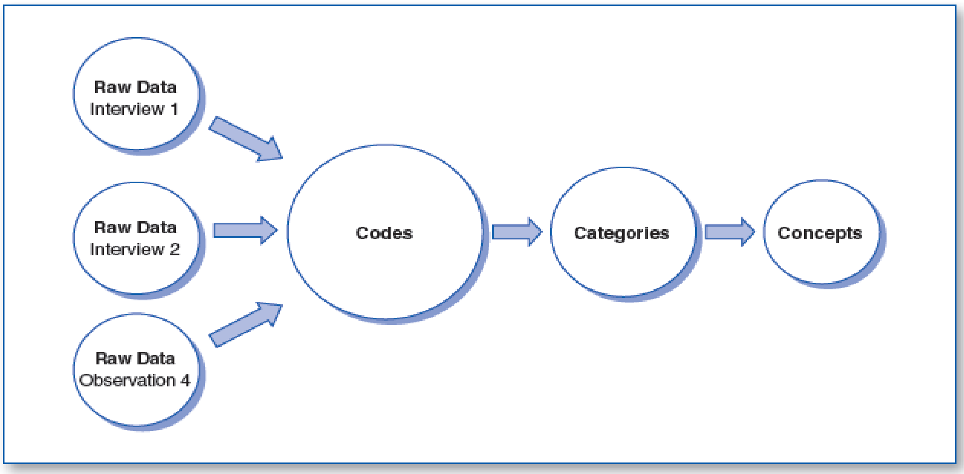

Figure 5-1 Three C's of Data Analysis, Codes, Categories and Concepts (Lichtman, 2014, p. 252)

Denscombe (2003), in discussing the initial choice of codes and categories, explains that, to begin with, researchers may use theoretical concepts, or perhaps professional judgment/hunches to arrive at these. Indeed, "as one proceeds through the initial coding of the data, there is usually much potential for pursuing a variety of themes and issues" (Benaquisto, 2008, p. 87). Saldaña (2009) suggests that a provisional list of codes can be chosen in advance "to harmonize with your studies conceptual framework or paradigm and to enable an analysis that directly answers your research questions" (p. 49). I started with a small provisional list of codes to assist in commencing the process.

The researcher's knowledge of the field is used to decide upon the saliency of the codes, although analysis tools such as the frequency of occurrence of codes in the interview may also be used as a guide. Some codes may overlap, and be seen to represent similar aspects, some may be found to be redundant. Initial codes are examined "removing redundancies, renaming synonyms, or clarifying terms" (Lichtman, 2014, p. 253). Codes are grouped together into categories, which can then be used to identify concepts to assist in developing an understanding of the phenomenon under investigation.

This approach to coding offered a suitable approach for my research, supporting the analysis of interviews in order to identify concepts, which could then be further analysed to develop themes related to the research question. I noted it had been utilised by McNutt (2010), which paralleled my own research in that it was also a research study conducted with IoT academics.

I envisaged that the categories and themes that emerged could lead to consideration of policy documents relevant to the inquiry. This stage is an opportunity to link the views of the participants to the policy, pressures and results that constitute the overall field within which the game is being played (Bourdieu, 1990). For example, as will be seen later, the issue of the balance of skills and knowledge being taught became quite important in the research, which led to national policy in this regard being interrogated and discussed.

I had planned that the process of coding would be carried out in phases, initially coding using two transcripts. After reviewing the initial coding I expanded the coding scheme to include many more aspects of consideration, forming initial categories. I returned to the field with the initial categories, allowing the later interviews to be used more effectively. I kept a log in which to keep track of insights gained while analysing the data, and which serves to show my developing line of thinking (Denscombe, 2003). My approach seemed to broadly follow the following description of coding:

> rarely is the first cycle of coding data perfectly attempted. The second cycle (and possibly the third and fourth, and so on) of recoding further manages, filters, highlights, and focuses the salient features of the qualitative data record for generating categories, themes, and concepts (Saldaña, 2009, p. 8).

The various versions of coding I had included the following:

- phase 1 coding of two interviews;
- phase 2 re-coding of these two interviews;
- phase 3 coding of new interviews as transcripts were generated, and revision of earlier coding of interviews to support new codes that emerged;
- phase 4 coding where codes were re-arranged into themes as part of initial draft of the analysis chapters, and some further re-coding took place;
- phase 5 coding where interviews were re-coded to fully support all aspects reported in the analysis chapters, with ultimately 424 codes in total.

The categories that resulted, once all interviews had been undertaken, transcribed and coded, were then analysed in the context of the conceptual framework and the literature review, to arrive at themes, and ultimately conclusions, as to the effect that OBE is having.

5.7.1 On the Inside Looking In and What I Didn't See

As I carried out the interviews for the fieldwork, I was conscious that aspects of the initial interviews "could serve as starting points for analysis *as well as for further data collection*[25]." (Charmaz, 2006, p. 3), and I actively looked for new sub-themes that might emerge, which could add to the topics I was discussing with the interviewees. I was conscious of my insider role (Leckie, 2001), but, I had neglected to fully think through the implications of this, in particular, that "individuals are often so enmeshed in their own experience that the adequate distance required to know their experience is not available" (Dwyer & Buckle, 2009, p. 59).

As coding progressed themes focussing on the major points of discussion emerged, with the analysis of each interview influencing how I approached the next. However, it was only in analysing the seventh interview that I noticed the preponderance of the use of the term "level", initially in that seventh interview, but, in retrospect, across all of the interviews, to describe aspects of the pedagogic discourse. On reflection I realised that since the introduction of the NFQ, I, my colleagues and peers in the IoTs, have, gradually, adopted what I will refer to as a 'language of levels' as part of our vocabulary as engineering academics.

In considering, from a methodological perspective, why I did not notice the significance of this earlier, I concluded that it is because as an insider to the research I am quite comfortable this usage. I believe that this realisation was a milestone in my development of a researcher identity, becoming an observer in the world as per Denzin and Lincoln's (2011) definition of

[25] My emphasis.

qualitative research. As part of my professional identity as an engineering educator I was quite comfortable with the language of levels, however, as a researcher, I wanted to understand more about why we used it and the implications this may have. My approach to the research needed to be dual-faceted, on the one hand, my professional identity allowed me to comprehend it "from the insider's perspective" (Fetterman, 2001a, p. 347), for which the interview approach is well suited (Fetterman, 2001b). On the other hand, from a researcher/observer perspective I needed to be able to "objectify patterns of behaviour" (Fetterman, 2001a, p. 347) to gain the insight I sought.

I also further highlight the importance of the language of levels from a methodological perspective. As will become apparent in the analysis, the language of levels pervades the pedagogic discourse of the fieldwork. Consequently, in order to usefully analyse the fieldwork, it was necessary to gain a comprehensive understanding of the phenomenon.

5.7.2 Presenting the Analysis

The analysis of the fieldwork is presented through themes identified in the coding, illustrated by the voice of my research participants as they related to those themes in the interviews. I place emphasis on the voices of some individuals, including a number of longer narratives, on occasions where they serve as particular exemplars of a theme (Gordon on the language of levels, and John regarding pedagogy), or offer particular salient insights (Ayah's managerial perspective). With one interviewee, Bill, I believe together we developed significant new knowledge related to progression during his interview, and I use themes that emerged from this to frame the analysis in this regard.

The focus group was at times supporting of the themes that emerged from the interviews. However, on other occasions their discussion generated a new perspective, and, where this was apparent, I highlight the focus group contribution.

As discussed earlier, Grace's interview recording was lost through equipment failure. Consequently, although her interview was not available in the analysis, I was able to make use of our agreed memo of the meeting, and I present Grace's contribution in the analysis where it is possible. For completeness, where I provide tabular overviews of the interviewees' views I include Grace, even though it was not possible to represent her views fully.

5.8 The Focus Group

Four of the interviewees accepted the invitation to the focus group, Thomas, Isambard, Vitruvius and Gordon, a sufficient number to proceed (Barbour, 2007). As the participants were all IoT engineering lecturers, this also met the criterion that the focus groups "should be homogenous in background" (Morgan (1998) as referenced in Barbour (2007, p. 59)). However, as I could attest from the analysis of the interviews with the same participants, not in "attitudes". Barbour contends that differences in attitude can lead to argument within a focus group, which, once it is kept within limits, can assist group members and the facilitator in teasing out the perspectives behind differing opinions, and facilitates understanding.

In preparing for the focus group I considered Fitzsimons (2015) description of how using focus groups contributed to an understanding of the concerns, views and attitudes of her participants in relation to the research. I also revisited the use of focus groups by McNutt (2010), where, given his research participants came from a similar pool to mine, his ethical concerns with regard to anonymity and informed consent partially mirrored my own.

In planning how to stimulate the focus group conversation I considered Barbour's (2007) suggestions of how to moderate focus groups, and the choice of stimulus material, and the use of reflective exercises by Fitzsimons (2015). However, as I struggled with how to structure the session, and what exercises to use to drive the focus group, I took heed of descriptions of stimulus materials that did not have the desired effect (Barbour, 2007; Fitzsimons, 2015). I concluded that the key to the selection of stimulus material was to be aware of who my audience was. Given I was an insider to the group I was interviewing I was confident that once the material was structured such that it would elicit my interest as an engineering academic, that it would similarly do so for the other participants. I consequently chose to use a set of 1-2 page hand-outs, structured around the themes of:

- the language of levels;
- the NFQ and EI;
- progression;
- pedagogy;
- knowledge.

These contained tables, upon which those presented later in the analysis chapters were later based, which related the engagement/agreement of my interviewees with the themes I had identified, along with associated questions that I wished to consider. A sample hand-out is provided in *Appendix* B. I chose this approach on the basis that, as engineers, my research participants would be quite comfortable with the use of tables, in particular to analyse situations (hence the supplementary questions). I was confident this approach would facilitate the participants in engaging with the topics and facilitate me in addressing the questions I had for them, and stimulating the discussion I desired (Morgan, 2008). The approach proved quite fruitful.

Following Barbour's (2007) advice on planning a focus group, I considered using a note-taker or assistant moderator. However, I decided that it would not be necessary, and that I would lead and moderate the discussion myself, and take notes using a flip-chart. I also recorded the focus group discussion, and later had it transcribed for use in the analysis. The focus-group was held in the ITB boardroom, and refreshments were supplied to the participants.

Prior to the focus group commencing I re-iterated the confidential nature of the process (which had been included in my letter of invitation to the participants), and all the participants signed the informed consent form agreed in the ethical approval protocol.

The focus group resulted in an animated and interesting discussion, the relevance of which to the research is shown in the analysis chapters. As agreed earlier with the participants, the session lasted approximately 1 hour and 30 minutes. The participants had received copies of the hand-outs prior to the focus-group, to give them the opportunity to read them in advance, but, I had made it clear that this was not necessary. As discussed previously, focus groups have research, pedagogical and political dimensions to them, and the research dimension was quite ascendant in the interviews. One participant did remark that they themselves were much more aware of the issues we were discussing through being involved in the research, which confirmed to me that the pedagogical element was present to an extent.

5.9 Ethical Considerations

I adopted the three principles proposed by Denscombe (2003) in working with research subjects, similar to the guiding ethical principles used by O' Malley (2012):

1. protecting the interests of participants;
2. avoiding deception;
3. ensuring informed consent.

Clandinin (2006) highlights the added importance on anonymity and confidentiality in a research methodology where people are sharing complex issues related to their experience. Research participants were recruited from across the IoTs, with their identities anonymised using pseudonyms to preserve confidentiality. This makes it difficult to infer the identities of research participants through consideration of published material associated with my research, primarily due to the fact that there are more than a thousand IoT engineering academics. Nevertheless, although anonymity can be attempted, it cannot be guaranteed. A note to this effect was included in the consent form, and this was discussed with participants.

Lynch et al (2012) in discussing the identity formation of senior management in the education sector, writes that "many identified themselves as change agents and were positive about bringing a more strategic vision to their organisations" (p. 112). Regardless of how I positioned myself in an interview my role as an academic manager nevertheless influenced me, and no doubt influenced those who I interviewed. There was a risk that the power relationship might unduly influence the interview, where "overlooking the complex power dynamics of the social construction process may, however, seriously impair the validity of the knowledge constructed", (Kvale, 2006, p. 485). I realised that I may be perceived as a change agent with a strategic view, as opposed to a colleague interested in the participants' views.

I was encouraged by Kvale's (2006) view that interviews can produce useful knowledge despite the presence of a power relationship. Bringing academics together in a focus group, where their group voice could emerge, and their strength in numbers would act to mitigate any adverse consequences of the power relationship, provided a suitable check (Kamberlis & Dimitriadis, 2014). Furthermore, the concept of academic freedom for IoT academic staff is established in legislation (Irish Statute Book, 2006), and well understood within our sector. Thus academic staff, whilst still in a relationship with me where there is a power imbalance, had significant protection to allow them to speak their mind.

The use of focus groups returned me to the issue of confidentiality. As discussed in Hofmyer and Scott (2007), confidentiality of the individuals who constitute a focus group is compromised, as the researcher cannot control the actions of those who form the group. In adherence to the principle of informed consent (Denscombe, 2003), participants were made aware of this potential issue. However, the participants in the research were all academics used to dealing with confidential matters, who I believed could be trusted to maintain confidentiality, and who would trust other academics to do the same.

Another aspect of protecting the interests of the interviewees that I needed to consider was that the "dominant position of the interviewer may lead to an invasion of the subject's privacy" (Kvale, 2006, p. 497). It would be possible that an interviewee might disclose personal information to me that they, or I, might later regret. Although I hoped it to be unlikely, I took the precaution of including the Samaritan contact number in the consent form, in case either I or the interviewees later felt the need to talk through issues that might arise.

I was committed to not coercing anyone to take part in the research, and I believe the contact approach which I document below, ensured this.

I was quite cognisant of confidentiality issues as related to data protection, and I describe comprehensive data protection mechanisms below.

In conducting my research I analysed documentation for programmes from ITB and other IoTs, and also from HETAC, QQI, EI and others, the majority of which is publicly accessible, although in a few cases I held personal copies of otherwise unavailable documents. However due to my position as HoD in ITB (now TU Dublin) I was careful to consider the effect of any critical analysis I undertook, in order to differentiate my views as a researcher from views I hold through my role as HoD in TU Dublin.

Ethical approval was sought, and received, from the Maynooth University ethical approval committee, and as an ITB employee at the time, also from the ITB ethics committee.

5.9.1 Contacting Potential Interviewees

When I designed the ethical protocol I was Registrar at ITB, and not in a direct line of authority over any of the potential participants in the programme. However, in my approach to seeking research participants I acted on the basis that I could be perceived to be in a strong power relationship with relation to all the participants, and that anyone I approached should be empowered to decline the invitation.

In order to address this I followed a two stage selection process to invite and discuss participation with potential research subjects. Initial contact was through email, identifying myself, explaining the research project within which I was engaged, and asking the potential research participant that, if they were interested in discussing their possible participation, to reply to my email. At this point there were three possibilities:

1) they would reply in the negative, in which case I would respond by email thanking them for their consideration, and make no further attempt to contact them on this matter; however, I received no responses in this category;
2) they would not reply, in which case I regarded this as a negative response, and I did not have any further correspondence on the matter with them;
3) I would receive a positive response. At this point I contacted the potential interviewee further by email to discuss the project in more detail, and to arrange an interview date. My experience of this was that once the initial positive contact was made an interview date would be agreed and an interview followed at some stage.

I had decided that if I received more than 18 positive responses it would not be possible to interview everyone (given time constraints), and I would have to make an informed choice with regard to selection. If I had received an oversubscription I would have biased selection towards those who have spent most time working as engineers, respecting their greater continuity of experience, consistent with Sargeant (2013). However, the matter did not arise, a total of fifteen positive responses were received, and all resulted in an interview.

The recruitment approach was effective in recruiting the desired number of research participants. In addition, I believe the ethical protocol achieved the desired effect of minimising the power relationship. One interview request, to a colleague I have known for some years, but always in a position of authority in relation to them, elicited no response. Although initially I speculated as to the reasons for this, I realised that, for whatever reason, they were not in a position to participate and I should accept that. However, at the same time I recognised that the contact protocol had empowered them to ignore my request, precisely the effect it was designed to achieve, turning this into a positive experience.

5.9.2 Data Storage

Storage and retention of data gathered during the fieldwork was carried out in with a view to protecting the identity of the participants, ensuring it is only used for the purposes of this thesis, and that it is deleted at an appropriate time (Maynooth University, 2015). Recorded interviews are stored in a secure IT system. Research participants were informed of storage arrangements, and of a delete date for the data. Participant data is stored using the anonymising identifiers agreed with them. A key to translate between anonymising identifiers and actual names is held in a separate, secure location.

Data will be retained for ten years after the thesis has been completed, in accordance with Maynooth policy. The electronic folder within which the data is retained will have a delete-by date indicated on it as part of the title, for which I will set a reminder in my electronic calendar.

5.10 Validity, Reliability and Limitations of My Research

In considering the reliability of my findings, the sample size, as discussed above, is sufficient (Ando et al, 2014; Boddy, 2016; Fugard & Potts, 2016; Guest et al, 2006; Saunders, 2012) to allow for the identification of themes that are important to my research participants, a selection of IoT engineering academics biased towards those from the Electronics/Mechanical disciplines, as a group, as well as individuals.

In following a qualitative approach my research allows for a deep exploration of my research question, generating understanding of how my research participants have experienced the social phenomenon (Denzin & Lincoln, 2011) of OBE in IoT engineering educations. Although qualitative research does allow scope for theoretical generalisations (Saunders, 2012), in adopting a realist stance (Sayer, 1992) in my conceptual framework it follows that the validity of my findings must be considered within the context of the socio-cultural and historic structures (Maton & Moore, 2009) of IoT engineering education within which I have observed and developed them.

Although my findings have validity for the IoT engineering education system, I do not consider that they generalise across all of Irish engineering education. In particular, in *Chapter 8* I will show the influence of progression on my research participants as they teach across NFQ level 6, 7 and 8 undergraduate engineering programmes. This pressure with regard to progression would not be experienced by university academics for whom the undergraduate offering is level 8 only. My research will also show that teaching across these different levels has contributed to the phenomena of the language of levels (*Chapter 7)* evident in the discourse of my research participants, and, similarly, I would not expect it to be evident in a similar fashion in that of 'traditional' university academics.

A limitation of my research, given it is situated in IoT engineering education, arises from the exclusion of IoT civil engineering academics from the sampling frame. Although, as I will show in *Chapter 6*, perceptions of EI's influence on IoT engineering education were pronounced in the fieldwork, a somewhat negative theme arose as to its relevance for graduate employment (*section 6.9.1*). As discussed earlier (*section 5.3*) EI accreditation is much more important for employment for graduates of civil engineering than for mechanical or electronic engineering. Given that none of my research participants were civil engineering academics, I do not consider my findings with regard to the relevance of accreditation for graduate employment to be applicable for this discipline.

My findings, as will become apparent in the analysis (*Chapters 6-10*) and the later discussion (*Chapter 11*), are quite related to the specific case or Irish technical engineering education, and the policy and other pressures we experience as educators. Other jurisdictions will experience similar pressures in their engineering education systems, and although my research will speak towards OBE related issues in other such engineering education contexts, care must be taken in any such comparisons.

5.11 Conclusion

In this chapter I expanded the research question, based upon avenues of interest identified in the literature review, and as considered through the conceptual framework. I explained how this led to my selection of a qualitative research methodology for the fieldwork, and to my selection of the research participants, IoT engineering academics. The details of the research methodology were presented: i.e. semi-structured interviews with engineering academics, followed by coding and analysis, with the use of a focus group to review the draft findings. Two document analysis techniques, which were used earlier in the literature review, and later in the discussion, were also described, along with my rationale for using them.

I then discussed the implementation of the research methodology, highlighting issues regarding conducting the interviews including: the iterative nature of the coding and analysis; the manner in which I present the analysis; being an insider to the research; ethical considerations, and the holding of the focus group.

The scene is now set for the analysis of the fieldwork that my research question, literature review, conceptual framework, and research methodology has led to.

Chapter 6 Influences and Prescriptions on Engineering Academics

> *Let us take as an illustration recent changes in medical and engineering curricula, which bring out the ways in which the characteristics and content of curricula are influenced by the changing values and interests of the controlling groups involved.*
>
> Michael Young (1971, P. 34).

6.1 Introduction

Issues of power and control were quite central to my consideration of how my research participants, and the education they offer, have been impacted by the introduction of outcomes based education (OBE) in our IoT engineering education system. My literature review highlighted the importance of considering not just the role of the National Framework of Qualifications (NFQ), but also that of Engineers Ireland (EI), alongside other drivers, including the global nature of the developments that led to both the NFQ and EI's OBE accreditation requirements. Drawing from social realism in my research provided a perspective from which I could consider the related power relationships and their significance. Through concepts such as stratification of knowledge (Young, 2008), pedagogic identity, and recontextualisation (Bernstein, 2000), and in stressing the importance of understanding the socio-historical context (Young, 2008), this influenced the design and implementation of my research methodology to examine how these power relationships might manifest, and what effect they might have.

The importance of exploring issues of pedagogy and power relationships in engineering education (Edström, 2018) with my research participants, in order to develop a fuller understanding of their experience of OBE, was borne out through the fieldwork, where issues of power and control came up repeatedly in our discussion. For example, Ayah, in reflecting on the use of the National Framework of Qualifications (NFQ), remarks "*this is the framework you have to stick to*", George considered that "*the state gives Engineers Ireland certain powers*" as he discussed the importance of accreditation, and Henry, in considering "*the learning outcomes or NQAI way of doing things*" felt that "*you're trying to direct people*" with regard to pedagogy. This influenced the development of my conceptual framework to further emphasise the importance of consideration of the power relationships at play in the field I was researching, and led to my adoption of the lens of Bernstein's (2000) pedagogic device as a model for the pedagogic discourse in Institute of Technology (IoT) engineering education.

As discussed earlier (*section 5.8*) I structured the focus group session around a number of themes that emerged in the initial phase of the analysis, namely: the NFQ and EI; language of levels; progression; pedagogy; knowledge. This served as a useful basis to facilitate the group voice that emerged in the focus group, and later allowed me to advance the analysis and relate it to the literature. Consequently, I used these themes, having expanded their scope somewhat to allow inclusion of all relevant findings, for presentation of the analysis in this thesis.

This first chapter of the analysis considers how the 'official knowledge' of the NFQ and Engineers Ireland (EI) supports and controls the dominant discourse of OBE. To begin with, the analysis examines *where* my research participants experience the influence and prescription (Slough-Kuss, 2015; Ingram, 2016) they associate with the NFQ and EI's accreditation requirements, and considers their impressions of the effectiveness of OBE. Later chapters consider their perceptions of *how* that influence and prescription has had an impact on their pedagogic identity and practice, and on the structure of engineering education.

In *Chapter 7* the analysis examines the phenomenon of the language of levels, the usage of which by my interviewees will be evident throughout this current chapter, and I will consider how and why they employ this in their pedagogic discourse.

In *Chapter 8* I develop the theme of progression that emerged from the analysis, which, in this current chapter (*6*) I show is regarded by my research participants as important in facilitating access and reducing elitism in engineering education. In *Chapter 8* I further analyse the fieldwork to consider the impact of the NFQ concept of progression on how and what we teach our students.

In *Chapter 9* I consider the pedagogy my research participants have adopted in our LOs based engineering education system. Whereas in this current chapter (*6*) I reveal that my research participants perceive a significant influence over their pedagogy from the use of OBE, in *Chapter 9* I consider how their approach to pedagogy has adapted in consequence.

The impact on engineering academics' approach to knowledge and skills, and their recontextualisation in the curriculum, which the analysis in this current chapter will show is firmly oriented towards a LOs approach, will be considered in *Chapter 10.*

6.2 Implicit and Explicit Control of the Pedagogic Discourse: Hearts and Minds?

Tuck (2007) sets out criteria for the successful implementation of a national qualification framework (NQF), including: ensuring an effective legislative framework is in place; that government policy is coherent; that account is taken of the realities of implementation; and that adequate funding is in place to support it. Additionally, Tuck (2007) proposes that:

> For an NQF to be really effective, hearts and minds – genuine and active support – have to be won. Otherwise, there is a danger that education and training institutions and social partners will simply pay lip-service to the framework. It is increasingly accepted that successful implementation depends on communities of trust (p. 25).

In analysing the fieldwork, I conclude that my interviewees offered a positive view of the NFQ, often somewhat qualified, but largely 'genuine and active support' (Tuck , 2007).

To begin with I present findings which illustrate the manner in which my research participants view the influence and prescription of the NFQ, and what they perceive it exerting control over in the pedagogic discourse. I later discuss how this is reinforced by EI, who form part of the community of trust for engineering academics, through their accreditation requirements.

Table 6-1 Influence of the NFQ on the Interviewees

	Research Participants														
Aspects of NFQ's Influence	*Isambard*	*Ayah*	*Kees*	*Rudolf*	*Vitruvius*	*Bill*	*Thomas*	*Gordon*	*Edwin*	*George*	*Edith*	*Henry*	*John*	*Alan*	*Grace*
NFQ seen as effective															
Societal impact and progression															
NFQ associated with semesterisation															
NFQ used as a Management tool															
Awareness of Legislative and Policy Context															
NFQ influences Pedagogy															
LOs influence course design															

The following reasons were offered by my interviewees for their positive impression of the NFQ (see *Table 6-1*): it is seen as effective; the use of LOs encourages more consideration of pedagogy; learning outcome's (LOs) influence course design and delivery; the NFQ offers management a tool for working with staff, including in advising lecturers regarding pedagogy, and in terms of allocation of resources; and it is seen by some to foster a societal role for the institutes, promoting equity of access to education and improved progression for students.

Although largely positive, for some their views were qualified by concerns that management had not fully bought in to the NFQ, and that the framework could be too prescriptive. Another concern related to the introduction of semesterisation, which although not linked directly to the NFQ, was seen as by many of the interviewees as consequential from it.

A sample of my research participants' impressions related to the NFQ and IoT engineering education are given below, sometimes qualified with criticism, and in one case a somewhat negative stance is presented.

6.3 Academics' Perception of the Effectiveness of the NFQ

My interviewees generally offer a view of the framework as a well-functioning, integral, aspect of engineering education, with interviewees using phrases such as "*very structured*" (Vitruvius), "*it works very well*" (Gordon), "*a fantastic tool*" (Rudolf), "*everybody's using it*" (Edith). Indeed, there was considerable agreement that the NFQ provides a structure within which they can work effectively (eleven of the interviewees).

This view was exemplified in John's interview, which showed his embracing of the NFQ across a range of matters, including: "*it is actually well structured, right and it makes some useful points*"; indicating "*how we should design or specify a curriculum*"; "*the know-how and skill and the competence strands […] are really important to employers*"; and "*it comes down to pedagogy, you know and it comes down to human nature in one sense that we have people who lecture who haven't gone through formal teaching and learning programmes, we were never taught to teach*".

A dissenting voice, Thomas, expresses a negative opinion of the NFQ, where, rather than seeing a deep impact, he perceived a more superficial interaction, where they don't "*impact on our day to day business in here*" except "*when we're doing programmatic review and […] we're making sure our LOs fit into the descriptors […] and that's about it. Maybe they should play more of a role in quality assurance*".

However, Thomas's interview demonstrated he was quite immersed in the use of the language of levels (see *Chapter 7*) e.g. stating, in discussing the types and focus of programmes that an IoT should deliver: "*at level 6 and level 7 where we should be, we're applying […] technology*". Similarly, Thomas was quite comfortable with the use of LOs in programmatic review. He also had considered that the NFQ came about "*to link into a*

European framework to allow transfer of degrees and for qualifications". Although not positive about the NFQ, it clearly had caused him to reflect on his role as an engineering academic, and is quite comfortable discussing engineering education with the terminology and structures provided by, and as a consequence of, the framework.

6.4 Awareness of Impact of the Legislative and Policy Context of the NFQ

Twelve of the interviewees had given consideration to the impact of the legislative and policy context of the NFQ, and the prescriptive effect this has had. For example, Rudolf states that the "*framework probably puts a control around the environment in terms (of) which module and programme development happens*". John is accepting of the regulatory nature of the NFQ as part of the society within which he lives and works, influencing how academics approach "*learning and assessment*". Edwin regards the NFQ as being something you have to use ("*there's no choice*"), and indeed that "*It's embraced by everybody*", which he regards as a "good thing". In terms of understanding why he thinks it must be used, he considers "*It's like the smoking ban, isn't it*", i.e. a legislative requirement.

Edith has adopted quite a pragmatic approach to the NFQ, neither embracing nor rejecting it, but clearly feels that "*you do have to use it*", regardless of its pros and cons, similarly recognising that it is part of the legislative framework within which the IoTs operate. Bill viewed the NFQ as a "*new system*" which "*changed the nature of things*", and Vitruvius feels that the NFQ is a "*very formal framework*" that was "i*mposed*".

Kees brings a management perspective, describing how "*a learning outcome framework*" can be used by the "*Department of Finance, or the Department of Education & Skills […] to justify how tax payer's money is used*", allowing the economic imperatives of value for money and the supply of appropriately trained graduates (at different NFQ levels) to be measured.

6.5 Academics Perception of Societal Impact of the NFQ

Bill perceived the advent of the NFQ as a discontinuity, with there being a before and after, where "*we suddenly changed over*". He feels that the NFQ, albeit at the cost of increased complexity, has introduced a more satisfactory system allowing comparison of programmes, making progression opportunities for students clearer, and supporting lifelong learning. Bill also feels that the NFQ has improved access to education, and made the system less elitist. Henry expressed similar sentiments: "*the student gets high points and they go and do their* *university degree and the student who doesn't get the points and they can come here and they get a really good education*".

The related societal role of the IoTs was a topic discussed by seven of the interviewees. For example: Edwin, in discussing mature students entering education to pursue a "*level 7 or level 8 degree*" stated *"they all come to have a second chance in life, and […] they do fantastically*"; or Alan "*I try and get the students [...] (to) believe in themselves in terms of […] 'If I work at this long enough I'll be able to figure it out'. If I achieve that irrespective of any learning outcomes or any of the rest of it I think it is actually a good job*".

The theme of supporting access and lifelong learning also emerged in the focus group, with the participants feeling that, whereas previously in Irish higher education an elitist system held sway, the NFQ has levelled the playing field. Indeed, even the use of the terminology of level 6, 7, and 8 to represent qualifications was put forward as "*putting everything on an even keel*". The fieldwork thus provides some evidence that the policy aims of using the NFQ to support access and lifelong learning are apparent to engineering academics.

However, the increase in numbers in third level, which is associated with access, also drew criticism, e.g. "*from a business perspective of these institutions it is in their interests to keep people in the system as long as possible*" (Alan). Thomas, despite seeing a role for the NFQ in improved access to education, particularly for apprentices, felt that there are "*more and more people going to third level […] twelve, fifteen years ago only those who wanted to go went. Now the career guidance in the schools is fill out the form anyway*".

Although equality of access is a fundamental value of the NFQ (NQAI, 2003a), the massification[26] of third level identified by Thomas and Alan is not fully attributable to the NFQ, which forms only part of state educational policy. This points towards the complexity of my interviewees' views of the NFQ, which are often intertwined with other facets of our education system. As further example, some ten of the interviewees conflated semesterisation and modularisation with the NFQ, even though they are not directly related. To illustrate this consider Kees, who, in response to a question about the effectiveness of the NFQ, stated "*I would have arguments about the efficacy of the semester. I would have arguments with regard to modules*", however afterwards stating that "*whatever issues that*

[26] Massification refers to widening of access to education to increase participation rates. (Hazelkorn et al, 2015)

might be there with regard to modularisation, semesterisation, they're not framework issues". These views provide evidence of the confusion that can arise in decentralised higher education systems, such as in Ireland, in the implementation of policy (Viennet & Pont, 2017).

6.6 The NFQ and IoT Engineering Academic Management

The manner in which academic management perceive the influence and purpose of the NFQ in their dual-faceted role as *academic managers* and *academic leaders* (O'Sullivan, 2014), is explored in this section of the analysis.

Kees played a leading role in the introduction of the NFQ in engineering education in his IoT, where he recounted organising seminars, guest speakers, but above all else dealing with the hard issue of how to "*motivate faculty staff*". Some took on re-writing their modules with enthusiasm, but, others had to be "*dragged kicking and screaming into doing it*". Kees regarded Heads of School and Department as the key people involved, "*the front line*" in moving academics to OBE. Kees describes the QQI Engineering Standards as a "*very good job*", which made module development more disciplined, and which engineering academics found quite effective. He regards modules developed under the NFQ as being clearer in their aims, and that it is easier to see if a module has delivered on these aims.

Ayah considers the NFQ assists students to understand what they are doing, and assists their lecturers to help them achieve success, i.e. promotes a learner centred approach. As an academic manager she feels responsibility for the student, and, also, recognises the benefit of lecturers having clear direction about what and how to teach. Although she considers the LO approach quite restrictive, she regards it as effective for level 6 and 7 programmes, but less suitable for levels 8 and 9. She may have to tell her staff that "*this is the framework you have to work within*", but also feels the "*need to leave a little bit of room*" to allow academic freedom. On the one hand Ayah is conscious of her responsibilities as an academic manager to help implement the NFQ. On the other hand, her interview shows awareness of her role as an academic leader to support her staff and help them work and grow as academics.

Isambard, from a management perspective, regards the NFQ as assisting in providing clarity of purpose and implementation to a programme, and making the desired graduate attributes clear. He also considers it benefits programme design, and assists in the allocation of limited resources within a restricted timescale. Isambard considers the NFQ assists students on their educational journey, moving from more prescriptive lower levels where the student is "*taught to follow instruction and a methodical process*" to where, later "*things become more complex*". He considers that the NFQ "*has made the depth a bit shallower but it has been rigorous in the sense that it has been able to allow for measurement of exactly what your output is, what they know, what they can do, and you can stand over that*". He speaks of graduates in terms of "*what product are you getting in the end*", reflecting earlier concern raised that OBE leads to a focus on process (Woolston, 2008), and suggestive of the strong framing (Bernstein, 2000) associated with performance pedagogy (Muller, 1998).

These views from academic management, which concur with my own experience, suggest that academic management see themselves in a dual role with regard to the NFQ. As academic managers they promote the use of the NFQ as part of engineering education in the IoTs. However, as academic leaders, they see their role, to an extent, as guardians of the academic integrity of what is being taught, how it is being taught, who is teaching it and who it is being taught to, which can cause them to question aspects of the use of the NFQ.

In addition to academic management acting to promote the NFQ with their staff, the analysis revealed they may also use the NFQ to assist with staff training, and to advise their staff on matters related to what and how they teach. Rudolf considered that "*I would never associate the framework with a management tool*". However, in comments representative of sentiment also expressed by Vitruvius and Ayah he states: *"I see it with new staff that come in […] as part of their induction that I give them, and say this is a level 7 module that you're teaching, here's where it sits, so you understand […] the type of approach that you need to take*".

Similarly Kees described trying to use the NFQ to influence a staff member who he felt needed to adjust their pedagogy: "*I would argue that [...], at least if you (have) got a framework, you've got, potentially, the ability to start trying to shape*" their teaching approach.

However, other interviewees were critical of the effectiveness of management's approach to the NFQ, e.g. "*I think management here don't understand the NFQ" (John), and "most of what it seems to me […] middle management does is kind of fire fight*" (Henry). Alan's experience as a relatively new lecturer is that he "*learned by doing*", not relating, as he described his introduction to his new role, any experience of having the NFQ and its use explained. Edith, in describing her first interaction with the NFQ, explained that she did not know "*anything* *about the framework until really we did the first (EI) accreditation*" Similarly Thomas sees little management buy-in to the NFQ: "*the only time it ever comes out is when we're doing programmatic review*" and programme and module outcomes need to be updated.

6.7 Influence on Pedagogy

Havnes and Prøitz (2016) suggest that the use of LOs, in addition to being a "central aspect of a policy initiative" (p. 206) is a "pedagogical undertaking". The interviewees acknowledge the influence of the NFQ on pedagogy in terms of how it had influenced them personally, but also in terms of the influence on their profession.

As an example, John, who has embraced the NFQ, reflected on the development of his personal pedagogical position within the context the NFQ provides:

> *I [...] like it because it gives me a context in which to enact what I want to do [...] having said that, I like it because I have a range of enactment skills now that I didn't have ten years ago in terms of looking at different learning theories, being more open to summative and formative assessment. I am now prepared to pull reflection in which is key in the NFQ*.

Although he considered that the NFQ is quite specific in terms of the course structures that have to be used, he still felt considerable autonomy in that lecturers "*can enact that specification any way we want in our classroom*". In doing so he drew a distinction between "*the specified curriculum, the enacted curriculum and the experienced curriculum*".

Vitruvius, in referring to the direct and constructive effect the NFQ has had on his pedagogy, stated that "*I find if you know what the student is meant to be doing afterwards […] then that tells me a lot about how I should teach them*", using LOs to guide his teaching.

Bill perceives: "*when you start bringing stuff in like LOs […] then people actually should or can or ought to be thinking about – what is the best overall educational plan here rather than just the necessary nuts and bolts of the syllabus*". Bill approached this change enthusiastically, explaining that he always considered "*how can I do my job better. And even at this stage I wouldn't have even remotely exhausted how you could be a better lecturer or a better educator*", which he would be doing "*as an engineer who has become an educator*".

Isambard takes an overarching perspective, linking LOs, pedagogy, and assessment, in which a strong sense is evident that he sees this as prescribed through OBE: "*if you are developing an assessment process for a particular module, you actually have to build in the pedagogy,* *the requirement that will enable the LOs to be achieved*".

Twelve of the interviewees recognised the influence of LOs on pedagogy, whether having a perception of influence on self, on the profession, or both. For some (ten interviewees), similarly to Vitruvius, they see how they themselves have been influenced e.g. "*You've set the list of learning outcomes and you have to basically cover those in your class, in some shape or form, whether its lab, lecture […] or exams*" (Edith) and "*I have come around to the idea of learning outcomes. I think it's good, it changes the way you think about teaching*" (Henry).

However, some (five of the interviewees) see, similarly to Isambard, an influence on their profession, e.g. "*when you have put learning outcomes into it, suddenly we had to think about education really*" (Bill). Ayah, when speaking of level 6 and 7 programmes had a positive view in that the use of LOs "*tells the lecturer what you need to teach and how you're going to do it and that's fine*". However, she was critical of their use for level 8 and 9 programmes, where the LO focus means "***they** are quite tied, **their** administration workload is heavier, everything, **their** assessments,* their *exams, everything is tied into these six or seven learning outcomes*".

A majority (twelve) of my interviewees recognise that change has occurred in pedagogy under the influence of OBE, using positive language such as "*it gives me a context*" (John) and "*I have come around to the idea of*" (Henry). For some there was a sense of enablement: giving John a framework in which to develop his pedagogy; and Bill feeling he grew to be a better educator. This leads to a finding that OBE acts as an implicit influence over the pedagogy of the majority of my interviewees, that they largely regard this as constructive, and it has encouraged them to give more consideration to how they approach teaching. The manner in which their pedagogy has been affected through this influence is analysed in *Chapter 9*.

6.8 Course Design

This section analyses my interviewees perceptions of the NFQ's influence over course design (curriculum) through their use of the LO based QQI Engineering Standards (QQI, 2014c), with a later section considering their perceptions of EI's complementary role. The manner in which the use of LOs has shaped the interviewees' approach to knowledge and skills in the curriculum, a key consideration for engineering education, is considered in *Chapter 10*.

All fifteen of the interviewees acknowledged the implicit influence of the NFQ on the use of LOs in course design. A representative sample of their views are presented below, illustrating the positive benefits they perceive.

Gordon regards the use of LOs in course design as very positive, allowing him to focus on teaching a smaller number of relevant curriculum topics in depth, as opposed to covering a larger curriculum in a shallower manner. Kees feels they introduce more academic rigour, regarding there to be "*more discipline associated with*" module and programme design using LOs, a sentiment shared by Rudolf. Vitruvius is similarly positively inclined towards the use of LOs in course design, particularly in terms of knowing what is expected of the students. George sees benefit from LOs in terms of understanding students' achievements, regarding LOs as "*a good summary of what they should achieve at the very end*".

Edwin, is conscious that, in module design, "*we have to be aware of these LOs*". Henry acknowledges that in course design he has to "*start with the LO*s", and then later "*think about the content*". Even Thomas, who views the influence of the NFQ somewhat negatively, states that "*we go from the top down, programme out, with the LOs and how can you achieve a LO*".

The use of LOs has, also, an explicit, prescriptive control over course design. Analysis of the interviews showed a broad acceptance amongst the interviewees (nine) that the NFQ is playing a significant controlling role in terms of specifying structures within which programmes must be designed and delivered. A sample of their views are given below.

John feels that "*the NFQ […] structures how we should design or specify a curriculum". Rudolf also viewed the NFQ as being quite controlling of module and programme development, and stated that "the framework provides [...] boundaries*" for course design. Course development is where academics decide what knowledge, skills etc. are represented in the LOs of modules and thence represent the competencies of a graduate. These boundaries are, thus, boundaries around, *inter alia*, knowledge.

Ayah, although not referring directly to boundaries, felt that, at level 8, more flexibility than that allowed by the NFQ was necessary in course design, and, indeed, was quite critical:

> *as you go higher up, I think it stifles the whole process and I think its stifling innovation and its stifling research and I think that problem is that they're going out into the real world where they don't actually have had the chance or the space to actually think outside of*

these very prescriptive LOs.

Ayah's use, and re-use, in her interview, of the term "*stifling*" is quite pronounced, reinforcing her perception of prescription. The NFQ has been previously described as "being too prescriptive, reducing the creativity and autonomy of the programme developer. Uniformity and conformity become the dominant mantra" (Kenny, 2009, p. 24). This resonates with an excerpt from George's interview, where, referring to writing LOs he states that "*I would be conscious that it has to be of the correct level*".

Kees, viewed programme design under the NFQ as prescribing a focus on LOs. In discussing module design under the NFQ, he viewed that "*for someone with a particular qualification, say at Level 7, that graduate should be able to demonstrate a series of competencies. [...] and that enabled then, programmes to be developed that were focused on that*".

Isambard, whilst agreeing with Kees's view of graduate competencies, has a somewhat nuanced approach to the meaning of LOs in the curriculum. On the one hand, he feels that any two academics teaching a module may, in interpreting them "*draw examples from different spheres and you are free to do that*", echoing John's description earlier of the difference between the specified curriculum and the enacted curriculum. However, this is only insofar "*as the LOs [...] allows you to achieve the same end*". Ultimately the module LOs, rather than the lecturer's expertise, provide a high level specification for what is to be taught, where "*the defining thing is the LOs*" (Bill).

Alan also views the use of LOs as a key part of module design, and that the NFQ causes him to "*adhere*" to the use of Bloom's taxonomy (the "*verbs*") in the design of modules and later to "*adhere*" to what is written in the module descriptor.

These views suggest that the NFQ is a significant factor in the increased "emphasis on control and oversight" (Kenny et al, 2015, p. 102) of the working environment for IoT engineering academics. Havnes and Prøitz (2016) succinctly capture the dominant nature of an NQF in describing that LOs constitute "a system 'from above'" (p. 220).

An earlier finding was that the NFQ is one of the principal tools used to support a policy-driven re-orientation of Irish higher education towards having a more skills focus. Complementing this earlier finding, the analysis leads to a finding that, through its LOs focus, the NFQ is perceived by engineering academics as an explicit control that is placing boundaries around what is to be taught, supporting the skills focus of government policy for higher education.

6.9 The Role of Engineers Ireland

In exploring EI's role in the pedagogic discourse a particular focus of the interviews was the duality of EI accreditation and programmatic review, alongside EI's influence on programme design. Their influence goes further, however, than accreditation: Kees related that the QQI Engineering standards (QQI, 2014c), were created via a process "*under the EI umbrella, of linking the generic learning outcomes associated with the National Qualifications Framework with engineering learning outcomes*". Isambard, whilst acknowledging this direct relationship, felt this is often not entirely clear to all engineering academics.

As an example of this duality, Henry in comparing a forthcoming EI accreditation visit to a recent programmatic review felt "*we would be much more focused on that than we would be on the programmatic review*". Henry also regarded EI accreditation as the main driver for updates of modules. He viewed EI's introduction of evidence driven accreditation as a positive change, whereas his view of programmatic review is that "*we don't spend enough time reflecting on the course as a whole […] I don't know if any of the IoTs do*".

George, expressing similar sentiments to Edith, states that "*I find that what we concentrate on a lot is the EI criteria, mainly because we try and get our courses validated by EI. And so, their criteria are equally as important as the framework, if not more important*". An even more pronounced view of the importance of EI accreditation is given by Grace, who related that, in her institute, the term level 8 is generally associated with EI accredited programmes. However, she emphasised this approach did not generalise across the IoT sector.

Bill discussed trying to map programmes into EI "*LOs and their programme outcomes, to satisfy what they hope to see for accreditation purposes*". Ayah refers to academics, in designing programmes, "*being forced more into […] the (EI) programme outcomes*". Alan discussed his experience of EI accreditation as a relatively new IoT lecturer. He regarded this as a strong influence on module design, informing "*the LOs*", and "*almost dictates in some respects what you should be doing*". Isambard speaks of "*what is required by EI*", and Gordon felt that "*it challenged us I think in ways that the programmatic review didn't*".

The analysis showed that EI accreditation requirements are regarded (by eleven of the interviewees) as more important in course design than the NFQ or institute level course design and validation processes. Indeed, for Grace, for whom, unfortunately, the interview recording was lost, the principal topic noted in the agreed memo of the meeting was the impact of the influence of EI accreditation on course design and structure. Of the remaining interviewees, three still recognised the significant importance of EI for engineering academics, and one of the interviewees did not comment on the subject.

This focus group were informed of the analysis pointing towards the strong influence of EI, and were asked "*What influence do you feel that EI have had on the adoption of the learning outcome approach by engineering academics"?* They confirmed the view of the extensive influence of EI in this regard, with the discussion centring on the significance of this influence.

Part of the discussion concerned the mobility of engineering graduates, with a feeling that "*EI accreditation certainly does give a greater mobility*" to students wishing to work abroad, causing students and graduates to place a value on EI accreditation. A dissenting voice felt that *"the graduates I would be in touch with who are still in Ireland have never heard a mention of EI*". However, another participant felt that part-time engineering students, who are generally in employment, were very conscious of accreditation.

In considering programme design, one focus group participant felt that EI programme area descriptors "*fit in flawlessly into programmes outcomes*". Another questioned the relevance of EI, who they recognised however as "*an external body who has a huge influence on what we're teaching our students*", in particular in terms of the maths content of programmes. They went on to question whether this significant maths content was of value to the students, when, instead, they could be taught more skills.

In discussing whether EI, through their adoption of LOs for accreditation, have influenced engineering academics acceptance of LOs, there was consensus that EI's influence meant that "*we really have no choice*". This is reinforced by practice across the sector: "*it's a combination of EI and every other college […] So maybe EI on its own wouldn't have that influence*".

These views point towards the significant influence of EI's OBE accreditation on the design of IoT engineering programmes. There was also a strong element of compulsion felt by the interviewees, who, in their individual interviews, used language such as "*dictates*", "f*orced into*", "*drive*", "*required*", and "*challenged*"; and when together in the focus group, "*no choice*", "*we're a small fish in a big pond and we have to do what we're told.*". It is not just that EI have accreditation *requirements*, but that clearly the interviewees saw them as overarching requirements.

Table 6-2 provides an overview of where my interviewees' perceive: the NFQ is *prescriptive* with regard to course design; LOs *influence* them in their approach to this; and EI are prescriptive regarding course design. All experience an element of prescriptive control from one or both of the NFQ and EI, with the exception of Vitruvius, who does experience implicit control. These views are consistent with the NFQ and EI constituting 'official knowledge'.

Table 6-2 Prescription and Influence from the NFQ and EI over Course Design

	Research Participant														
	Isambard	***Ayah***	***Kees***	***Rudolf***	***Vitruvius***	***Bill***	***Thomas***	***Gordon***	***Edwin***	***George***	***Edith***	***Henry***	***John***	***Alan***	***Grace***
NFQ LOs influence course design	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
NFQ prescriptive for course design	■	■	■	■		■			■	■			■	■	
EI prescriptive with regard to Course design	■	■	■			■	■	■		■	■	■		■	■

6.9.1 Views Critical of EI

A number of interviewees (five) questioned the relevance of EI accreditation for graduate employment, whilst still recognising its influence on engineering education. It is significant that any engineering academics would question the relevance of accreditation from their professional body. However, the interviewees were predominantly from the fields of electronic and mechanical engineering, where, as discussed earlier, for electronic in particular, and also mechanical engineering to an extent, although accreditation is an important consideration for engineering education, it is less so for employment.

For example, Alan, speaking of EI's role in his field of ICT, states, of his time in industry, that, regardless of the importance of EI accreditation from an academic perspective, *"I have interviewed people in industry and […] the thought never even entered my head to turn or evaluate if this course was accredited by EI*".

Similarly, Edith, on a personal professional development level, with regard to pursuing Charted Engineering status, asked herself "*to what benefit am I doing this […] we don't need it for our working environment*", considering EI "*biased towards civil engineering*". George considers that, whilst he supports the idea of EI accreditation, for graduates "*it is hard to know how important it is because I think most people who go out and work in the industry, especially* *in electronics, they don't need to be a member, for most of the industry*"

Edwin states that "*the benefits to me as an academic I know, it's a prestigious accreditation*", but at the same time feels that, for some engineering degrees such as electronics "*I don't think the employer asks […] is that EI accredited or not*". Thomas feels that accreditation will be of relevance to few graduates: "*I'm not sure how many will actually avail of that Chartered Engineering status from a programme*.", and that if you dropped it "*you could redesign your courses […] and you could eliminate some content that's only in there to satisfy the IEI*".

In the focus group some negative views of EI's influences were expressed, with regard to the emphasis on maths mentioned earlier, but also concerning the quality assurance system they use to evaluate evidence for accreditation, with some of the participants questioning the value of their approach. One participant stated that "*I can't say I've ever given EI a moment's thought during the delivery of anything that I've ever taught*", but on the other hand conceded that EI's accreditation requirements had a huge influence on programme design, and thence on what he would deliver.

EI is thus seen as a particularly strong influence, which, in parallel with the NFQ, has reinforced the adoption of a LOs approach to course design amongst my research participants, even though not all saw EI's accreditation requirements as fully relevant for employment. Even in this case they still influence the structure of engineering education, and most IoT engineering academics participate in five year accreditation cycles (QQI, 2019).

One interviewee expressed a particularly critical view of the impact of EI's interpretation of Bologna on IoT engineering education. In their view, one reason EI raised their Chartered Engineering educational requirements to master's degree was to "*keep a separation between the types of qualifications that were coming from IoTs, and coming from universities*". I have heard, and shared, such views before in a private capacity, however, the accessible literature contains little of a critical nature in this regard, with the exception of Kelly (SEFI, 2002), who described this as an attempt to "change our engineering degree structure" (p. 23) that had "nothing to do with Bologna". These views support my earlier argument that EI's interpretation of Bologna acted to curtail the provision in the IoTs of programmes accredited on the path to Chartered Engineer, reinforcing vertical stratification in engineering education.

6.10 Conclusion

The analysis presented above leads to a finding that a significant majority (twelve) of my research participants have given a positive, albeit qualified, acceptance to the role the NFQ plays as part of IoT engineering education, and that they regard its OBE approach as effective. This reflects my own view of the NFQ as I assisted in leading the transition to OBE in ITB engineering. Of the remaining interviewees, only Thomas, was recognisably negative, with the other two recognising pros and cons to the NFQ. Of the interviewees who are academic managers, all were generally positive regarding the framework, albeit somewhat critical on occasion. For those interviewees I regard as holding neutral views, in one case they had joined the IoTs post-NFQ, and what I viewed as a neutral stance could instead be a reflection that the NFQ is just part of the system as they know it. All of my interviewees, it was clear, whether they held positive, neutral, or negative views regarding its effect, considered the NFQ a significant factor in engineering education.

The fieldwork also provides evidence that EI's LOs based accreditation has been a significant additional factor in promoting the acceptance of OBE in engineering education, although engineering academics do not always regard this as important for graduate employment.

This chapter outlined the control experienced by my interviewees over their engineering education system, through official knowledge promoting OBE, which Kees referred to as "*that control issue we talked about earlier, right. Fascinating, fascinating area*". Further chapters of the analysis consider how this has impacted the pedagogic discourse and the pedagogic identity of my research participants.

Chapter 7 The Language of Levels

> *Because without our language, we have lost ourselves. Who are we without our words?*
> Melina Marchetta (2009, p. 65).

7.1 Introduction

As I carried out preliminary analysis of each interview I was keen to see what themes might emerge, and use these insights to guide subsequent interviews. My initial analysis showed that they were yielding rich data regarding the perceptions of my research participants of the impact of outcomes based education (OBE). However, only in coding the 7th interview (John) did I notice that in our discussion on the pedagogic discourse of engineering education we both repeatedly referred to National Framework of Qualification (NFQ) levels in describing various aspects of Institute of Technology (IoT) engineering education. In subsequently reviewing the significance, it became apparent that this was a common feature of all the interviews I had undertaken. I was quite comfortable using this terminology as it was employed in our pedagogic discourse, which explained why I had not noticed it previously.

To reflect on the phenomenon the analysis had revealed I returned to the literature which suggested that the policies associated with NQFs bring with them an associated terminology (Allais, 2010b; Biesta, 2015; Raffe, 2011). This aims to support features of qualification frameworks such as access, transfer, progression, approaches to teaching, employment opportunities, student choices, etc. (Allais, 2010b; Raffe, 2011). In observing the international experience of national qualification frameworks (NQFs) Raffe (2011) considers their effectiveness depends on the “widespread understanding and fluent use of the ‘language’ of learning” (p. 70), and refers directly to “a language of ‘levels’” (p. 75). Within Europe “LOs are perceived as a key approach to the establishment of a common language, an understanding of learning as quantifiable units” (Kenny, 2006, p. 197).

I had already noted it was intended that the nomenclature of the NFQ would become part of the language of Irish higher education (Collins et al, 2009), with Kenny (2006) referring to a “language of learning outcomes” (p. 187). In the fieldwork I observed the term ‘level’ being used by all fifteen interviewees, not just to describe NFQ levels themselves, but also other aspects of engineering education, *inter alia*, students, programmes, graduate attributes, jobs and even knowledge. This strongly suggests that IoT engineering academics, including myself, have, consequent to the NFQ, adopted a 'language of levels' as part of our academic vocabulary.

As would be expected given the policy driver for OBE, this language of levels is used by my research participants as they engage with policy discourse as modelled through the concept of the official recontextualising field (ORF) This includes in referring to awards, programmes, graduates, transparency, interactions with employers, progression and the structure of higher education.

The use of the language of levels, however, goes deeper than being part of the policy discourse, it has also become part of the language of everyday academic practice of my research participants. Considering this through the lens of the pedagogic device, it is part of their instructional discourse in the pedagogic recontextualising field (PRF) and in the field of reproduction, displacing more traditional terminology associated with engineering education. In this context it is used to refer to progression, the educational positioning of the IoTs, students, knowledge, projects, pedagogy, module design and delivery, and even the production of lecture notes and other teaching material. A summary of these different usages is provided in *Table 7-1*.

Table 7-1 The Use of the Language of Levels : including where it is used to reflect discourse on policy, where it is used as part of academic practice, and where these two areas overlap

			Isambard	*Ayah*	*Kees*	*Rudolf*	*Vitruvius*	*Bill*	*Thomas*	*Gordon*	*Edwin*	*George*	*Edith*	*Henry*	*John*	*Alan*	*Grace*
Language of Policy Discourse		***Awards***															
		Programmes															
		Graduates															
		Transparency															
		Jobs															
	Language of Academic Practice	***Progression***															
		Positioning of IoTs															
		Students															
		Student Projects															
		Knowledge															
		Pedagogy															
		Modules															
		Learning Outcomes															

The focus group considered the language of levels part of the academic norm, and discussed aspects of its usage. However, they extended the discussion to encompass *why* it was used, which, they felt, is because everyone uses it, and you need to use it to be understood. Indeed it is "*confusing now when you try to talk (about) our current system and you don't use levels*".

To begin with I illustrate the manner in which the language of levels has become an integral part of the totality of the pedagogic discourse through considering Gordon's interview, which I use as an exemplar of the usage of the terminology.

7.2 Gordon's Interview and the Language of Levels

Gordon's interview took place before the analysis revealed the language of levels. However, when I re-analysed his interview in the context of the phenomenon, I realised it had been an integral part of our dialogue as we discussed our education system. Our conversation is indicative of the manner in which my interviewees, and I, used this language in our pedagogic discourse in the interviews. I believe that for someone familiar with IoT engineering education the interview is quite cogent. However, I suspect it might be somewhat opaque to engineering educators from the Irish universities[27], who moved much later as a sector to embrace the principle of mapping of programmes to LOs (FIN, 2009). Additionally, they do not have the same concern regarding the relationship between undergraduate engineering programmes at level 6, 7 and 8. Furthermore, as the focus group suggested, the language of levels would be expected to be quite unclear to those from other jurisdictions.

The extracts below illustrate the manner in which Gordon used the language of levels in referring to: courses; student projects; students; modules; pedagogy; knowledge; graduates; curriculum and assessment.

In discussing the use of the NFQ to guide the design and delivery of programmes Gordon's usage of the language of levels goes beyond merely associating courses and projects with levels, it is also used to consider what the student is expected to achieve, what might be taught to them, and how it might be taught to them:

> *we very, very often talk about, 'Well is this a level 7 project or is this a level 8 project?' […] we have guidelines that we share […] that […] would match the difference between level 7 and level 8, for instance the stages in the product development process where we have a*

[27] With the exception of TU Dublin, formed from the amalgamation of three IoTs.

marketing department, the engineering department, the fabrication department I guess and they would be working together […]

To be very over simplistic about it, I find at level 6 might match to the fabrication. Level 7 might be fabrication plus design. So, a level 7 student might need a statement of requirements to do what she does. Then coming up to level 8 I would feel that the input into the problems that they would solve would be more, the questions that they would be able to answer would be more open.

Gordon discussed the instructional discourse using the language of levels: to differentiate between student projects in different years of programmes; to differentiate the educational aims of such projects; and in discussing their technical aspects with his peers.

In responding to a question regarding how his approach to knowledge in the curriculum is influenced by the levels in the framework Gordon firmly associates knowledge with LOs. NFQ levels may be used to consider the depth of the competencies expected of the student:

I think the way I would put together the modules would be in terms of the questions that the students should be able to answer at the end of it. And what they should be able to do at the end of it, like given this thing, can they do that thing? [...] So, for instance a practical where you are given a thing, you're asked to predict how it works and then you're asked to measure it and then compare the two. I think that's as applicable at level 6 as at it is at level 7 and at level 8. Perhaps the depth might be different

Gordon differentiated LOs by level:

NFQ levels can map pretty well onto […] some kind of taxonomy, like Blooms taxonomy where there are key words, at level 6 it could be, measure, analyse, graph. At level 7 it could be things like, compare, investigate [...] I find those words very, very useful to guide me in how assessment gets done and that then feeds back into how the stuff is delivered.

Gordon discussed his interactions with an EI accreditation panel using the language of levels, considering pedagogy, and what could be expected of a student:

one of the panel […] said to me 'I deliver C++ or object orientated programming in second year through C++. I deliver Java and algorithms at the moment, well in Java of course, but he suggested at level 8, would it be a thing to say to a student, 'OK you know how to programme in C++, there's a really good book about Java, now go to it.' And you know that could be valid.

Towards the end of our discussion I asked Gordon if there were any particular aspects of the NFQ he wished to highlight:

the upside is, yes. Like I say, the definition of the difference between level 6/level 7/level 8 is very useful to me in designing modules and even in thinking about courses and thinking

> *about the kind of graduate that comes out of these, that's great, that's very clear. Downside, I find the modular structure of it […] tends to de-emphasise in a student's mind that it's all interconnected.*

Gordon concluded the interview by stating, with regard to the opportunity the interview gave to share his views of the NFQ, that "*I have had the chance to give a pretty full account of what I think about it*", an account throughout which he made use of the language of levels.

7.3 The Use of the Language of Levels to Engage with the Regulative Discourse

I now move on to illustrate the manner in which the language of levels is used by all of my interviewees in their engagement with the regulative discourse of the ORF, in reference to awards, programmes, graduates, the NFQ value of transparency, and employment.

7.3.1 Describing Awards and Programmes

Kees experienced the tension between the NQAI and EI regarding the naming of level 7 qualifications as ordinary degrees, explaining HETAC insistence's "*that they were going to regularise and minimise the number of different types of qualifications*". However, notwithstanding the official name changes, and the earlier disagreement by EI (IEI, 2001a), the analysis suggests that it is now quite common, in academia, for awards to be described using the terms level 6, level 7 etc. (twelve of the interviewees).

Henry's words were reflective of the views of Bill and Edwin: "*the degree word now doesn't have the same meaning it used to have but level 6, 7, 8 does have currency*" and we have "*replaced using old words like certificate, diploma, degree with these new levels*".

Edwin had doubts as to the effectiveness of such descriptions, feeling that the effort to attain a degree is diminished in describing it as a level. He expressed concern that *"nobody asks anymore questions. How long? Where? Who gave it to you?*". He concludes the levels concept is not sufficient to fully comprehend the basis for an award. The terms PhD or doctorate have significant traction in academia (Park, 2007), bringing with them connotations of effort, experience, research, peer review and academic excellence, but Edwin considers "*a level 10 degree, and in three words, it's minimised somehow, the huge effort to get there*".

Alan described that, prior to joining the IoT sector, "*I was aware of the cert and diploma but I had no understanding, I had never heard of level 6, 7, 8, 9, 10 until I actually started here*". This suggests that although the IoT 's may make heavy usage of levels terminology, it may not have been adopted by all stakeholders. On the other hand Edith discussed dealing with companies seeking graduates at particular NFQ levels (7 and 8).

Continuing with the theme of stakeholders understanding the use of levels to describe awards, Rudolf noted an issue with students returning to education. He found they did not always understand the new terminology "*we often confuse them because we are speaking at level 6 or level 10 and they are talking about diplomas*".

George's interview was noteworthy in that he seemed to avoid the use of the term level to describe awards. When queried about this he emphatically explained that he did not consider levels to be appropriate for describing qualifications and graduate capability, stating that "*I liked the idea of the cert, the diploma and the degree. I liked that concept because […] I had a good idea what that actually meant*". However, George did use the terminology on occasion, for example in differentiating universities and IoTs and their students.

What emerges clearly, however, is that regardless of the concern with regard to the use of the term level to describe awards indicated by five of the twelve interviewees, even those with such disquiet accepted that this usage was now prevalent.

The use of levels to describe programmes (by thirteen of the interviewees) further illustrates the manner in which the NFQ has impacted on engineering education.

For example, Gordon regards the levels of the NFQ as allowing differences between programmes, and their future graduates, to be conceptualised at design stage. George, in viewing programmes as levels, regards it as easier to decide that they are fit for purpose, i.e. whether "*that degree is of the correct level and that degree isn't'*".

Henry sees the term level as useful at CAO[28] application time, i.e. applicants have "*their level 8 form, their level 6 and 7 form and I think that's a very good thing*", as, he feels that, for prospective students "*we've made deciding on courses on what to do much more difficult*", as there are now so many to choose from. However, Rudolf feels that students are not overly familiar with using levels to describe programmes, and that "*they have no real idea what level 6, level 7 or 8 mean*", or how long it will take to complete them.

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[28] The CAO, or Central Applications Office (CAO, 2017), is Irelands principal application route for potential students who wish to study in the university or IoT sector.

Ayah used the term level to refer to higher certificates and ordinary degrees, where "*at level 6 and 7 we could probably try and be a little bit more global in the approach rather than being so prescriptive*". This prescriptive view aligns with the NFQ level 6 indicator that graduates should be able to "formulate responses to well-defined abstract problems" (NQAI, 2011).

To summarise the significance, my research participants were quite comfortable in the use of the term level to represent various aspects of programmes, implying that the policy led discourse of representing programmes using NFQ levels has been accepted by academics.

7.3.2 Referring to Graduates and Employment

Government policy regarding supply of graduates is often couched in terms of NFQ levels, (HESG, 2011; Oireachtas Library & Research Service, 2014). Graduates were referred to as levels by eleven of the interviewees, principally in discussing graduate capabilities.

Alan compared graduates, and their consequent employment, using their programme level designations, in doing so highlighting situations where the role they take up is not commensurate, in his opinion, with the level of their qualification: "*I know guys that are coming out of here with level 7s who are doing the same job as a level 8, no doubt. You know? I can think of one example last year*". This may have occurred due to an element of confusion amongst employers with regard to what degrees at different levels mean. Kees described in the early years of the NFQ "*we would have seen evidence (of that). I don't think it was widespread*." and I would share a similar experience of the early years of the NFQ.

Isambard, similarly to Edwin and Kees, used the term level to describe graduate capabilities:

> *a level 9 is […] somebody who can follow through a structured research process, whereas in a level 10 which is a PhD, you expect that is somebody who can bring in novelty and they can bring in new knowledge and they can push the frontiers*.

At the other end of the NFQ level spectrum of higher education, George also viewed higher certificate graduates in terms of their capability: "*people used to be fairly skilled at level 6*".

Kees and Grace described professional engineering graduates as level 8 graduates. Henry, on this subject, feels that "*you can't just say a professional engineering degree, full stop the way you did at one time so you have to say [...] what level degree and where is it from*".

Edith discussed graduates in the context of the reduction in government funding of third level, relative to student numbers, that has occurred since the hard recession in the aftermath of the Celtic Tiger, and difficulties this has created (IBEC, 2015; Expert Group in Future Funding for Higher Education, 2016; HEA, 2017a):

> *the government are asking for all these levels of students coming out, level 6, level 7 […] but they're not contributing to the colleges […] our labs and I'm sure your labs are the same, they could do with a bit of a facelift; they could do with an upgrade [...] with maintenance.*

Nearly half (seven) of my research participants use the language of levels to refer to the type of employment that someone completing a course might take up in industry. This usage is consistent with the emergence of the language of levels in the national policy discourse to refer to up-skilling and employment (IBEC, 2015; DES, 2016).

Bill succinctly linked levels and jobs, referring to the end result of an honours degree as "*you're an engineer level*", which Ayah similarly referred to as "*professional level*", also describing the capabilities of higher certificate graduates as "*operator technician level*". Thomas similarly used the language of levels in discussing how he views the technician role, stating that level 7 "*doesn't give you technician level*".

Edwin described that, when large companies visited his IoT seeking to employ graduates they look to fill posts at level 7 and 8. In this case, the language of levels has also become part of the discourse with key stakeholders, the large employers who not only provide jobs for many graduates, but also contribute to (and sometimes dictate) programme design. Edith also provided evidence of this, speaking of a recent recruitment drive from industry in her IoT, stated "*they were looking for technicians, so they specifically said 'we only want level 7'*".

Rudolf uses the language of levels to articulate a different position regarding industry engagement with the framework:

> *They struggle with the ladder, the progression pathway, 6, 7, 8. You know I think that is a challenge for them. So, certainly the bigger employers you know it's honours degrees, it's a language that they talk about it and they are comfortable in that but really they have very little knowledge of the framework and its purpose.*

This usage of the language of levels to refer to employment provides further evidence of the manner in which the NFQ, as part of the regulative discourse of the ORF, is influencing educators, inculcating a jobs and skills focus.

7.3.3 Transparency

Eight of my research participants used the language of levels to discuss transparency.

Edith refers to the usefulness of the language of levels for prospective students and their parents "*that are sending their kids to college, they can see what levels they can achiev*e". Edith described further evidence of levels and transparency, where "*at graduation yesterday the President was talking about different levels*" in a speech to students and their families.

Isambard felt that the NFQ "*has actually enabled a very clear demarcation of the different levels of the awards*", which, in terms of transparency, allows awards from different HEI's to be compared against one another. Edwin's interview also discussed transparency being applied to compare HEI's, their qualifications, and their students in terms of levels.

Rudolf was sceptical about how transparent programmes were, to prospective students, to current students, and also to employers:

> *some of the HR and the training managers certainly in the engineer space understand the level 6 space because they may be looking to develop programmes where they can up-skill craft-workers or operatives, but that middle ground and level 7 and the validity of it, I would have a sense that its zero or nothing.*

Henry, on the other hand, felt that although "*employers have now become a little bit confused*" with regard to what a Bachelor of Engineering award means, "*the level does help clarify that to some extent*".

The language of levels is used by over half of the interviewees in reference to transparency. All but one felt the NFQ facilitated transparency, but even Rudolf, who did not fully agree with this, discussed his concerns using the language of levels. This provides further evidence of the use of the language of levels in academic engagement with the policy discourse.

7.4 The use of the Language of Levels to Engage with Both the ORF and the PRF

This section discusses how the language of levels is used by my research participants in referring to aspects of the pedagogic discourse that encompass both the ORF and the PRF.

7.4.1 Progression

Progression is part of the national policy discourse for further and higher education (GoI, 1992; Irish Statute Book, 1999b; NQAI, 2003a; OECD, 2003; SOLAS, 2014), and a key aspect of the NFQ value of *Comprehensiveness and Coherence*. Furthermore, progression raises fundamental issues for IoT engineering education, as will be considered in later chapters. The use of the language of levels in relation to progression is thus both a means for engagement with national policy discourse, and also of relevance to academic practice. Over half (eight) of the interviewees referred to progression in terms of levels, predominantly in discussing the intended policy impact of supporting students in moving upwards through NFQ levels. However, as will be discussed later (Chapter *8*) my interviewees also perceive progression as having a wider impact on the education they offer, and they made use of the language of levels in this context also.

Thomas felt that progression was positive for tradespeople, who, previously "*stopped at their particular level with their apprenticeship*". He considered the NFQ required IoTs to remove barriers to their progression, and create paths to allow them to further their education.

Bill firmly linked progression to the concept of levels, comparing it to the previous system where there "*wasn't an automatic progression route*", and also felt the NFQ acted to remove barriers. He used an engineering analogy to explain his view:

> *with the National Framework, the fact that you have levels; if you've levels in anything like a tank, it's always seen that you can take up any of these levels and you can move between them. So level 6 automatically means you should be going to level 7 and 8.*

Several of the interviewees similarly discussed progression between NFQ levels 6, 7 and 8. Edith sees "*everybody's into level 7 and then level 8 and it's a feeder route to getting your degree, whether its honours or ordinary*". Ayah described her personal experience of progression in a similar manner "*I would have done the ladder system so the level 6, 7, 8 and then 9*".

Isambard, however, rather than focussing on aspects related to the policy discourse, reveals his perception of the impact of progression on teaching, where he states that:

> *if someone who is teaching has interpreted correctly then they would need to recognise that at some stage through all adjacent levels, for example between level 6 and level 7, there is bound to be some unifying […] overlaps in what you teach or in the way the learning outcomes are assessed or even in the way the syllabus is interpreted.*

This is an important point I return to in *Chapter 8,* when I discuss the wider impact my research participants perceive progression has had on our engineering education system.

7.4.2 Educational Positioning of the IoT Sector

This subsection shows the language of levels as used by five of the interviewees to describe the IoT sector, in terms of where it is situated from an educational perspective, where it should stay, and where it might evolve to. This is related to the analysis in *Chapter 6* of the societal impact of the NFQ, which discussed the concerns of the research participants with regard to their students, funding for the sector, and the impact of massification.

Ayah, herself a graduate of a ladder based system, uses the language of levels to differentiate the IoTs and the universities, describing that "*the level 6, 7, 8 and then 9*" of the ladder system made her "*very aware as a student of a LOs approach*", more so than if she had been a university student. Thomas uses the term level in a similar context, feeling that the IoTs should be focussing on teaching technology "*at level 6 and level 7 where we should be*".

Alan on the other hand came "*from the university system*" and "*didn't even know what level 6 & 7 was*". He was somewhat aware of, but not fully appreciative of, the differences between the IoT sector and the university sector before he joined an IoT:

> *I actually learned more in six months in industry than in terms of applied focus than I did in four years (in university). I will be honest, whereas when I started here I was shocked with the level of contact in lab environments.*

To further illustrate, he described an experience as a student, where IoT graduates had joined his university class: a lecturer asked a question of the class with the accompanying instruction that *"'I don't want anyone from an IoT to answer this*", on the basis that their different knowledge base made the answer obvious to them.

Edith uses the language of levels in a similar context, speculating that it may be the case that in a future "*technological university they just do level 8 onwards*", i.e. the creation of technological universities from the merger of IoTs might cause a shift in programme offerings. Henry conjectures that, "*the differentiation between us and the universities is we are now going to produce level 8 students and they'll produce level 9 students*".

Those of the interviewees who used the language of levels in the context of the IoT educational positioning used NFQ levels in expressing views of the past, the present, and what may be the future of the IoT sector. This was done at both a policy level (e.g. the technological university, funding) and in regard to the type of education offered in the IoT sector, e.g. in terms of laboratory work, the teaching of technology, and the type of students.

7.5 The Use of the Language of Levels in the Instructional Discourse

The language of levels was used by the interviewees in discussing their academic practice, to refer to: students; student projects; approaches to teaching; modules; and knowledge.

7.5.1 Referring to Students

The interviewees (ten) used the term 'level' to refer to students, in terms of situating them at the stage they are at in their programme of study, and their educational needs.

Alan identifies students as levels, ascribing different educational needs, to the different levels. He differentiates how he would "*present the content to a level 6 or 7 students versus how you direct the student at level 9 to actually go on and almost figure it out themselves*".

John identifies his research master's students as "*level 9 research students*". Edith referred to students as levels in discussing whether some programmes are too academic, explaining that she regarded the focus as "*wrong for the level 7 students, because I do think there should be a more trade element for a lot of those students*".

Ayah considers that "*level 6, its very much hands-on practical focused, very prescriptive, step-by-step approach, a lot of hand holding*" (Ayah). With similar concern, Vitruvius "*will supply more backup material to the level 6 students*". In contrast, level 8 students "*need to be able to go out into the world and solve problems and navigate through different systems that they've never seen before*" (Ayah).

The key points that emerge from this analysis is that lecturers regard students, at least partially, as being at a "*level*", and seek to educate them appropriately on that basis.

7.5.2 Approaches to Teaching and Student Projects

Levels were used by seven of my research participants to describe different contexts within which the students are educated, and how different types of learning and teaching are associated with the levels.

Isambard, reflecting sentiments shared by Ayah advocated, that "*as you move from the lower levels to higher levels of the NFQ, they need to move from prescription and give more or less open-ended problem solving type of challenges*". Thomas similarly recognised differences in the teaching approach required at the different levels "*at level 8 [...] its [...] about creativity and that has to come from the individual and level 7 its more guidance based*". Although he felt that "*there's a lot to be said for guiding a student a bit more even at level 8 as well as opposed to just letting them off on their own and submit something*".

Vitruvius similarly regards levels as a guide to teaching students, going so far as to use it to explain to students the amount of self-directed learning he expects from them. When the students question "*the level of which they must go and find stuff out themselves [...] I can have that argument and ultimately I can pull out the NFQ framework documents and quote them at them*". Alan also adapts his teaching "*based on the level*" he is "*trying to teach it at*".

A small number of interviewees (two) directly used the language of levels when describing lecture notes. For example, Vitruvius describes how he considers lecture notes:

> *When I read over my notes over the course of the summer, before I launch them again, I'm always trying to think "Now hold on. I keep writing this material that I deliver for level 7, level 6, but they're the same notes: something's up there.*

He further explains he uses the levels the students are studying at to decide how in-depth and challenging his lecture notes should be.

The analysis reveals that some of my research participants actively consider the manner in which they are teaching students in the context of the level at which they are teaching. This is further illustrated in considering projects, which for engineering students, are critical pieces of work. They provide a student the opportunity to integrate the knowledge, practice, technology and application that they have learned across modules, and demonstrate their engineering ability in the production of an engineering artefact (Lipton, 2010). At honours degree it might typically be worth 20% of the marks for the year. As a guide to their importance, I can say, based upon my industry experience, that the most likely interview question a new graduate engineer will get is 'tell me about your project'. Where engineering student projects were raised by my interviewees (four), the language of levels was integral to the discussion.

Gordon differentiates projects across years using the language of levels: "*is this a level 7 project or is this a level 8 project*". He uses levels in describing the essential meta-characteristics of student projects, stating that "*a level 7 student might need a statement of requirements to do what she does*" whereas "*a level 8 student would be able to get [...] a* *general statement of [...] design a bread-maker [...] that can wake a person up with fresh bread'*."

For Bill, "*a level 6 project is year two*", which involves getting the student to build, test, and verify an engineering solution to a problem. He described teaching students "*this is how you would do a project, you just need to follow this in doing, you build something, you get it working*". He considers projects more self-directed at level 7, with this implicit in the level. Finally, at honours degree level, Bill states "*you're very much on your own*", i.e. projects are very much self-directed at this stage, with this implicit in using the term 'level 8 project'.

Bill described the relationship *between* these different types of project in terms of the language of levels. He views progression as having changed the nature of what it is being delivered, ensuring the project supervisor establishes linkages with the student in terms of what went from one year to the next. Projects at levels 6, 7 and 8, are all part of "*one system*". Thomas similarly describes projects at different stages of a programme in terms of what can be expected at different levels, and the guidance the supervisor will give.

Not all agreed that projects were clearly differentiated by the level concept, with Alan stating that for "*project work, I have to say, there is a significant blurring of lines between level 7 and level 8*". However, he still considers this in terms of the language of levels.

To conclude, although a relatively small number of lecturers used the language of levels to discuss engineering student projects, those who did were using it in considering the depth a project should have, and the relationship between projects at adjacent levels. This is a key point related to the instructional discourse, which I was to revisit in the focus group.

7.5.3 Knowledge

Lecturers' acquisition of new knowledge, their recontextualisation of that knowledge into curriculum, and their related pedagogy, are key aspects of academic practice. Eight of my interviewees discussed knowledge in terms of NFQ levels, with for some (two), levels used to represent or designate the knowledge.

Alan is comfortable using levels to represent types of knowledge, stating, in relation to graduates who were proficient in practical skills, that "*they would have struggled with [...] level 8 theoretical concepts*". In acquiring knowledge to teach at a particular NFQ level, Alan states "*I am teaching this at level 6 so I need to learn it to that level*". In the recontextualisation of that knowledge into teaching, Alan states that he would "*learn as much as I can about it myself and then I adapt based on the level I am trying to teach it at*".

Bill was very conscious of the level he would be teaching at when he acquired new knowledge, describing that new material "*had to be learned enough to be able to teach it, maybe not to be an expert in it, but enough for the level that you were teaching*".

For some interviewees knowledge is considered from the point of view of assessment, e.g. Isambard, describing post-NFQ, of syllabi and LOs being written to "*allow for assessment at a particular level*". Edwin considers that, as external examiner, he evaluates the assessment of knowledge in terms of "*the level that it's pitched at*".

Vitruvius uses NFQ levels in terms of revising his notes, and, similarly to Alan and Bill, regards the NFQ level as helping to define the knowledge required to teach. Also, mapping on to Isambard and George's views, he sees the role the NFQ levels plays in the recontextualisation of knowledge into syllabi. Ayah also sees the role of the NFQ in curriculum design, recounting how she found it restrictive having to design level 8 programmes using the NFQ.

Considering knowledge in terms of levels causes me to reflect on how we regard knowledge as engineering educators. On the one hand, I have a concern with the contingent nature of the use of NFQ levels to provide an epistemological perspective for engineering knowledge, rather than this being something with a disciplinary basis. More commonly, my research participants viewed their recontextualisation of knowledge in the curriculum in terms of the level it was to be taught at. Bernstein's (2000) concept of recontextualisation identifies the role of pedagogues in selecting and sequencing disciplinary knowledge for the curriculum, and the use of levels to consider knowledge, has become, for some of my research participants, part of this process. I will consider the implications of this further in *Chapter 10,* when I consider my research participants' views of knowledge, skills and the curriculum, and also in the discussion in *Chapter 11*.

7.5.4 Modules

Modules are designed, mapped, and validated at a particular level on the NQF. Referring to modules as levels, is thus to be expected, but does illustrate another of the multiple ways that 'level' is used in common parlance by academics. I observed this usage in five of the interviews, which I illustrate below with examples.

Of his early years teaching Alan states "*I taught computer networks, cloud computing architecture at level 9 and I taught computer networks at level 8 for BSc in software design*". Alan also discussed lecturers "*inheriting and then owning certain modules at different levels*".

As noted earlier (p. 140), Rudolf, as an academic manager, discusses modules with new staff in terms of levels to guide them in their approach to teaching. Rudolf also refers to modules he teaches himself in terms of levels, talking, for example, of "*a level 8 module that I am teaching online*".

7.5.5 Learning Outcomes

Not surprisingly, some of the interviewees (eight) use the language of levels in relation to LOs.

Mirroring the earlier discussion on forms that projects take at the different NFQ levels, Ayah describes differences between the LOs of different years of a course in terms of levels:

> *the biggest jump is from level 7 to 8 where you're now going into more analytical type phase and often I think students struggle an awful lot more when they move from 7 to 8 [...] there probably could be a softening of lines between the LOs at 7 and 8 in order to equip students to be more self-directed learners at the level 8 stage or possibly that we could have a little bit more at the level 6 rather than very kind of prescriptive type modules.*

Alan has a related stance comparing "*what you're supposed to be able to achieve on a level 6 LO in one subject versus a level 8 or 9 in the same subject*". Alan prefers "*the higher level LOs because it is [...] different, it is closer to what I am trying to describe here in how to think*". For level 6 LOs, which are often quite skills based, he feels that "*sometimes the lower level LOs [...] they don't explain*" the context fully, i.e. "*what skill is this proposing*".

George feels that LOs assist lecturers: "*when you have taught for a while you do have a feeling about what level they should be at the end of the course [...] the LOs are quite useful because they can say what, how much in depth the actual content is*". Isambard regards LOs, combined with levels, as making it clear to a lecturer what they can achieve within the time available to deliver a module. Kees is even clearer that the QQI Engineering Standards give direction to the lecturer "*you could look at a cell in the matrix in terms of programme outcomes, level and read what you were supposed to do*". This sentiment is mirrored to an extent in a comment by Vitruvius, in referring to programme validation documents: "*you can go to those Word* *documents, show what the outcome must be, and then delve into the framework and it'll tell you the level at which you might challenge, the level of independent learning*".

Kees concern was with how LOs and levels guide the lecturer, whereas Vitruvius's considers this should be in terms of how they can teach the student. Rudolf holds a more student centred view, regarding that "*you help the students achieve LOs at that particular level*".

7.6 Criticisms of the Effectiveness of the Language of Levels

A disquiet regarding the language of levels is visible in some of the interview transcripts. Rudolf's perceives part-time lecturing staff "*don't understand, level 6, level 7, level 8*", ascribing this to the NFQ not being part of the context of their non-academic lives. He expressed similar concerns regarding industry understanding of NFQ levels.

Henry, in discussing the use of the terms level 6, 7 and 8 to describe graduates, states that:

> I *think we have muddied the waters [...] I've had employers ask me [...] explain [...] to them what's going on because they are looking for a particularly person and they're saying what should I look for [...] they may be looking for a technician.*

As discussed earlier, George did not feel describing a graduate as a level was an appropriate reflection on their achievements. A similar concern was expressed with the representation of a PhD using the phase 'level 10'.

Concern was also expressed with the NFQ principle that the mapping of awards to levels can be used to compare awards directly, without considering the awarding or educating body.

7.7 The Focus Group and the Language of Levels

The focus group discussion led to a deepening of my understanding of the language of levels, which I also highlight in considering the effectiveness of the research methodology. In this stage of the fieldwork I sought to enable a group conversation that would shed more light on the phenomenon I had observed. I presented a preliminary finding that the language of levels had become part of our pedagogic discourse, used to refer to both policy and academic practice. To support this I illustrated the manner in which my interviewees had used the terminology when I spoke with them individually. The focus group agreed that the use of the language of levels was pervasive in our education system. Rather than exploring in depth how this terminology was used, the principle discussion that emerged was of reasons that it had become so important, for which the following key points of consensus were established.

An overarching theme was that the focus group felt everyone is using the language of levels, and in order to be understood, individual academics must use it also.

The use of the terminology by students, who seemed to have adopted the level of the course they are doing as part of their student identity, was regarded as a key driver:

> *I use it now, because the students use it. Because they tell me I'm doing the level 7, or I'm doing the level 8. I would be old school, and I'd still call the level 7 the diploma and I have to correct myself, the ordinary degree [...] They're talking in numbers now.*

Student usage was seen to be influenced from two directions outside of higher education: "*that's coming from the career guidance teachers; you do a level 7, you do a level 8"*; and also "*It's feeding in as well from industry [...] similar grades in Company X, you know where, they have a system of levels. That's right yeah, for their engineers*"

The group felt that the language of levels brought clarity to understanding the difference between an ordinary and an honours degree. Indeed, they felt that it is "*confusing now when you try to talk about our current system and you don't use levels; it's a lot easier to say, 6, 7, 8*". The focus group consensus was that it is less likely that master's and PhD's would be described as NFQ levels than undergraduate awards, speculating that this might just be because they did not "*have many level 9s and level 10s*" in their IoTs.

In discussing the international mobility of graduates, the focus group was concerned that the perception of an award in the "*international arena*" was important, but where the terms level 6, 7, 8 etc. to describe programmes have little meaning. Indeed, even Ireland's NFQ levels, referenced to the EQF, are differently numbered than the EQF levels. One group member highlighted the impact on the work they do for EI. They stated that "*I would use the levels secondary to the primary description of a degree. For example, BSc NFQ level 7, simply because in whatever work you do, you look at how it's going to be perceived in the international arena, rather than the national arena*".

Further disquiet was expressed by one participant, who, although accepting of the usage of the language of levels to describe awards, harked back to formal naming conventions: "*although I speak in levels now, I still prefer the old system, and I think we have simplified education by giving it numbers. I would prefer to refer to as a bachelor in science or a bachelor of engineering, or an ordinary degree, as opposed to just going number*s".

There was a sense from the focus group discussion that they considered the NFQ improved access to education, inculcated a sense of inclusivity and facilitated recognition of IoT engineering qualifications: remarking "*it's putting everything on an even keel*", as earlier noted in *Chapter 6*. The use of the terminology of levels, as part of the NFQ, was seen by the group to counter elitism: "*I think the terminology changed; the old system [...] was an elitist system, it was for an elite portion of soci*ety".

Related to this concept of countering elitism, the focus group considered that the use of the language was a reinforcing influence regarding progression: "*if you just start talking about level 6, 7 and 8 qualifications [...] it's also emphasising the progression between them [...] It gives it that greater sense of you simply went as far as you could do*".

Supportive of a finding from the interviews, the focus group considered the language of levels assisted in clarifying the relationship and distinction between student projects at different levels: "*In the project presentations, we kind of say that's a bit level 7, where's the level 8'ness in that. [...] It's also just easier to use, it's just easier to say*". A consensus was that projects for different years are defined by different levels, which aids and clarifies communication.

I attempted to explore the relationship of the usage of the language of levels to the regulative discourse of the ORF through discussion of its usefulness in engagement with quality assurance. The focus group, in recognising that the language of levels had a role in this, steered the conversation to the academic practice of course design. One focus group member commented that "*it makes it easier to design programmes, or to lead a team",* and another felt that the language of levels was effective in mapping from programme LOs to module LOs in curriculum design.

The focus group discussion confirmed my preliminary finding that the language of levels had been adopted by my interviewees as part of their pedagogic discourse, and also, offered insights into why it might have occurred. It also added another facet to the fieldwork, in which I was both a participant and observer. My observation of the use of the language of levels in action in a group discussion regarding our engineering education system provided direct evidence of engineering academics, including myself, using it as an effective means of communication in our pedagogic discourse.

7.8 Conclusion

A policy goal of the NFQ is to create a culture where lecturers, students, and employers use the nomenclature of the framework as a language of engagement with higher education (Collins et al, 2009). A finding is that the analysis shows that my research participants have adopted a language of levels as a consequence of the NFQ, as part of a language of policy discourse, and as a language of academic practice. A summary of the use by academics of the language of levels is captured in *Table 7-1*. Whether academic management or lecturers, the use of the language of levels to engage with matters related to policy discourse is quite pronounced. This reflects Kenny et al's (2015) finding that Irish academics are keenly aware of the impact of government policy on their role, and their ability to perform it effectively.

Edwin considered that "*everybody's talking with these levels*", with its use pervasive in the interviews and the focus group. A finding, enabled through the focus group discussion, is that the language of levels is so pervasive and important that not only *can* it be used to discuss academic matters but rather it is *essential* that academics do so in order to be understood. The level concept has become so integral to our pedagogic discourse I believe it would have been quite difficult to usefully analyse the fieldwork without developing the understanding of the phenomenon of the language of levels I have presented.

A further finding is that the language of levels is seen in a positive manner, enabling effective communication between academics, and supportive of some of the aims of the NFQ. In particular, it is seen to support improved access to education, in doing so countering elitism in the system. It is also seen to be a significant factor in emphasising progression for students and academics, the impact of which is considered in the next chapter of the analysis.

Chapter 8 Progression in IoT Engineering Education

Nothing would be done at all if a man waited until one could do it so well that no one could find fault with it.
John Henry Newman (1851, part 7, para. 1).

8.1 Introduction

The importance my research participants ascribe to student progression in IoT engineering education was a topic they chose to emphasise, highlighting its relationship to other interview topics. This chapter builds upon an earlier finding that the level terminology of the NFQ foregrounds progression for my interviewees. Through this I identified a perception amongst a selection of my research participants that progression stresses for them the importance of ensuring earlier years of all undergraduate study primarily prepare a student for later years, whereas previously the delivery of engineering higher certificate, national diploma, and honours degrees programmes was more compartmentalised.

This chapter explores in more depth my research participants' perceptions of how progression has influenced their approach to teaching of level 6 higher certificate and level 7 ordinary degree students. This leads into analysis of the manner in which they consider that IoT engineering technician education has changed under the influence of outcomes based education (OBE). An earlier, related, finding was that the language of levels, in emphasising progression, acts to improve equity of access to education and counter elitism, and I further consider my research participants' views of the relationship this has to progression.

To begin with I analyse progression through Bill's eyes, who, in the first interview of the fieldwork, wove progression, and the effect he perceived it had on the engineering education that he had made a career, and on him as an educator, in a powerful narrative. Commencing the analysis in this chapter with Bill's interview is more than a matter of presentation: in gaining his perspective of the impact of progression I developed a new understanding of this aspect of the National Framework of Qualifications (NFQ), which I use in framing my further analysis of the fieldwork regarding progression.

8.2 Bill's Interview and Progression

Bill described being on a personal journey throughout his career as an educator, stating that "*over the years then I think I've reinvented myself I don't know how many times*". He explained that he was always considering "*how can I do my job better. And even at this stage I wouldn't have even remotely exhausted how you could be a better lecturer or a better educator*". In relating his experience as an engineering educator in the Regional Technical Colleges (RTCs) in the 1980s and 1990s, Bill described how a national certificate could lead to a "*decent enough sort of technician level job in some industry*". A further year to gain a diploma could allow a graduate "*to be a really good technician*", who could then choose to enter a 2 year add-on engineering degree, at which point education started "*to prepare someone to be an engineer*".

Bill used the term 'sudden' in relation to the introduction of the NFQ, the consequent change in how students were educated, and the progression opportunities it introduced; highlighting the strength of the change he perceived. Bill described how the NFQ introduced a new structure to Institute of Technology (IoT) engineering education: programmes (and students and graduates) became defined in terms of level 6, 7 and 8, as opposed to previously being programmes for technician, advanced technician, and professional engineering students. Progression became an item of "*a bigger relevance and a newer relevance*" compared to pre-NFQ days. Students of higher certificates (level 6) began to be seen as destined to do ordinary and honours degrees, rather than these sub-degrees being ends in themselves. Bill associated the NFQ not just with increased progression opportunities for students, but as making such progression automatic.

Bill's pedagogy, and, in his opinion, those of his peers, changed as a consequence, and he "*started doing things differently*". Bill perceived that the progression that was now built in from years two to three to four (level 6 to 7 to 8) caused him to link modules taught in earlier years seamlessly to those running in later years of programmes. He considered he, and his peers, now "*taught in terms of progression*". He explained his view that "*the minute you put in a progression system from FETAC, HETAC and levels, then you immediately start changing the way you're thinking. Well, I did anyway*".

As articulated earlier, Bill used student projects as a particular example (See p. 163). Projects structures became clearly defined from one level to the next: the make/build/test/verify of level 6; the more self-organised but still directed level 7 project; and the largely self-directed projects of level 8; with successful completion of each the "*next stage of your progress*". For Bill, the level of the project came to define the pedagogy of the lecturers in relation to projects. Bill, influenced by progression, changed to view projects across years as being part of a single system, as opposed to separate modules on different programmes. For example, a student taking a level 6 project in year two is in "*training for year three*". Bill, an experienced lecturer, regarded this change in emphasis as "*interesting and new for me*".

In discussing the manner in which level 8 projects prepare a student for employment, Bill feels "*you're going to have to present stuff on time to your boss, and they're not going to be impressed if it's not done on time. So right now is your time to shine on that one*". However, preparation for employment was only mentioned by Bill with regard to level 8 projects. It seems that Bill now expects students to remain in education till completion of an honours degree, with students on higher certificates and ordinary degrees being educated from the outset to be professional engineers.

In concluding the interview Bill re-stated his views on the change he had seen from the introduction of the NFQ: "*we went to this fluid system that goes through all the level 6, 7, 8's and 9's, and then progression is almost a paramount thing*". He explained that, as opposed to the previous rather elitist system, people who previously would not have been educated to the same extent are now "*getting the chances that they wouldn't have (previously)*", albeit it raised a concern with him on maintaining academic standards.

An overarching theme in Bill's interview linked progression and the NFQ to a change in his perception of what he was teaching his students to be and how he was teaching them. A number of related sub-themes emerged from my consideration of Bill's interview:

- how progression to level 8 has become the aspirational target for students;
- the effect of progression on technician education, including the effect on higher certificates;
- how progression has effected pedagogy;
- the manner in which progression has effected how student projects are regarded by engineering academics.
- progression and equality of access to education;

In the following sections I develop these sub-themes through examining how they were viewed by the other interviewees, and how the focus group related to them, with the exception of the effect on pedagogy which I consider in *Chapter 9*, and the effect on how engineering academics regard projects, which has already been considered in *Chapter 7*.

However, Bill's interview leads to more than just a set of sub-themes to guide my exploration of the fieldwork. It is noteworthy in itself in illustrating how an individual academic, in regarding their career as a personal journey as an educator, perceived the NFQ, and progression in particular, as such a defining, positive influence on how he approached being an educator. Bill's interview shows evidence of his pedagogic identity being influenced by the skills focus of the NFQ, expecting of the students that "*when you get to level 8, you're certainly expected to have very detailed writing skills for reports, organisation, timetabling, to make sure you get the thing done in time*". His interview also shows evidence of his pedagogic identity being influenced by the student-centred, lifelong learning policy drivers, e.g. he is trying to find "*new ways of doing things that were more relevant to students*". An earlier finding was that the change in pedagogic identity of academics as the RTCs expanded their role was consistent with Bernstein's concept of pedagogic identity changing under the influence of a changing pedagogic discourse. It is a further, related, finding that Bill's interview provides evidence of an engineering academic embracing the change in their pedagogic identity brought about through the influence of the NFQ, and progression in particular.

8.3 Progression to Level 8 as the Aspirational Target for Students

The analysis suggests that over half of the interviewees (eight) perceive that level 8 has become the aspirational target for all new entrants to IoT engineering programmes, whether initially registered on level 6, 7 or 8.

Rudolf considers the concept of progression as well-understood by staff and students. However, he regards this as not the case for external stakeholders, stating, for example, that "*parents struggle with it*", where they want their children to go straight into honours degrees, rather than progressing through the ladder system. Rudolf similarly felt that employers[29] struggle with the concept.

Kees, in regarding progression within the ladder system, expects students to aspire towards the end-goal of an honours degree, "*stacking*" up the intermediate qualifications en route. In some cases, the interviewees felt that, from the students' perspective, it was an imperative, rather than an aspiration, to progress to level 8. Thomas regarded level 8 qualifications as the "*end goal*" of all students, and that "*if you don't make it [...] your exit award is your ordinary*

[29] See p. 146.

degree, you couldn't cut it". This sentiment is mirrored in Edwin's comment that "*a lot of students now, they feel like if they have only a level 7 degree, they've nothing*".

Edith recognised the opportunities that progression offers to students, but felt that progression had introduced some educational issues, proposing that not all students were placed to engage well with level 8, and that "*there should be a more trade element for a lot of those students [...] They're going in to be a technician, so they need the practical skills*".

Ayah questioned the manner in which studying at one level of the NFQ prepares the student for the next, in the context of whether a student who commences a level 6 programme is, from the outset, being prepared for a professional engineering qualification. Ayah considers that achieving awards at different NFQ levels requires particular, and "*completely different*", mind-sets in the students, which mirrors the position on the differing epistemologies of technician and professional engineers articulated earlier in the literature review (Shay, 2012; Wolff, 2015). She expresses a concern that "*as the student progresses up the ladder more, it can leave them quite vulnerable in that now they feel they're exposed and they're lost at level 8, 9, 10 if they're not applying the LOs approach*". She feels that the education required for associate engineer, which is quite prescriptive and aimed at "*operator technician level*", needs to be adapted to prepare students properly for progression to level 8 where they can aspire to professional engineering status.

In the focus group I queried *whether the level 6 and 7 qualifications (are) becoming merely precursors to professional engineering qualifications (level 8)?* This sentiment was supported by the focus group discussion, with a consensus that "*we now see a level 7 as a person on a journey to a level 8 as opposed to being an exit award*[30]*. So, we're not training technicians anymore*". One focus group member went so far as to say that a level 7 graduate appears to be someone "*who couldn't make it to level 8 for whatever reason, they consciously make a decision to exit at level 7, saying 'Great, I'm not a qualified technician, that's my ambition'*".

The fieldwork provides evidence that a significant proportion of my research participants view level 8 as the aspirational qualification for all undergraduate students. Some of the

[30] Completing a 3 year engineering level programme in an IoT usually allows a student to receive an ordinary Bachelor of Engineering degree. However, completing the first 3 years of a level 8 programme may entitle them to receive an exit award at level 7 if they so wish, although it is unusual for them to take this exit.

interviewees expressed concerns with smoothly moving, from an educational perspective, between the different levels, feeling that the prescriptive nature of the earlier levels does not prepare a student well for level 8. Others queried the appropriateness of what is being taught at the lower levels as a consequence of progression.

The difference, indeed conflict, between level 7 and level 8 graduate attributes was also raised. The importance of this is considered further below.

8.4 The Effect on Technician Education

A sub-theme that emerged from Bill's interview was that, post-NFQ, "*you felt that even at third year level, you were teaching somebody to be an engineer, rather than a technician*". In exploring this, the analysis revealed the perception of two-thirds (nine) of the interviewees that progression has led to a change in higher certificate (level 6) and ordinary degree (level 7) engineering technician programmes towards being regarded as pathways towards honours degrees. This is consistent with a survey of first year level 7 engineering students in the DIT which revealed over 75% already intended, on completion, to transfer to an associated level 8 degree (Llorens et al, 2014). It is further consistent with the data on IoT engineering enrolments presented in *Figure 2-4,* which shows a shift in emphasis to honours degrees.

It has already been argued that this change might be attributed to the increased affluence of the country (Barry, 2007), and to the benefits students see of holding an honours degree to allow them to engage with careers in the knowledge economy (Skilbeck, 2003). However, it may also be at least partially an artefact of the NFQ concept of progression. This section explores the impact the interviewees perceived from this refocusing of IoT engineering education towards honours degrees.

Alan discussed students who, he felt might make very good technicians, but would have struggled with more theoretical level 8 topics. He felt that the technician identity has been diluted from its practical focus through the theoretical topics introduced in level 6 and 7 to support progression, with "*the IoT sector in general moving away a little bit from developing these kinds of skill sets in the lab*". Thomas similarly saw diminution in the skills focus of the technician identity, viewing that, rather than a level 7 graduate being equivalent to the old National Diploma, "*It doesn't give you technician level*".

Thomas feels that the technician focus of the national diploma has been lost, with the ordinary degrees that replaced them taken by students for the purposes of progressing to level 8 rather than to secure employment. He sees EI's influence also, considering that accreditation criteria has led to an overemphasis on maths in level 6 and 7 engineering programmes, in order "*to tick the box for EI*". In his view EI accreditation is positive, as is progression, but he questions if we are "*serving the needs of our students by designing courses with such a high level of knowledge content in it, mainly in the maths and they're never going to use it*". Thomas proposed that we should be emphasising engineering practice at level 7, and that, to teach technicians, we need to be less theoretical and, "*do more skills-based learning*".

Edith related that, over the course of her career in the IoTs, programmes have become less technician focussed and "*much more academic focussed*". She regards current level 6 engineering programmes as being "*an academic level 6 as opposed to a technician*".

Henry feels that the de-emphasising of skills is also related to the lack of funding of the IoTs: blaming the Department of Education "*because it takes funding [...] it takes facilities*", an issue also identified by Edith[31]. Alan also regarded the reduction in skills emphasis as being funding related, "*to keep people in the system as long as possible*" (the IoTs are funded (partially) based upon student numbers (HEA, 2014)). Alan also feels the change in emphasis on practical skills is related to pressure to reduce contact hours. This became apparent to Alan during programme reviews, relating that every time there is "*an industrial advisory board or some sort of external panel coming in they are going, 'there is too much contact in here'*".

I have earlier discussed the views of some of my research participants who associate the NFQ with the massification of higher education (Hazelkorn et al, 2015). The views expressed above leads to a concern that the reduction in practical focus has come about through a 'credentialism' (Allais, 2014), where an over-emphasis on qualifications for all leads to "*an ever-diminishing relationship with the skills needed for specific jobs*" (p. 9). Whilst Henry, similarly to Alan, felt that where formerly for students being trained to be technicians there was an emphasis on engineering practice, in the new post-NFQ programmes the emphasis is on analytical subjects. However, the engineering focus of such programmes is not being

[31]See p. 145

questioned, rather the balance of knowledge and skills being taught to students. Edith viewed the cause of level 6 and 7 programmes becoming more academic as policy driven. She considers it a "*selling point*" for foreign direct investment (FDI) to have a population that is seen as highly educated, and that this requires more university and IoT level 8 graduates. Edith, however, doesn't "*think it's right that everybody has to go to university [...] or an IoT*". These perspectives imply a professional engineering focus to level 6 and 7 engineering education, with Henry stating "*they're not technicians*".

George identified the change in skills emphasis as related to industry requirements. In considering whether he felt current level 7 graduates were equivalent to the technicians that used to be produced with the old national diploma qualification, George discussed the changing roles of technicians in industry. Drawing from his own industrial experience, George gave a detailed view of the type of work technicians used to do:

> *years ago the technicians when they came out would often be doing things like board repair, they would have a very good understanding of using tools like oscilloscopes and you know, and they would take instructions. They do have a fairly high technical level. Like, when I was working in xxx the technicians were able to debug boards, they would be able to run code, change codes slightly, run tests and debug and be able to figure out what was wrong with different chips or, you know? They were very skilled.*

He feels that the technician role may have become less technical, ascribing this change to industry requirements, "*most of that work is gone now*", rather than the NFQ. He views the technician role of today as ill-defined, further stating that "*I think the roles have changed but it is very hard to figure out what their role should be*". Henry feels that the renaming of the National Diploma to Ordinary Degree (level 7), has "*muddied the water*s" with employers, who are now not always clear what it is they are looking for in a graduate employee, and may need to be advised that "*they may be looking for a technician*"

Rudolf also gave consideration to employers' views on progression. His experience is that employers understand the honours degree concept, but not the concept of progression across levels. He did feel that some employers, particularly HR departments, see a role for technicians, they "*understand the level 6 space because they may be looking to develop programmes where they can up-skill craft-workers or operatives*". However, Rudolf feels employers do not understand level 7 awards. He does feel that this can be resolved through working with industry, and is part of an industry/academia group that is carrying out "*work* *on progression and to create pathways, easily understandable pathways for the industry partners and for potential staff within those industry partners to look at*".

The general thrust of my research participants' views suggest that they now regarded level 7 ordinary degrees in engineering as preparatory programmes for level 8 honours degrees, with an increased emphasis on theory at the expense of practical skills.

I explored this sub-theme in the focus group, where we considered education through a vocational lens, discussing whether progression has influenced the balance of skills vs. theory on level 7 and 8 programmes. There was broad consensus in the focus group that IoT engineering education had become less vocational, with one participant referring to "*gentrifying*". The focus group recognised the conflicting educational requirements of technician and professional engineering education, and the difficulties in trying to satisfy both simultaneously. One participant queried if "*somebody who's in third year [...] are they both a fully-fledged technician and half way on the road to being an engineer as well?*".

The focus group did not view progression as the only cause of change in technician education, and offered further insights. One view was that the learning of skills, which involves, in many cases, repetition until the task can always be completed correctly ("*repetition is the natural instinct of learning*"), does not map easily on to the[32] learning outcomes (LOs) approach, where "*if you have tested an outcome once don't test it again*". The constraints of semesterisation were also regarded as having a strong effect "*given all these LOs over a semester that you must tick, you must hit all of those, so we can't do the repetition*".

To summarise, level 6 and 7 engineering programmes are seen as less-skills based and more academic than the certificates and diplomas they replaced. Indeed, Kees noted that holders of national diplomas were not allowed to replace them with transcripts indicating degrees:

> *We would have had hundreds of enquiries from people saying 'I have a diploma from IoT from 1975. Can I now get my ordinary degree?' [...] The answer to that was very simple, it was 'No, you have a qualification, it's a great qualification, and congratulations'*

The fact that the pre- and post-NFQ awards are not seen as directly equivalent by awarding bodies is an indication that it was expected some differences would arise. However, I will

[32] Of course a LO could call for a skill to be successfully repeated a number of times.

argue later that the manner in which what were previously higher certificate and national diploma programmes would change their focus was not anticipated.

I have already contended that progression in the NFQ acts to reconfigure the stratification of engineering education into technician and professional engineering[33]. The analysis suggests progression has been part of a transformation of the focus of IoT engineering education towards more academic, less skills focussed, engineering qualifications. Someone who graduates with an ordinary degree can be regarded as not having managed to make the engineer grade, but not necessarily educated to be a technician. Several of the interviewees related concerns that the emphasis on progression was disadvantaging those who wanted to be technicians, which concern the focus group shared.

Although it as a factor, the interviewees did not fully ascribe this change to progression. Other perceived causes were: the influence of EI accreditation; changing industry requirements; decrease in funding of engineering programmes; and the use of LOs in engineering education.

The fieldwork suggests that, influenced by the NFQ concept of progression, alongside other factors, level 6 and 7 programmes now tend to be regarded by academics as preparatory programmes for level 8 degrees, with a consequent increased emphasis on theory over practice in such programmes. The fieldwork also suggests that, consequent to this, progression has contributed to a diminution in the skills focus of the technician identity in engineering education, with level 6 and 7 programmes now more academic and less vocational.

Some of the interviewees discussed whether progression was appropriate for all students. Although it is an aim of the NFQ to provide all students with the opportunity to progress to honours degree, George feels they may not all be capable, "*the standard of students that you're getting in in first year are finding it quite difficult*". Related to this, Edith regarded progression for those "*that want to progress further up the ladder*" as disadvantaging those who want to become technicians. Ayah similarly viewed progression as not necessarily appropriate for all: "*not everybody wants a degree and not everybody wants to be a professional engineer [...] where would we be if there were no operators and technicians*". There is suggestion of a negative socio-economic impact if all engineering students take the

[33] See p. 14

professional engineering route, resulting in a consequent technician shortage, which would have serious implications for industry and attracting FDI (HESG, 2011).

8.5 The Effect on the Higher Certificate

The Higher Certificate in Engineering was the original building block of IoT engineering education (McLaughlin, 1999), and, in considering the views expressed by my research participants with regard to it, deserves specific consideration. My research participants considered that progression was seen as contributing to a decline in enrolments to higher certificate, but that there were other factors contributing to this, particularly industry demand.

Bill viewed that "*if somebody has a certificate in the 1980s, early 1990s, you could probably still expect to get a reasonably decent enough sort of technician level job in some industry*". However, in more recent times he saw a reduced demand for technicians with higher certificates. George also sees less industry demand for the higher certificate, and that now for technician roles you "*need level 7s*".

George also feels that the higher certificate is downgraded through being referred to as a level, stating that "*level 6 sounds like it is nothing*", and Edwin views that "*higher certs, unfortunately they are fading off*". He feels that employers no longer value them: "*they don't say I'm looking for a higher certificate. Now they look for a BTech*[34]".

Thomas similarly believes the higher certificate has become defunct: "*they appear to be gone*", considering that "*it's as if the state doesn't want them anymore*". However, educational policy (HESG, 2011) is to ensure that the IoT sector continues to produce level 6 graduates. Kees, in referring to pre-NFQ policy from the Department of Education to keep up the supply of technicians, regarded it as ineffectual as he could already, pre-NFQ, see a trend for students to stay in the system once they had gained a certificate, who "*unless they drop out, were going on to the diploma*".

Thomas believes the multinationals played a role in the diminution of the higher certificate, where they changed the game in starting to insist upon employing degree level graduates,

[34]Edwin was referring to level 7 Ordinary Degrees, which are, on occasion, referred to as Bachelor of Technology (BTech). As noted earlier (p. 70), in the DIT level 7 degrees were Bachelor of Technology, a deliberate decision, one interviewee related "so we're not confusing them with Bachelor of Engineering".

instead of seeking to employ higher certificate holders. This would have had a huge influence on students' take-up of level 6 programmes. Thomas still sees value in the higher certificate qualification as "*a great stepping stone*" for someone to become a technician.

Edith similarly saw a reduction in the demand for level 6 technicians from multinationals, who previously up-skilled their workers to be technicians using certificate programmes in her IoT. However, this is no longer a common approach to up-skilling the workforce for multinationals, which requirement she feels has now become "*much more [...] academic*".

Edwin, similarly to Kees, considers that students perceive a lessening in the value of level 6 qualifications. Edwin perceives societal influences, which calls for "*higher and higher degrees [...] in everything*", which "*is not for everybody*". However previously someone who had the potential to become a very competent technician, i.e. who "*could be a fantastic technician, able [...] to fix everything*", would have been quite happy to do so. A technician, highly skilled and capable, is rewarded financially and mentally through their career.

A conclusion from analysing the fieldwork with regard to the higher certificate is that this is regarded (seven of the interviewees) as significantly less in demand than previously. Referring to *Figure 2-2,* it can be seen that, in fact, numbers of full-time level 6 engineering students had reduced in 2017 to 40% of their 2008 figure, with an even higher drop in those pursuing part-time programmes (*Figure 2-3*). The NFQ concept of progression seems to have been a factor, but, the perception is that industry requirements are a significant influence.

A finding is that, for those of the interviewees who expressed views regarding level 6 higher certificates, they regard them as significantly less important than they were pre-NFQ, and that, although progression may be a factor, this decline in their status and in enrolments in education is principally associated with reduced industry demand.

8.6 Progression and Equality of Access

Bill's interview provided evidence that he regarded progression as facilitating a greater equality and acting to counter elitism in engineering education. Similar sentiments were directly apparent in the views of two of the other interviewees. Edith saw progression as improving access and opportunity for students: "*I do think it's nice and I think it's fair that there are students that you get that come in with very poor Leaving Cert, but have fallen in* *love with engineering and they get an opportunity to progress upwards*". For Thomas "*the NQF to me it was about access and progression*", in particular:

> *people that really gained from that framework at the time appeared to be the apprentice guys, that they were given progression. So where they were, they stopped at their particular level with their apprenticeship and this framework allowed them to progress. So it took away that barrier, so it forced the hand of IoTs really to make progression for those guys, to accommodate them if they wished to progress.*

This resonates with my own experience, where I have led the design of programmes with inbuilt routes for advanced entry for tradespeople into level 7 and onwards to level 8 degrees (TU Dublin, 2019a, 2019b, 2019c). The NFQ's level structure, and mapping of National Craft Certificates to level 6 of the NFQ, allowed us to make the argument at engineering degree programme validation for advanced entry of qualified tradespeople to level 7 programmes.

The issue of elitism in education, and improved access to education, arose as a significant topic in the focus group, as has been discussed in the earlier chapter on the language of levels. To re-iterate in summary form, the focus group felt that the NFQ and progression helped provide more equitable access to education, and improved opportunities with regard to how far an individual could take their education.

A finding, based upon the evidence provided from the fieldwork, which has contextualised my own experience of the design of engineering programmes, is that my interviewees consider the concept of progression as a specific feature of the NFQ that acts to improve access to education.

8.7 Conclusion

The fieldwork suggests that progression has contributed to important structural changes in IoT engineering education. The old pre-NFQ certificate and diploma technician qualifications have been replaced with new level 6 and 7 qualifications, but the fieldwork reveals concerns that they are not equivalent. Given they are regarded as principally pre-cursors to honours engineering degrees, the skills focus has been downgraded in favour of a more analytical, theoretical, education. Considering *Table 8-1*, the rows representing "*Progression to Level 8 viewed as the Aspirational Target for Students*" and "*NFQ has influenced Technician Education to become more academic*", appear to be different sides of the same coin. Viewing them as one, then eleven of the interviewees regarded progression within the NFQ as having changed the nature of technician education to having a more academic focus.

This change in the theoretical/practical weight of level 6 and 7 programmes is also seen to be related to industry influences, funding difficulties and pressures to reduce class contact time. EI accreditation of programmes was seen as influential in changing the balance of theory and practice of level 7 programmes by one interviewee, who perceived a tendency for accredited programmes to have increased theoretical content.

Table 8-1 Influences of Progression on Engineering Education in the IoT Sector

	Research Participant														
	Isambard	***Ayah***	***Kees***	***Rudolf***	***Vitruvius***	***Bill***	***Thomas***	***Gordon***	***Edwin***	***George***	***Edith***	***Henry***	***John***	***Alan***	***Grace***
Progression to Level 8 viewed as the Aspirational Target for Students	■	■	■	■		■	■		■		■				
NFQ has Influenced Technician Education to become more academic		■		■		■	■		■	■	■	■		■	
The decline of the Higher Certificate			■			■	■		■	■	■	■			

A significant, policy-related issue emerges through the voices of the research participants, which suggest that progression is another factor, alongside the skills focus of government policy, EI's influence and industry requirements, contributing to structural changes in the education of engineering students at level 6, 7 and 8. The literature associates a skills focus with the use of OBE (Young, 2008; Young & Muller, 2010; Allais, 2014; Corbell, 2014), and government policy promotes skills in higher education (HESG, 2011; DES, 2016). The missions of the IoTs included a focus on sub-honours degree qualification to help implement this policy focus. However, engineering academic staff on the ground, whilst recognising this skills focus, feel a stronger counter pressure from progression for more academic oriented programmes. A finding of this thesis is that the views of my interviewees regarding progression, amongst other factors, as contributing to the increased academic focus of technician education appears to be in contradiction to government policy promoting a skills focus for higher education. This will be explored more in the analysis in *Chapter 10* of the views of the interviewees regarding the balance of knowledge and skills in curriculum, and also in the discussion.

Chapter 9 The Impact on the Pedagogy of Engineering Academics

> *The self is not something ready-made, but something in continuous formation through choice of action*
> John Dewey (1916, chap 26, para. 8).

9.1 Introduction

I earlier identified that an important line of inquiry for my research would be to investigate the effect that outcomes based education (OBE) might be having on the pedagogy of my research participants (Havnes & Prøitz, 2016). The literature review revealed the lack of consideration of pedagogy in the development of the national framework of qualifications (NFQ), and Engineers Ireland (EI) make no stipulations or suggestions regarding pedagogy in their learning outcomes (LOs) based accreditation requirements (EI, 2014). Collins et al (2009) reported little evidence of an impact on pedagogy in the early years of the NFQ, although noting some disquiet in higher level education that it might be curtailing flexibility in that regard.

I had expected, when I conducted the fieldwork some 7 years on from Collins et al, with the NFQ more firmly embedded in higher education, any impact would be more clearly discernible. This was borne out through the findings reported in *Chapter 6*, which included that a majority of my research participants regard the use of LOs as an implicit influence over their pedagogy, largely regarding this in a positive, constructive, fashion. This chapter builds upon this earlier analysis, examining the effect this influence has had, inculcating in my research participants a pedagogy focussed around teaching towards assessment of LOs. Although I have noted (*section 3.10*) that constructive alignment was advanced, during the transition to OBE, as an approach to link LOs, assessment and pedagogy, I saw no evidence in the fieldwork to contradict my earlier conclusion that it had not been influential. The majority of my interviewees were aware of the reorientation of their pedagogy, which could be characterised as moving from assessing what they taught towards teaching what they assess. However, even where they did not regard their pedagogy to have changed, the analysis revealed this focus.

I commence the analysis in this chapter through illustrating my interviewees' emphasis, in discussing their pedagogy, on the teaching of engineering practice. I then present a sample of my interviewees' views to illustrate their focus, in this teaching, on assessment of LOs. I further analyse this theme through the voice of John, who was very self-aware of the impact on his pedagogy, and had reflected in some depth on the topic. Although very focussed on the assessment of LOs, John uses his identity as an engineering academic to give this context. Ayah's interview presents a managerial view of the change in pedagogic identity of engineering academics, in which she is somewhat critical of the prescriptive nature of the LOs approach. I make use of the focus group discussion on pedagogy to provide further insight.

9.2 An Emphasis on the Practical

My research participants all chose to contextualise discussion of their pedagogy in the teaching of the application of engineering, linking theory, skills and practical work, and relating, as they did so, their own approaches to that of their colleagues. I illustrate this with some representative views.

Bill gave an account of this full of engineering detail, a practical focus within a practical focus:

> *it's through talking to other colleagues. Finding out what particular chips will be used or if we have used something with micro controllers or something like that, what micro controller are we going to use, and what ones are people using. I suppose a good example of that would be the way we use a lot of Arduinos now for project work.*

John described how he linked the teaching of engineering practice to the workplace from an earlier stage in a students' education, and the engagement he perceived from this approach:

> *I took a first year class and I structured the practicals where they worked in groups and I facilitated the groups and they produced a work product at the end. Really enjoyed it. Students really enjoyed it.*

Thomas, who emphasised skills in his interview, highlighted the need to link theory and practice in a skills context:

> *there should be more criss-cross between we'll say a maths tutorial and a practical way of measuring temperature and integrating it and averaging it and things like that. See the application of a particular skill, of a particular bit of knowledge that you're trying to convey to them.*

Edith explained "*I try to make the subject as practical as possible*". She does this so that:

> *the problems that they're working on they're real problems and you try and do it in class time. You know and I find that that approach, because mechanics is my subject and you could stand up all day and give them a lecture about how to do the analysis, but unless they sit down and actually try it, they don't have a chance.*

In the next section I use the views of my research participants to show what this focus on teaching means for them in our OBE engineering education system.

9.3 Teaching to Assessment of LOs

Isambard regarded the NFQ as demanding a particular pedagogical approach, even though not explicitly specified. An extract from his interview used earlier in a related context (p. 141) illustrates this in a powerful manner: "*if you are developing an assessment process for a particular module, you actually have to build in the pedagogy, the requirement that will enable the LOs to be achieved*".

Vitruvius pointed out that pre-NFQ curriculum documents in his Institute of Technology (IoT) included a section on the teaching methodology to be used for particular modules, which post-NFQ, has been dropped. Despite feeling that including a teaching methodology was useful, he argues that under the NFQ it is not really necessary, as LOs make it clear what is to be taught, and how it is linked to assessment. Vitruvius describes a module as being written in terms of LOs, taught ("*communicate*d") to the students in terms of LOs, and assessed in terms of LOs. Kees provided an insight in discussing the simultaneous introduction in his IoT of semesterisation and the NFQ, where he related that academics "*had to figure out how to assess modules on a semester basis*". The significance is that he emphasised not that academics had to learn how to *teach* modules using LOs, but how to *assess* them.

Bill felt that "*LOs and the programme outcomes try to put a structure into how this fits together as an educational package as much as a technical package for an engineer*", and that "L*Os reflect the process*" of teaching.

Henry was "*very positive*" about the use of LOs, and the effect on his pedagogy. He describes initially not quite understanding LOs, as he was focussed on "*conten*t" (knowledge as defined in the syllabus). He describes LOs as having changed his approach to teaching, becoming more focussed on assessment, particularly continuous assessment, of which he further states "*I would have changed labs and I would have changed how I do the assessment of labs*". He also feels that LOs have had a strong influence on his colleagues' approach to teaching, and made him and his colleagues much more conscious of the process of education.

He does see a downside, in that whilst some LOs are quite specific to a module, others "*are very generic*" and could be applied "*to any module*", raising connotations of a fundamental concern as to whether generic LOs can be used to effectively describe discipline specific curriculum, (Young, 2008; Simpson & Jackson, 2003).

Rudolf, in discussion of leading and being involved with course design, described assessment of LOs as the main pedagogical consideration during module development, with any further considerations taking a back-seat. Rudolf considers staff actively try to adapt their pedagogy to the new academic structures they face (LOs, semesterisation) and that they are concerned with the effect that over-assessment may be having on student welfare:

> *we see lecturers struggling with how to manage the delivery and the creation of assessments [...] you mentioned semesterisation, modularisation, you know where people are moving from year-long to semesterised programme or module delivery and I suppose recalibrating themselves in terms of their pedagogy and their assessments and trying to avoid the student suffering from over assessment.*

George regards the NFQ as a guideline for writing and delivering modules. As with many of the interviewees, George views that "*LOs help to drive the assessment*". However, George also makes it clear that, in his case, assessments are not fully driven by the LOs, but are based upon his own knowledge of what it is appropriate to deliver on the programme. Indeed, in writing a module he will "*generate the LOs either as I go along or at the very end*".

However, not all interviewees viewed themselves as influenced in pedagogical terms by the NFQ. For example, Alan describes his industrial experience as being much more influential on his pedagogy than the NFQ. On the other hand, regardless of his stated view, Alan describes that "*I do all the assessment based on the LOs*", and, for module design states that "I dictate the text of the LOs based on the verb" (from Blooms taxonomy).

When questioned on whether the NFQ is an influence on her pedagogy, Edith responded that "*I don't think it has*". She went on to describe her pedagogical approach as "*I try to make the subject as practical as possible, so that [...] the problems that they're working on they're real problems*". However, she also seems to focus on LOs in teaching: "*You know you have to follow these. You've set the plan out. You've set the list of LOs and you have to basically cover those in your class, in some shape or form, whether its lab, lecture or tutorials or exams*".

Edwin recognises some influence from the NFQ on his pedagogy, in that "*I have to make sure all the LOs are covered*". However, he feels he is largely teaching as he was before, albeit in a more structured context. On the other hand in discussing the relationship between LOs and assessment Edwin described a teaching approach inextricably linking LOs and assessment.

Kees, in academic management and not actively teaching, considered that the engineering professional bodies are trying to improve the application of LOs based accreditation standards "*by trying to modify how the material is learned by the students. So I think they actually do foster a more active and collaborative approach to learning*". However, he questions if pedagogy should be prescribed, stating "*whether a framework should, in some sense promote or require a particular active pedagogy, as opposed to passive, I don't know*".

To summarise, a pedagogical approach of teaching to assessment of LOs emerges strongly from the fieldwork (fourteen interviewees). The next section, through analysis of John's interview, gives a detailed account of what this means for one individual engineering academic.

9.4 The Influence of LOs on John's Pedagogy

John's interview provides a compelling account of actively developing his pedagogy through his engagement with the LOs approach, which provided him with guidance that was previously lacking. Although John's pedagogy is tightly focused towards the assessment of LOs, there is no sense of someone slavishly following a teaching to assessment approach. Instead John has thought deeply since becoming an IoT engineering academic on how to work with a LOs approach to engineering education.

John feels that it imperative on him to use the NFQ and its LOs approach, recognising its regulatory function: "*society has put the NFQ in place right, we are hired at one level to teach both learning and assessment in the context of the NFQ*". He relates that:

> *I have accepted the controlled [...] way society is structured', right? So, I am not at that level critiquing that control aspect where you could get into an argument about being in control. But what I am saying is, we have structured our society and I've benefited and I think you've benefited.*

However he also sees value in the NFQ approach to teaching and learning: "*if you read the NFQ, [...] it is actually well structured, right and it makes some useful points*". As the analysis below reveals, John values aspects of the NFQ such as LOs, its view of knowledge, and its inclusion of teamwork.

In discussing how it has affected his pedagogy (which he terms enactment) he feels:

> *it gives me a context in which to enact what I want to do, right? But having said that, I like it because I have a range of enactment skills now that I didn't have ten years ago in terms of looking at different learning theories, being more open to summative and formative assessment. I am now prepared to pull reflection in which is key in the NFQ as well, [...] in terms of self-assessment and peer assessment, things I would never have looked at.*

John refers to LOs on occasion in terms of the "*verbs*" used to write them using Bloom's taxonomy. He regards teaching as an approach in which "*you map your LO to your assessment*", in an effective manner: "*if you come up with the right assessment type that puts meat on the verb*". However, he perceived that not all of his colleagues integrate LOs and assessment in this manner: "*a lot of lecturers here, no formal teaching or learning experience, very good in their discipline, constantly go back to the old assessment methods that they have relied on in the past*". John thus perceives that the pedagogy of engineering academics either had changed, or should have changed, under the influence of the NFQ.

John regards knowledge and assessment as intertwined through the NFQ: "*we can't teach all knowledge or we can't assess all knowledge for example but the standard is only interested in knowledge that can be assessed under the three strands*". Although John recognises his role in imparting knowledge, he feels that:

> *I am not teaching you knowledge that is permanent, some of it might be, some of the concepts are permanent but particularly with the skills, the tools, the approaches and if you are in a different context, if you are in a medical device company one day and telecommunications company another day, context is different.*

Instead, students must learn to learn, or, in fact, learn outcomes that can be assessed: "*you have to learn to adapt and part of the learning to adapt is assessing where you are at this point and assessing where you want to go to*".

As a new lecturer John "*still assessed content*", but, as he has reflected on the NFQ, in particular the three strands of knowledge, skills and competence, he has changed his pedagogical approach, restructuring his classes "*So I go in now every day and say, 'This is the LO we are going to have today*'". John had assumed that his students should understand LOs, but, he found "*they knew none of that*". He now tells students at the start of each class "*that we are looking at this LO, this is how it's going to be assessed, be it a practical or written exam or whatever and this is what you need in order to understand the LO*". It is striking that John does not describe what knowledge, or even skills, that the students will learn, but rather that they learn outcomes in the context of how they are to be assessed.

John, although conscious of the three strands of knowledge, skills and competencies of the NFQ, regards the focus of curriculum as the assessment of LOs, stating that:

> *LOs have to be viewed in the context of assessment and I think LOs have to move past just summative assessment really particularly for the know-how and skill and the competence strands, you are looking at formative assessment, self-assessment and peer assessment [...] It's how I structure and enact the curriculum, a lot of it is coming back to, and something I am looking at, is my assessments.*

However, John's pedagogy is more complex than a focus on assessment driven by use of LOs. It is contextualised through his reflection on how this should be used in engineering education, which, for him is "*about becoming a software engineer*". He describes, as a new lecturer, teaching software engineering through group work, where he tried to get the students to form teams and relationships similar to those he had seen himself in industry. He uses terms such as "*engage*", "*brought into play*", and assertive language such as "*right, we are doing group work*", implying an active, exciting approach, where he formed educational "*relationships*" with the students, and got them to "*believe in themselves*". He explained he did not use any particular educational theory in doing this, instead it was based on his industry experience, and a dissatisfaction with alternative approaches. However, he is redesigning his approach, using the team-work aspects set out by the NFQ, stating "*that's what I want to use now. It didn't happen in the past because to be honest I didn't know it was in the NFQ*".

Although John is very assessment focused, he does see issues associated with this approach:

> *we are overloading then with assessments then in the semester. So you have six modules in a semester and in engineering we find that all the assessments hit in week four and week eight, and all modules have to have at least two. So [...] I believe in this idea of cross modular assessment. Modules are related but we don't look at how they are related.*

He suggests how this could be addressed: "*we could reduce the number of assessments and we could share LOs across modules if we went and designed better and still meet the rules of the game and improve learning*".

At the conclusion of the interview, John made it clear that he regarded the NFQ as a positive influence on his pedagogy: "*I am not critiquing that, I am saying 'OK I have accepted that'*, and then the question is '*How can I improve what I am doing?*'". Similarly to Bill, a finding is that John's interview shows he has actively embraced the change in his pedagogic identity brought about through the influence of the NFQ. In his case the assessment of LOs is a particularly strong influencing factor, in line with the skills-oriented policy drivers of the NFQ. He is very conscious of the regulatory nature of the NFQ, and feels that his colleagues should also change their approach to assessment to align with its LOs approach.

9.5 Ayah's Managerial Perspective

Ayah spoke with regard to the effect pedagogy was having on academics, and students, rather than on her personally. She describes the pedagogic identity of engineering academics as a group reorienting towards a LOs and assessment based approach. Although Ayah is positive with regard to some aspects of the NFQ, she adopted a somewhat critical view regarding pedagogy. As discussed earlier, Ayah viewed the prescriptive approach LOs entailed as quite appropriate for levels 6 and 7, but not for levels 8 and 9. She stated that, for engineering lecturers:

> *because they have to work through this very prescriptive approach. So they're basically working through these ten or twelve LOs that they need to stick to which doesn't really allow the time for [...] demonstrating the knowledge that they've built up.*

In the past Ayah would have encountered lecturers that she considered really engaged the students "*it was the knowledge back that they had built up, so whether it was somebody who had a passion for marine, nearly all of their examples throughout mechanics, materials, thermodynamics were all related back to that field*". Now however, Ayah views the prescriptive approach of the NFQ as curtailing the ability of academics to fully bring their knowledge and experience to the classroom. At this point in Ayah's interview I got a sense of teaching under the NFQ as a pedestrian activity, the working through by the lecturer of a number of LOs, rather than demonstrating their knowledge of the topic to the benefit of the students. Ayah's words that "*knowledge is lost sometimes now*" resonate with *The Neglect of Knowledge* (Allais, 2014) and *Bringing Knowledge Back In* (Young, 2008).

Ayah does feel that an academic's pedagogical approach might depend somewhat on their confidence, with some getting support from "*following a framework and a process that's very clearly outlined*". She felt that academics "*who are more confident and have greater experience out in the real world in industry*" would be better placed to teach outside the prescription of the NFQ, highlighting her view of the importance of staff industry experience.

9.6 The Focus Group Views on Pedagogy

I sought the views of the focus group with regard to the change in pedagogy under the influence of the NFQ and EI's LOs approach. They agreed that, under these dual influences, they were generally teaching to assessment of LOs. One participant keenly felt the lack of a teaching qualification, and the difficulty they considered this created for lecturing: "*we have to teach ourselves first how to teach and then how to assess whether the student has understood, and by the time we do that the term is over*". Indeed, he agreed that "*a default mode of teaching towards performance is what would result which is effectively teaching to assessment within constrained timeframes*".

Another focus group participant felt that "*it is appropriate then that the NFQ is quiet on the matter of pedagogy so that we don't feel constrained [...]. I think the LOs are useful that way*". However, another participant argued that LOs are constraining, identifying the manner in which they reduced a module to passing LOs which represent a "*bit of knowledge*". Another view put forward in the focus group, reflecting views expressed by Ayah in her interview, was that the level of a module influences the manner in which it is taught: "*a level 6 or a level 7 would be dealing with more closed questions, [...] how much, how many, yes or no. But then the level 8 [...] would be throwing more open questions at them*".

A related focus group conversation developed in response to a comparison I gave on teaching pre- and post- NFQ. Previously, teaching the subject of micro-processors, I would have taught the students what I valued, for them, about the topic, whereas I proposed that post NFQ I would be bound to teach a prescriptive list of LOs about micro-processors. The consensus of the focus group was that, although a lecturer may feel constrained by LOs, in fact they had considerable freedom to change and adapt these as they saw fit, which would be clear to an experienced lecturer.

This view was further expanded upon by one participant, who stated that:

> *remember that LOs should not constrain you to how you achieve the end. LOs just tells you what the learner should be able to do and should be able to know at the end of it [...] there is a bit of flexibility there that people tend to misinterpret and put rigidity and you can be quite innovative in the way that you convey your message.*

Indeed, within the group there was consensus that as lecturers they would teach what they felt needed to be taught, regardless of what might be stated in the LOs, but would seek, later to correct the curriculum to reflect that. I should note that the lecturers in the focus group were all highly experienced, although not all had experience in the IoT sector pre-NFQ.

9.7 Conclusion

A finding of this chapter is that under the influence of OBE, it appears that nearly all of my research participants (fourteen) have adopted a pedagogy which emphasises teaching towards assessment, with LOs used to decide what those assessments should be based upon. John's interview reveals that, although an engineering academic may adopt such a pedagogical approach, there is still room for them to contextualise this in their engineering experience, and in how they approach the identity formation of their students. Reflecting the insight from John's interview, the focus group also considered that this pedagogical approach still allowed them to bring their engineering experience to the classroom.

Although the NFQ does not "*promote or require a particular active pedagogy*" (Kees), it has been argued that it causes LOs to "become central to teacher–learner interaction" (Kenny, 2009, p. 24), promoting a skills focussed education. Teaching towards assessment is not described or prescribed within the NFQ or EI's OBE accreditation approach, but the analysis suggests that, for my research participants, such a pedagogical approach is contingent.

However, a further finding is that the influence of the parallel student-centred, lifelong learning policy drivers of the NFQ was also evident, although to a lesser extent, as the interviewees described their pedagogy (for fourteen of the interviewees). Bill, for example, stated that he would try to find "*new ways of doing things that were more relevant to students*". John, though very focussed on assessment, states of the students, in describing a new assessment approach that "*it was all about getting them to work and getting them to believe in themselves and ask questions*".

Kees expressed sentiments that presented a balanced view of the two influences. Although he felt the importance of "*the right blend of theoretical knowledge with an understanding of how we connected with industry*" he also feels that we need "*what's best for the individual and what's best for society, we need to have that balance*".

The findings from this chapter will be further considered in the discussion, where I will draw on literature that considers the pedagogical approaches that may emerge in the context of OBE (Muller, 1998; Deacon & Parker, 1999; Torrance, 2007; Havnes & Prøitz, 2016).

Chapter 10 The Impact on Knowledge, Skills and the Curriculum

Its objectives being an introduction to the world of knowledge.
John Heywood (2016, p 296).

10.1 Introduction

In my conceptual framework I have stressed the importance of knowledge in engineering curriculum, and the difficulty that has can arise in ensuring that this is correctly balanced with engineering skills. This chapter analyses my interviewees' perceptions of change in their approach to knowledge, skills, and the curriculum through the influences and prescriptions of the National Framework of Qualifications (NFQ), Engineers Ireland (EI) and other drivers.

I examine whether the introduction and embedding of outcomes based education (OBE) in IoT engineering education has influenced my research participants' approaches to acquiring new engineering knowledge required for programme and module design and delivery. I then explore their views of the appropriate balance of knowledge and skills for engineering curriculum. To conclude the analysis, the views and practice of my research participants are explored to gain insight into the influence of learning outcomes (LOs) on their approach to recontextualisation of knowledge in the curriculum.

10.2 Engineering Knowledge

For engineers, knowledge is viewed as that which can be usefully applied in engineering activities[35]. My research participants (fourteen) expressed sentiments consistent with this perspective. For example, Bill explained that he was able to assess whether a particular topic was relevant because "*you know from industry that it's an important topic*". Isambard regarded that the student should "*be able to contextualise what you have in theory in respect of what you can achieve*" in practical application. In Ayah's view "*everything that you've learnt in the confines of the classroom*" is only relevant if it can be applied "*to work through all of that in a pressurised environment when your team is falling apart, when your manager's telling you how much money you're losing for every hour that we're down*". Similarly, Edwin talked of someone becoming an engineer "*when you start making money from your knowledge*". Thomas questioned whether a particular type of knowledge was relevant for

[35]See p. 86

students as they were "*never going to use it*". For my interviewees, the utility of engineering knowledge is extant under the influence of OBE, which is not to be unexpected given the competency focus of LOs, which, if anything, is supporting of this worldview (Allais, 2014).

10.3 Knowledge Acquisition

Educators recognise that they must continue to develop their knowledge of the field over their career. For example Edwin considered*." I can't say, look I've learned something in my university and that it's enough knowledge for the next thirty years. So we have to keep reading, reading, reading*" and Bill contended that "*if you were just using the stuff that you had at the start of your career, you'd just be dinosaur*s". We discussed how this might be changing in the context that knowledge is now recontextualised and taught to students in modules defined by levels and LOs. The interviewees presented a range of views, in a small number of cases tightly aligning knowledge acquisition with the NFQ levels, with the majority regarding knowledge acquisition as independent of the NFQ, although recognising that it had to be recontextualised into NFQ levels and LOs afterwards. One interviewee questioned whether new knowledge acquisition should be a priority at all, whereas in contrast others focussed on the importance of research.

Consider John, in whose view the type of knowledge that a lecturer should be concerned with is dictated by the NFQ: "*we can't teach all knowledge or we can't assess all knowledge for example but the standard is only interested in knowledge that can be assessed*". This is suggestive of claims for qualification frameworks, reported (critically) by Allais (2014), that they will fundamentally alter the understanding of what knowledge is, i.e. will change epistemology itself. However, it is not clear what form it is proposed these "new notions of knowledge" (Allais, 2014, p. 14) would take, other than a hint that they are somehow learner centred. Is knowledge, in John's epistemology, represented through LOs that can be assessed? Certainly when he discussed pedagogic practice, knowledge was represented in those terms. Furthermore, John's interview showed strong evidence of a learner centred aspect, speaking of how he "*engaged or enacted the curriculum with my students*", and in the analysis presented earlier (p. 189) he could be regarded as attempting to inculcate in the students a LOs approach to constructing their personal worldview as engineers.

For Alan the acquisition of new knowledge is now closely associated with NFQ levels, being very conscious of the level knowledge is to be taught at as he acquires it, "*Yeah, that's the approach I take*". However, this is so that: "*it gives me more confidence to adapt how I am presenting it then or how I am trying to engage the students on it*". He expects more capable students will want "more and more", and ensures he is not in a position where he has to say "*I actually didn't read that part*".

For Bill, the acquisition of new knowledge has been ongoing throughout his career: "*most of what I teach now didn't exist when I left college*". Bill, working in an academic field characterised by rapidly changing technology, experienced the need to learn new technologies, systems and skills on many occasions. Bill described the process, in his early days as a lecturer, pre-NFQ, of acquiring knowledge and structuring it so as to be able to teach it (the process of recontextualisation):

> *The very first semester, one of the subjects I taught was a subject that existed at the time of all the various characteristics of components, capacitors and stuff like this, how different ways resistors are made and so on. And I of course knew what these things were, but didn't really know in that level of detail, so all of that had be learned. Other stuff that I had done in college just had to be learned, maybe again or just had to be clarified in what you needed to actually get it across to somebody else.*

Bill does use the level at which a module to is to be taught as a guide in acquiring knowledge, however, he implies that he has taken a similar approach throughout his academic career.

However, for more of the interviewees, the knowledge acquisition process was independent of the NFQ level, although, once knowledge was acquired, the process of recontextualisation into curriculum was LOs and levels focussed.

Vitruvius explained that "*new knowledge itself, that would still be me, the original [...] me, as it were, reading up something, delving into something*". However:

> *as soon as I move from acquiring the knowledge to even beginning to put it in some sort of framework to teach others, I'm already thinking of NFQ. I'm already thinking of who am I delivering this to, by which I mean, where are they, on the NFQ? Are they 6, 7 or 8, or 9?*

In recontextualising this knowledge into module syllabi, Vitruvius recognises that some academics feel "*there's too much emphasis on the LOs*", but he himself feels that it works well "*if you write your LOs in sufficient detail [...] to communicate it properly*".

George similarly describes the process of acquiring knowledge required to design and teach a new programme as being independent of the LOs, although the knowledge is afterwards used to develop the LOs. George does not consider LOs during the development of a syllabus, finding them "*to be quite difficult to actually base a course on".* George explains that he would first prepare a draft syllabus "*before I would actually go into the LOs*".

Gordon, in describing acquiring knowledge for new subject areas, considered employers' requirements and the relationship to other modules. Once he has a general concept of what the curriculum entails he considers how to assess it, and then develops LOs (using Bloom's taxonomy), which become key drivers for establishing what knowledge is to be taught.

One of the interviewees, Thomas, questioned whether new knowledge acquisition should be a priority. Thomas felt quite strongly that the IoTs should focus on level's 6 & 7 of the NFQ, "*where we should be*". He feels the technology at these levels is well defined, and "*how much research do we need to do to be good at that? I don't think we need to do a whole lot*". In this world-view, new knowledge acquisition is not a priority as the knowledge to be taught in relation to level 6 and 7 of the NFQ is relatively static and hence research is not necessary.

In contrast, two interviewees focussed on research in discussing new knowledge acquisition. Isambard considered that the NFQ has influenced curriculum such that *"anything that we deliver has to be research informed*". Henry who had been research active in industry and academia, related his impression that the research process had changed over the years, to focus much more on questions, and could not pinpoint any influence from the NFQ.

I discussed the theme of knowledge acquisition with the focus group. They considered that, rather than the NFQ level at which a module is situated guiding the lecturer in their acquisition of the knowledge required to teach it, the level was more likely to guide how it is taught. They considered that the act of teaching itself may influence knowledge acquisition: "*as I have acquired material I have always measured my understanding by being able to explain it to students"; and "you have to look for supporting material depending on how the class reacts*".

My interviewees portrayed their acquisition of new knowledge through working with employers, considering what students need to be taught and how to teach it to them, reflecting on their own experience and expertise, and through being research informed. These, from my perspective as an engineering academic, all appear quite reasonable approaches. Although our conversation may have been couched in the context of LOs and NFQ levels, I do not believe the interviews provided evidence that OBE has significantly influenced knowledge acquisition in these cases. Nonetheless, for a small number of my interviewees, OBE has been a significant influence. John appears to regard knowledge largely in the context of assessment of LOs, and Bill and Alan indicates they use the levels of the NFQ as a guide to determining what knowledge they need as academics.

The analysis of the fieldwork leads to a finding that the NFQ has not had a significant impact on the acquisition of new knowledge for the majority of my interviewees, although a small minority use NFQ levels as a guide to what that knowledge should be.

Some of the interviewees considered that their workload, 18-20 hours a week of lecturing, alongside administrative and other duties, was interfering with engaging with acquiring knowledge, including engaging in research. They identified the increased administrative work consequent to the NFQ as a further contribution to this, e.g. Isambard, who felt that workload "*does not give you any room whatsoever to delve in depth into enhancing your knowledge*".

Ayah also believes that OBE has placed an increased workload on academic staff which completely dominates their work[36]. Ayah feels that consequently academics are "*not as research active*" and that LOs and their associated workload are "*stifling innovation and it's stifling researc*h".

George also perceived "*that there has been a lot of additional workload*" in the form of quality assurance (QA) and related procedures and requirements, although not directly attributing this to the NFQ. He made reference to the difficulty of doing 18 hours of teaching per week and trying to maintain, for example, good industry contacts. Henry felt that the workload on Heads of Department is inordinate, making it difficult to properly manage their staff whilst simultaneously leading activities like programmatic review, "*they don't have the time*". He felt this contributed to this important activity being "*a paper exercise*" that "*doesn't have a positive input [...] as it could have or should have*" in refreshing the knowledge in syllabi.

Edith questioned the workload associated with conducting both EI accreditation and programmatic review, which interfered with "*getting the knowledge to teach*". She regarded EI accreditation more positively, although still considering it "*paperwork*".

A clear impression emerged (from five of the interviewees) of the heavy workload on lecturing

[36] See p. 131.

staff, from administration and particularly from 18 hours teaching. Although the NFQ is perceived by some of my research participants as playing a role in this increasing workload, it appears to be as part of the overall system, rather than a principal determining factor. A heavy workload was seen as being detrimental to their capacity to engage in other activities such as research and other aspects of knowledge acquisition.

10.4 The Balance of Knowledge and Skills

Engineering curriculum are a type that face "both inwards to disciplines and outwards to professional or workplace practice" (Blackie et al, 2016, p. 763), and with the IoTs so linked to industry and business, it would be expected that there would be a skills emphasis in IoT engineering education. Skills would thus be expected to feature strongly in my research participants' views of curriculum, which OBE, given it is generally associated with an increased focus on skills (Allais, 2014; Young, 2008), would strengthen. However, an earlier finding, in considering progression, was of the academicization of engineering technician education. I sought to tease out these apparently contradictory positions through investigating my interviewees' views of the balance of knowledge and skills in curriculum.

John, in a recent programmatic review, related that he and his colleagues placed less emphasis on skills than on knowledge, they "*chose verbs that valued definitely the knowledge strand over know-how and skill and definitely over competence*". He regarded the different strands as complementary, allowing skills to be delivered in relationship to the other strands.

Reflecting the importance of skills, and the context provided by the NFQ, Isambard, when "*at the initial stage of my academic career*", considered that "*you need to teach the students the theory first and then support that with practice to enable it to embed*". However, as he became more experienced, his views changed:

> *I then realised that actually in order to embed the practical concepts that are the practical skills, they should actually be done in tandem, it should be together. There are some cases for example like in problem based learning, you find that you actually learn the theory better when you are actually doing it and to be able to contextualise what you have in theory in respect of what you can achieve or what you can implement practically.*

He feels that under the NFQ, particularly at honours degree level, it has "*distilled [...] refined what area needs research*", making it clearer what is needed for and from the student "*in terms of skills and knowledge*".

Bill described having to reconceptualise the manner in which he approached engineering student projects due to the NFQ. For final year level 8 students he considered "*you're certainly expected to have very detailed writing skills for reports, organisation, timetabling, to make sure you get the thing done in time*". A level 8 engineering project will typically be trying to solve a real-world problem using theory and practice, applying analysis and design techniques, but the level of emphasis on skills from Bill is pronounced.

Partly sharing this perspective Ayah described how, under the NFQ, lecturers need to consider "knowledge, skills and competencies", and that this maps very well, for example "*when you're talking about explaining how a machine works and it's a step-by-step approach and that fits very much into the framework for a [...] 6 & 7*". However, for a level 8 graduate Ayah expects that "*they need to be able to go out into the world and solve problems and navigate through different systems that they've never seen*". Ayah does not feel that "*the LOs approach helps that particular position at level 8, particularly with [...] skills*".

However, some of the lecturers felt that there was not enough emphasis on skills, e.g. Edith "*they're going in to be a technician, so they need the practical skills. Now we do try and incorporate a bit of practical stuff, but you're very limited in what you can do*". Thomas also feels that the IoTs should be focussing more on teaching skills, and less on theory: "*We should stick to teaching the technical subjects, the skills". Henry felt that "we've lost our applied bit*", referring to a reduction in the teaching of practical skills.

In summary, a perception of the relationship between skills and knowledge was evident in the views of twelve of my research participants. In some cases they viewed the NFQ as providing a context within which to combine the three strands of the NFQ, knowledge, know-how and skills together, and were accepting of the skills emphasis even at level 8 (Bill, Isambard, John, Gordon, Rudolf, Kees). In one case (Ayah) the interviewee felt that the skills emphasis, whilst acceptable at level 6 and 7, was not appropriate at level 8. However, four of the interviewees (Edith, Thomas, Henry, Alan) felt that there was not enough emphasis on skills, attributing this at least partly to the NFQ. One interviewee (Vitruvius) felt that the question was not relevant to what they taught.

A finding is that the interviews provide evidence of conflicting opinions amongst my research participants with regard to the balance of knowledge and skills: some regard there as being an insufficient emphasis on skills, whereas others felt that the use of the NFQ led to an appropriate balance of skills and knowledge. This stands in comparison to an earlier finding that the views of my interviewees regarding progression as contributing to an increased academic focus for technician education appear to be in contradiction with government policy promoting a skills focus for higher education. As will be discussed in *Chapter 11,* that these contradictory positions became apparent from the analysis are quite significant.

10.5 Recontextualisation of Knowledge in the Curriculum

Curriculum design, the recontextualisation of knowledge into syllabi, is a key aspect of the use of LOs. I sought to understand my research participants' perceptions of what has changed, for this important activity, under the influence of the NFQ and EI. *Table 10-1* provides a representation of how the interviewees' view this in terms of: LOs as a driving force in recontextualisation; knowledge secondary to LOs; and how they bring their personal knowledge to the curriculum.

Table 10-1 Recontextualisation of Knowledge

	Research Participant														
Recontextualisation of Knowledge	***Isambard***	***Ayah***	***Kees***	***Rudolf***	***Vitruvius***	***Bill***	***Thomas***	***Gordon***	***Edwin***	***George***	***Edith***	***Henry***	***John***	***Alan***	***Grace***
LOs a driving Force	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Knowledge Secondary	■	■		■	■		■		■		■	■	■		
Bringing Your Personal Knowledge to the Curriculum	■	■		■		■	■							■	

10.5.1 What has changed in the Design of Curriculum?

Under the NFQ, modules are represented using LOs, alongside an indicative syllabus. The QQI engineering standards provide a reference point for module design. Suggested practice is to design the module LOs first (Kennedy et al, 2006), and then develop the indicative syllabus.

Isambard perceived the use of LOs in a positive manner, explaining that pre-NFQ he regarded graduate attributes as not well defined, even if graduates were "*very competent engineers*", whereas post-NFQ it is easier to stand over the details of a qualification. He perceived a reduction in the depth of programmes since the NFQ, where in his IoT honours engineering degrees were "*squeezed*" from five to four years. He attributes this change to financial pressure and the extra time involved for students. As discussed in the literature review, this change was, in fact, consequential to EI's accreditation process changing to align with Bologna, albeit it occurred in the same timeframe as the introduction of the NFQ.

Vitruvius, was similarly positive, stating that, pre-NFQ as "*you were just relying on your own intuitive grasp of what a particular module*" should contain. He considers the NFQ structure makes module design and delivery easier, and as an academic manager:

> *explaining to a colleague [...] and in particular [...] explaining to a relatively new colleague how to write a module, how we should go about it, what you should look out for, and also how to deliver a module, was made much easier by the framework*.

Bill feels that knowledge still has a role post-NFQ, where "*you design your subject around a syllabus and a set of labs and everything like that, and then from that you say – well what are the key things that this is achieving? And there's my LO*". He feels that "*the emphasis is probably more on LOs*", whereas pre-NFQ "*in the old system it was that syllabus that was the defining thing*". This is consistent with the policy shaping the formation and use of the EQF (and the NFQ), where "*the emphasis is on defining key competences and LOs to shape the learner's experience, rather than giving primacy to the content of the subjects that make up the curriculum*" (CEDEFOP, 2011, p. 9). However, Bill thinks the overall design process is:

> *Just different more than anything. I think what we always did was still the same, when we were here or any other staff for that matter, or a group of staff in our department wherever they were would do the same thing. You would sit down you'd say well what kind of a degree do we want to do, and what areas are we good at, and what is our expertise – and that's your starting point".*

John describes himself, pre-NFQ, as being un-inspired by just thinking about a "*content based approach to the knowledge*". However, as his understanding of the NFQ has grown, John associates knowledge with LOs, and after that "*it's the fact that you map your LO to your assessment*" that creates learning. Edith regards syllabi as subservient to LOs, describing the syllabi content as something that "*feed in from your LOs*".

The use of LOs in curriculum design was not without criticism. John described a programmatic review where they "*ended up retrospectively mapping [...] module LOs to programme LOs*". Here John revealed a back-to-front approach, where the need for programme LOs was only identified towards the end of the review process, as opposed to early on. Although this may have satisfied programmatic review, it was not how LOs were intended to be written, which requires definition of the programme outcomes first, and design of modules LOs to meet those. However, such an approach was quite characteristic of the approach during the introduction of the NFQ, referred to by Kees as "*re-badging*", and is something thing I myself took part in at that time.

As discussed earlier, John uses assessment as a lens to relate to knowledge, which is secondary to assessment (of LOs). Indeed, John implies that knowledge is secondary to LOs themselves, where, when, referring to lecturing students he states that he gives them an "*overview of what the content of the knowledge associated with that LO is*".

Edwin provided a view of LOs based curriculum from his experience as an external examiner, stating you "*have to make sure that the learning outcomes are there*", with the indicative syllabus a secondary consideration. This is consistent with the QQI (2015) guidelines for external examiners, which focus on ensuring alignment LOs and student achievement with the appropriate national standards as related to the NFQ. This reflects QQI policy where "the impact of LOs on QA processes is significant. In general terms, the object of QA shifts from the curriculum and the teaching to the QA of the learning that is achieved as a result of the curriculum and the teaching" (Coles, 2016, p. 11).

Thomas implied an at times lip-service approach to the NFQ, which only really assumed importance at programmatic review:

> *There needs to be a way of ensuring that programme outcomes are being met, that knowledge is being conveyed, you know, how one does it, I don't know, but and maybe that should be the job of [...] the framework here, but they don't seem to do any of that. Every three years, programmatic review, that's about it, come out for a day or two.*

However, Thomas is keenly aware of EI's influence, regarding them as a key driving force in the use of LOs. He feels this approach has no regard to "*syllabus content really. They just wanted to see LOS. We don't care how you achieve them so long as you achieve those LOs*". In this worldview, LOs have risen to the fore, with knowledge quite side-lined. Thomas's view does seem a reasonable, if somewhat emotive, interpretation, in that EI's accreditation procedure (EI, 2010), focuses around providing evidence that programme outcomes match accreditation requirements, and have been met.

Blooms taxonomy is an enabler for the design of module LOs. However, five interviewees expressed sentiments of the taxonomy being the primary driver in LOs design, as opposed to knowledge. For example, Alan states that "*sometimes I actually find it difficult to find an* *appropriate verb from Bloom's Taxonomy [...] to actually reflect what you're trying to do*".

To summarise, the majority of the interviewees (fourteen) described that they now saw LOs, under the influence of the NFQ and EI, as a key aspect of curriculum design, with the module content (knowledge) being dependent upon LOs, and, for some (nine), knowledge secondary to LOs. However, some academics were critical in their perception that the LOs approach is not fully followed in module design and review processes, although they agreed the end result of such processes required that modules and programme were presented using LOs.

The focus group agreed that engineering academics regard LOs as the primary driver in LOs in curriculum design. In exploring the implications of this, they took the view that well written LOs in syllabus design actually empower the lecturer with regard to the delivery of knowledge e.g. "*the module leader retains the freedom to cover all or most or some of the points in the syllabus*". However, a dissenting voice stated "*in general, do lecturers pay much heed to the LO's? Or are they driven by the syllabus content*".

A finding is that the fieldwork provides strong evidence that engineering academics now perceive LOs (influenced by both the NFQ and EI) as the key driver for the recontextualisation of knowledge in the curriculum, with, for some, knowledge secondary to LOs.

10.5.2 Bringing an Academic's Personal Knowledge to the Curriculum

A further topic of discussion, raised by six of the interviewees, was with regard to how lecturers brought their own personal knowledge to the curriculum.

For Rudolf, the fact that a syllabus mapped to the NFQ is *indicative* allows scope for academics to be innovative in teaching the knowledge they feel is appropriate, i.e. "*if a relevant topic area is now irrelevant or superseded by another subject area*" it can be replaced.

Isambard similarly sees the LOs approach as providing the necessary flexibility:

> *I would be surprised if given two academics with the same level of qualification working in exactly the same area [...] would have exactly the same sequencing even of the material that they deliver [...]. You draw examples from different spheres and you are free to do that, as long as the LOs which in most cases should be broadly defined, allows you to achieve the same end.*

Thomas, expressing similar sentiments to Bill, provides a related viewpoint that regards disciplinary knowledge as being held within a group of academics, rather than individually. He speaks of course design teams: "*a good small team of people that have the skill, they have the knowledge, experience, you could develop a good course from the bottom up*". Thomas values not just the knowledge of the group, but also their skills and experience, and sees LOs as helping to bring all of this together: "*you've got to have good programme outcomes*".

Ayah was concerned that the prescriptive nature of LOs may inhibit academics from fully utilising their knowledge and experience. In her own case she "*would have brought an awful lot of experience*" from industry and considered "*a more holistic approach to learning was needed […] than what we were using at level 6 and 7*", which she found "*quite restrictive*".

Alan described his experience on joining an IoT from industry: "*I worked in telecoms and networks for seven or eight years but it wasn't until I had to come back and design a course for it that I actually started to learn it in a different way again*". He had to recontextualise his industry knowledge in order to use it in teaching, using NFQ levels to assist in gauging how to pitch lecture material. However, he finds this does not always fully delineate the knowledge to teach: "*a level 7 versus a level 8, really there might not be an awful lot of difference*".

The literature on LOs is largely silent on how to approach this recontextualisation of a lecturer's disciplinary expertise in the delivery of a LOs based programme. Consideration of guides on the use of LOs illustrates the deficit (Office of University Evaluation, 2001; Kennedy et al, 2006; COBE, 2007). These were created by HEI's to assist/direct their academic staff in the implementation of OBE. They avoid discussion on academic staff disciplinary expertise, focussing on generic issues related to delivery and assessment using LOs. EI state that academic staff should "*have the ability to design, develop and implement courses*" (EI, 2014, p. 5), but other that this rather general statement, do not comment on this matter. It could be argued that the QQI Engineering Standards provide this disciplinary guidance (QQI, 2014c), but, as already discussed, they are quite generic across different engineering disciplines.

However, the focus group consensus was that it was important to keep LOs generic, as opposed to specific. This to ensure "*we are not constrained by them*", and that "*the module leader retains the freedom*" to cover material they consider relevant.

The analysis reveals what could be described as a doublethink in some of the interviewees' views on how to use LOs. On the one hand they are accepting as a group of this approach to curriculum design which emphasises what a student should know and be able to do on completion of a module. On the other hand, for some academics, including the focus group, LOs should be written more generically, or "*written well*" (focus group), not specifying precisely what the LOs should be or how they are assessed. In the capable hands of an experienced academic this provides a framework within which they can deliver the module in the context of their own expertise, and does not tie them down to a prescriptive approach. This leads to a finding that, for some academics, LOs, if written such that are not overly prescriptive, can be enabling, facilitating individual expertise to module delivery.

A further finding from the analysis was that curriculum design and review was regarded, by all of my interviewees, and the focus group, as a social process, whether at department level or involving smaller groups. For example, Rudolf described, in relation to programmatic review, that "*we had a really interesting debate about mapping module learning outcomes to programme learning outcomes*". John described pre-NFQ curriculum design as "*I don't think we engaged in the verb game then*".

10.6 Conclusion

The analysis reveals the interviewees approach to new knowledge acquisition for curriculum design: through being research informed; using industry consultation; reflecting on what to teach and how to teach it; and through considering their own expertise and how it might need to be further developed. They do not appear to have been overly influenced by the OBE approach, although a small number did appear quite cognisant of NFQ levels and LOs in acquiring knowledge. Once new knowledge is acquired, it is recontextualised into LOs in curriculum mapped to NFQ levels. The use of LOs in curriculum was generally regarded in a positive fashion, with LO's regarded as a key tool of curriculum design.

In investigating the views of my research participants with regard to what they considered an appropriate balance of skills and knowledge in curriculum, contradictory positions became apparent. Some participants saw too little skills, whereas other participants were happy with the balance of knowledge and skills promoted by the NFQ. The fact that my research participants hold such disparate views on this key issue appears related to an earlier finding that progression is contributing to an increased academic weighting in technician education, in apparent contradiction to government policy promoting a skills focus for higher education.

The discussion will consider the implications of these issues for engineering curriculum.

Chapter 11 Discussion

For what we wish we readily give credit to, and what we think ourselves, we hope is the opinion of other men

Julius Caesar (Commentaries on the Civil War, para 2.27)

11.1 Introduction

My research is situated in a time which sees the alignment of political, societal, cultural and economic structures and values with neo-liberal doctrine (Finnegan, 2016). The re-orientation of higher education, including engineering education, to having a more skills focussed orientation targeted towards the needs of employers is a key enabler for this change. As noted earlier, this employability focus has been supported internationally by the introduction of national qualification frameworks (NQFs) (Allais, 2014), and reinforced in engineering education through the adoption of outcomes based education (OBE) accreditation (Matos et al, 2017). However, as will be apparent from the analysis, and as will be developed further in this discussion, in Institute of Technology (IoT) engineering education the parallel learner-centred facet of the National Framework of Qualifications (NFQ) has also had some influence.

The views and practice of my interviewees in relation to impact and change they perceive from the LOS based engineering education system in IoTs have been revealed through the analysis of the fieldwork. The findings from the fieldwork, supported by earlier findings and themes regarding IoT engineering education, the National Framework of Qualifications (NFQ), the government skills agenda for higher education, and Engineers Ireland (EI) accreditation, suggest that there has been substantial consequential change in IoT engineering education.

Although some of the change I have observed, for example the emphasis on learning outcomes (LOs) in curriculum, were intended to follow from the adoption of OBE, other changes appear contingent, and in some cases their appropriateness is questionable. For example it is clear that it was intended that the nomenclature of the NFQ should become part of the policy discourse of higher education (Collins et al, 2009). However the usage of the related language of levels I observed in the pedagogic discourse of my research participants at times displaces disciplinary terminology, and, in emphasising the importance of progression for my research participants, has further curriculum and structural implications for engineering education. Furthermore, international experience of the implementation of

NQFs reveals that is it common for them to lead to contradictory policy positions (Fernie & Pilcher, 2009; Allais, 2010a; Havnes & Prøitz, 2016). The fieldwork revealed that not only are such contradictory policy positions apparent in the implementation of OBE in IoT engineering education, but, also, that they have had important, and at times concerning, resultant effects on engineering educators and engineering education.

In this discussion I consider the implications of my research for IoT engineering educators and the education we offer. I also consider what my fieldwork reveals about the effectiveness of the NFQ, and EI's OBE accreditation processes. These considerations are part of a broader context where the societal logic relating to education and knowledge is being reconfigured through the use of OBE, and I show how my research contributes to debate on these matters.

I include a reflection on my framing of the analysis of the fieldwork using the pedagogic device, which I developed, for IoT engineering education, through: a synthesis of ideas from social realism; my own experience as an engineering educator; consideration of the socio-historic context within which our contemporary IoT engineering education system has arisen; and working with my research participants in the fieldwork.

11.2 Engineering Educators and Engineering Education in the IoTs

In seeking to describe and understand the social logic (Morgan et al, 2018) of IoT engineering education through a conceptual framework influenced by social realism and EER critical or questioning of OBE (Woolston, 2008; Riley, 2012, Rajaee et al, 2013; Wolff, 2015; Heywood, 2016; Akera, 2017; Matos et al, 2017; Klassen, 2018; Nudelman, 2018), my findings are inherently mediated by what Glynos and Howarth (2008) term "the *constructed* and *politic*al character of social objectivity" (p. 7). Consequently, in framing the analysis of the fieldwork using the pedagogic device, my findings already incorporate a considerable aspect of discussion in which I have adopted "ideological and normative arguments" (Edström, 2018, p. 39) which take a critical stance towards the use and impact of OBE in engineering education. In this section I expand the discussion in considering my findings from an engineering education research (EER) perspective.

As I have shown, the field of EER pays considerable attention to research issues associated with the application of LOs in engineering education, where, generally, OBE is considered a benign approach, leading to a better engineering education. EER in relation to engineering educators is largely focussed on how to improve their engagement with the use of LOs in teaching and curriculum. However, as identified by Matos et al (2017), there is a research gap, both theoretically and empirically, with regard to the impact of the use of OBE on engineering faculty, for which, through my findings, I contend that OBE may have, at times, adverse and unintended effects on pedagogy and curriculum structure.

11.2.1 Pedagogy

Pedagogy had not been a significant consideration in my own experience of our transition to OBE in IoT engineering education, although over time I noted the pre-eminence that LOs assumed in collegiate discussions regarding teaching. Consequently, a particular concern I had from the outset of my research, and which the fieldwork provided the opportunity to explore, was whether, despite my perception of a lack of explicit focus on pedagogy, the use of OBE might, nevertheless, have an implicit effect on our pedagogy as IoT engineering academics. My research revealed mine was not an isolated experience, where a key finding was to show that the pedagogical basis of the NFQ received little attention during the development process that led to its implementation (NQAI, 2001a, 2001b, 2002c, 2003a). Similarly EI give little guidance on pedagogy (EI, 2014), and Heywood contends that EC2000 (ABET, 1998a), the genesis of the international transition to OBE for engineering accreditation, was developed without due consideration of student "learning and development" (Heywood, 2016, p. 290), and that this has not been corrected in more recent proposals from ABET.

My research participants, however, were deeply interested in their pedagogy and that of their peers, similar to the experience related by Andrews et al (2019) in their exploration of their colleagues' pedagogy in the WMG engineering department in the University of Warwick. Our discussion on pedagogy generally centred on teaching the practice of engineering, both theory and skills together, "*the IoT way of doing things*" (Vitruvius). The fieldwork confirmed the influence of OBE, where a finding was that the NFQ acts as an influence over the pedagogy of my interviewees, which they largely regard as positive and constructive. For example consider Bill who stated: "*certainly in the last 10 years, I've spent more time on the process than necessarily on the content*". The fieldwork revealed that, influenced by OBE, my interviewees have adopted pedagogical approaches emphasising teaching towards assessment, with LOs used to decide what those assessments should be.

As Collins et al (2009) have argued, the use of LOs requires "a radical shift in teaching" (p. 39); and Kenny (2009) proposes that pedagogy is directly affected as teaching turns towards the requirement to meet LOs. OBE for engineering can lead to "the generation of long lists of checklists" (Heywood, 2016, p. 290), stifling educational innovation, and may affect engineering academics approach to pedagogy (Matos et al, 2017), as my research has shown. In the case of the NFQ it, like other NQFs, simultaneously promotes a learner centred approach alongside an employability emphasis, which leads to tension and contradictory pressures regarding pedagogy. Although OBE in IoT engineering education does not stipulate, or suggest, a pedagogical approach, these two different drivers for OBE in the Irish educational system appear to require different approaches.

If NQFs truly support a learner centred approach, assessment will examine whether learners meet LOs within a learning environment encompassing "a shift from a transmission-content pedagogic model to an acquisition-competence model" (Muller, 1998, p. 182). This can be considered a competency pedagogic approach which "emphasises learner opportunities to shape their own engagement in learning, create learning conditions and enhance their own learning" (Havnes & Prøitz, 2016, p. 216). However, it has been argued that the reality is that the learner centred approach of OBE is offset by engineering students not necessarily having the self-awareness and capability to engage with it, alongside the traditional role of engineering academics as presenters of knowledge rather than guides (Rajaee et al, 2013).

On the other hand, a principal purpose of OBE is to provide an employment focus for qualifications (Young 2003; NQAI, 2003a; CEDEFOP, 2009), including engineering (Prados, 2004; Matos et al, 2017). These must meet the skills needs of employers, within a time-frame determined by the market in order to be of value, leaving little scope for learner-centeredness. A concern I share is that "extensive use of LOs and assessment criteria might risk resetting the horizon of learning or situate learning in the context of passing tests or achieving specific LOs, instead of perceiving these as milestones in an expanded qualification process" (Havnes & Prøitz, 2016, p. 218). This process oriented influence from OBE in engineering education (Woolston, 2008) results in the "valuation of product over process in traditional engineering education" (Riley, 2012, p. 5). The potential for this focus on assessment was identified by Tyler (1949), who cautioned that "the diverse objects appraised by evaluation" (p. 124) might come to dominate. This suggests teaching may become focussed on the assessment of LOs, a performance pedagogic approach, which can be referred to as "*assessment as learning"* (Torrance, 2007, p. 282).

In order to gain a deeper understanding I drew on literature that examined which of performance or competence pedagogy might come to dominate under the influence of OBE (Muller, 1998; Deacon & Parker, 1999; Torrance, 2007; Havnes & Prøitz, 2016). Consider:

> "in response to weakened institutional boundaries, increased calls for public accountability in the new reflexiveness of risk society and […] market calls for relevance, effectiveness and efficiency, the pendulum in all national systems conscious of their competitive position in the global economy swings towards performance models (Muller, 1998, p. 189).

I explored this with the focus group, who highlighted that IoT engineering academics are not expected to be trained in education. They regarded this as an impediment to effective teaching, which, combined with the workload of a LOs based, semesterised system, entailed that achieving anything other than teaching to assessment was quite difficult. Indeed none of my interviewees discussed receiving any significant training in the pedagogical aspect of LOs.

Given the economic imperatives on the IoTs, that the NFQ and EI are relatively silent on pedagogy, and that IoT academics do not require teaching qualifications and are most unlikely to have been trained in competency oriented pedagogy, then conditions are favourable for the emergence of performance pedagogy. Furthermore, for accreditation a key focus is on "assessment of what students have learned" (Felder, 2012, p. 9), and which can lead to "accompanying rigidities" (Heywood, 2016, p. 290). From a Bernsteinian perspective my interviewees have adopted what he called tightly 'framed' pedagogical approaches (Bernstein, 2000), where they make it clear to the students, and themselves, what will be taught and assessed, set in the context of LOs (Nudelman, 2018) and the time constraints of a semesterised system. This provides evidence, supported by related studies (Muller, 2004a; Rami, 2012), that a consequence of the use of LOs, regardless of policy aims of promoting a learner centred approach (Rajaee et al, 2013), may be to influence academic's pedagogic identity towards the adoption of performance pedagogy.

In contrast to my findings, Woolston (2008), despite regarding the OBE focus on process as inappropriate and ineffectual, and identifying the emphasis on assessment rather than on how learning takes place, believed that it had little effect on engineering pedagogy. Similarly to the deepening of the impact of the NFQ I have observed since Collins et al (2009), I suspect that, as OBE accreditation has become more established, so has its impact become more pronounced for engineering educators. As Kees speculated regarding the NFQ, it appears that "*over time […] people are normalised into a particular way of looking at […] learning*".

My critical, practitioner oriented, analysis of the consequence for our pedagogy of the move to OBE for IoT engineering academics is in contrast to EI's position (Owens, 2016a), who consider that their accreditation assessment process provides space for academics to reflect on their pedagogical approaches. My findings, however, concur with those who question the contention that OBE is associated with an improvement in the quality of teaching and learning in engineering education (McCullough, 2007; Woolston, 2008). While I accept that there is still some room for the "various pedagogical processes" (EI, 2014, p. 10) EI suggest may be applied, they will, inevitably, given their positioning, be focussed towards assessment of LOs.

Although I have been somewhat critical of the pedagogical consequences of OBE for my research participants, the fieldwork also revealed that their pedagogic approaches are not fully defined through their orientation towards performance pedagogy. For example, the focus group made it clear that, although they recognised constraining aspects to the OBE approach, for some, LOs, if written to avoid being overly prescriptive, can be enabling, facilitating academics bringing their individual expertise to module delivery. This finding is reminiscent of Coffield et al's (2007) description of teachers in UK further education, for whom policy constraints were "not all powerful and pervasive" (p. 738), with many still feeling "they have the space to exercise their most cherished professional values" (p. 739). Similarly, the fieldwork provided considerable evidence of mixed-mode pedagogies (Muller, 1998; Bernstein 2000), in particular aspects of the competence based pedagogy that can be associated with the learner centred facet of an NQF. For example Isambard, who felt we should "*meet the needs of individual or [...] any of the students that you have in the class*".

My interviewees emphasised the importance of the application of teaching and learning approaches in teaching engineering practice, similarly to other engineering academics (Brent & Felder, 2003; Knowles et al, 2019). This points towards my interviewees having embraced OBE precisely because they perceived it as a framework within which they could develop their pedagogy for the betterment of the practical aspects of students' education. This is exemplified by John's interview, who, although he has strongly aligned his pedagogy with a LOs approach, was very conscious of how this was impacting on the student experience.

This discussion causes me to reflect on my own pedagogical position as an engineering educator. I see value in outcomes or competencies, as it is important for engineers to be able to achieve tangible, useful, effect. However, the emphasis on LOs creates, for me, a significant difficulty, reflecting a pragmatist influence. In valuing the educational experience students receive on their journey to becoming engineers (Woolston, 2008; Somerville-Midgette, 2014), I cannot divorce the outcome from the journey, where new knowledge becomes part of the experience, and the experience in acquiring it is part of the knowledge. As Frezza and Nordquest (2015) write "in some sense the purpose of design education is not to create an artefact but rather to grow as an engineer" (section *Implications for Engineering Pedagogy*). This journey to becoming an engineer should provide adequate opportunity for reflection (Socha et al, 2003; Bowe & Duffy, 2010; Adams & Forin, 2013) as a key part of the process of engineering student identity formation (Haase, 2014). I thus have a concern that the overemphasis on assessment I have observed, on achieving outcomes rather than learning from experience, interferes with the inculcation of this reflective capacity.

Clearly assessment is important for engineering educators, but, in my experience, in engineering education it is formative assessment (Heywood, 2016), the use of which is regarded by Froyd et al (2013), alongside LOs and other aspects derived from educational research, as part of a major shift in engineering education, that is critical. This gives students feedback on what they have done incorrectly as well as correctly, which is most important in giving them the opportunity to reflect not only on what they know, but also on what they don't know, and how they have arrived at their current disposition. Summative assessment, where outcomes are measured, is also important, but principally in terms of ascertaining that the other aspects of a students' education that I value have taken place.

In the absence of a pedagogical model as part of our OBE engineer education system a default, performance oriented pedagogy has emerged, which I consider does not fully serve our educational goals, and which has, arguably, inculcated in our pedagogic identities an alignment with a neo-liberal oriented employability focus. I suspect that, previously, my pedagogy was quite aligned with the performance approach I have observed in my interviewees. However, I do not consider my pedagogy *now t*o be LO focussed, which I believe has followed from the awakening that this research has engendered. This leads me to believe that IoT engineering faculty enthusiasm for becoming better educators, and their consideration of the importance of their role in educating future generations of engineers (Haase, 2014), can be harnessed through encouraging the development of a clear view of their own educational philosophy (Heywood, 2016). This could be inculcated through appropriate, engineering oriented, pedagogical training, as has been recognised as important for engineering educators (Heywood, 2016; Kersten, 2018). For example the IGIP (International Society for Engineering Pedagogy) offer certification as an 'International Engineering Educator' (Morell et al, 2018).

In the next section I consider the impact on curriculum, where the tension between the skills-oriented employability facet of OBE and its learner centred aspect is also a significant factor.

11.2.2 Curriculum

My research revealed counter pressures on curriculum in IoT engineering education. The first is the employability emphasis associated with OBE, a tool of government strategy to achieve a more skills focussed higher education (HESG, 2011; DES, 2016). I have identified the importance of considering how the skills emphasis of OBE may have impacted on IoT engineering academics regard for curriculum, and in the fieldwork all of my research participants acknowledged the influence of LO's on curriculum, as exemplified by Gordon's view that "*for me it's been very, very positive*".

However apparently acting in contention to this skill emphasis is progression and the NFQ's level structure, associated with the NFQ's parallel promotion of learner-centeredness (Allais, 2014). As I noted earlier, progression arose as a prominent theme in the fieldwork, providing evidence that, alongside other factors including industry requirements, EI accreditation and funding, progression has led to level 6 and 7 programmes being regarded by IoT engineering academics as preparatory programmes for level 8 degrees, leading to an increased emphasis on theory over practical skills. IoT engineering academic focus on engineering practice, so my interviewees were already very skills focussed in any case, meaning this has not been a complete re-orientation, rather a tempering of our approach to engineering education. The views of my interviewees with regard to the effect of progression can be summarised through the focus group consensus that "*we now see a level 7 as a person on a journey to a level 8*".

Progression has implications for engineering education beyond the opportunity it provides to students. Whist recognising the role of progression in countering elitism, Llorens et al (2014) consider that the level of expectation of students to progress "almost removes the legitimacy of the Level 7 programme in its own right; the vast majority of students see it as a back-door to [...] Level 8" (p. 5). Allais (2010a) reports a similar effect in Scotland, where "Higher National Diplomas became more accepted as a route to a degree" (p. 11), rather than employment. My fieldwork supports concern (Llorens et al, 2014) that level 7 engineering programmes are changing their focus from a path to employment to further study, reflecting change at national level. This is resulting in all IoT engineering students being educated from the outset to be honours degree graduates, rather than technicians. Those who leave early receive a qualification that "*doesn't give you technician level. No. I guess the ordinary degree now is someone who couldn't cut it and make it to the honours*" (Thomas).

Given my earlier argument[37] that technician and professional engineering education require different emphases, the implication for curriculum is significant. The diminution in the skills focus of technician programmes can be considered through the contention that NQFs can lead to a weakening of the boundaries between vocational and academic education (Young and Muller, 2010). However, "boundaries can serve educational purposes – they underpin skill and knowledge specialisation" (Young, 2011, p. 98), providing opportunities for learners "in establishing their specialist occupational identities" and serving "as guides for those designing curricula". This provides argument for retaining boundaries between technician and professional engineering education, to preserve their occupational identities (IEI, 2001d).

These issues are illuminated by the South African experience (Wolff, 2015), where higher education is driven by a socio-economic agenda, with progression through levels of a qualification framework regarded as a key enabler for a "social justice agenda" (p. 12). As part of the reconfiguration of South African engineering education towards these aims, a new, more theoretical, Bachelor of Engineering Technology (BTech) qualification has been established, to run in parallel with more traditional skills oriented technician diplomas. However, it is not clear that its theoretical emphasis meets industry requirements, and the new curriculum, which it has been argued does not clearly position the type of graduate identity it seeks to develop, has created difficulties for educators (Doorsamy & Padayachee, 2019). This is not an argument against progression, but certainly sounds a note of caution as

[37] See p. 23.

to how it is facilitated by the NFQ, which concern is reflected in my findings.

In considering how engineering academics construe student identity formation in contemporary Irish engineering technician education, I am not going so far as to say that level 6 and 7 engineering graduates are not technicians, but, certainly there has been a change in the graduate identity, orienting it towards preparation for further study, as opposed to an immediate role as a technician. This is captured succinctly in "*it is much more academic*" (Edith), or as articulated by Thomas, "*if we're teaching to technician level […] we need to do more skills-based learning*". It may not have been intended that progression would reduce the skills focus of technician education, but it appears that it has contributed to change, alongside other factors, in this important aspect of IoT engineering education.

However, this change can also be regarded positively, where the more theoretical focus engendered by progression in my interviewees reinforces those aspects of engineering knowledge which encompass a hierarchical, disciplinary, discourse in curriculum (Wolff, 2015; Wolmarans, 2017). Indeed, as noted earlier, this has been suggested may be a feature of the level structure of NQFs (Baynham, 2012; CEDEFOP, 2017). Progression also appears to have an integrating effect, for my research participants, across NFQ levels, on the knowledge of engineering practice, as has been suggested is a characteristic that is essential for modern engineering education (Duderstadt, 2008). For example Gordon, Bill, and Thomas stress the relationship between projects at different NFQ levels: level 6 projects prepare students for the more involved projects at level 7, which in turn prepare students to engage with level 8 projects; a vertical discourse, "hierarchically organised" (Bernstein, 1999a, p. 159).

When the impact of progression is coupled with that of the skills emphasis of LOs, a complex picture emerges. Contradictory policies, again associated with the parallel employability and learner centred facets of Irish OBE, simultaneously promote more skills, whilst orienting programmes to be more theoretical, acting in contention with the academic discourse on technician education (IEI, 2001c, Shay, 2012; Wolff, 2015). Although my interviewees identified the influence they perceived from progression to increase the academic content of technician programmes, they were, also, and apparently in contradiction to this, generally accepting of the skills focussed LOs approach to engineering education. Furthermore, through the analysis of the fieldwork I identified that they at times held conflicting opinions on the appropriate balance of knowledge and skills in curriculum: some seeing an insufficient emphasis on skills, whereas others felt that the NFQ supported an appropriate balance. I suggest their contradictory positions on this critical aspect of engineering education have arisen through being influenced to different degrees by the opposing pressures suggested above. This confusion is not too dissimilar to the difficulties reported for curriculum developers in decoupling the new, more theoretical, South African BTech from the more established technician diploma programmes (Doorsamy & Padayachee, 2019), although at least in that case the difficulty had been identified.

As noted earlier, it is not without precedent that contradictory, unintended, positions could arise through the use of NQFs, although the problem I had identified appeared quite novel. In considering the challenge of how to explain it more fully, I explored it through Bernstein's (2000) contention that tension can arise between official knowledge and academic disciplines. Bernstein (1999b, 2000) makes reference, without great elaboration (Singh, 2018), to the term "pedagogic schizoid position" (Bernstein, 2000, p. 71), to describe situations where policy considerations and the market drive pedagogy, as opposed to "the intrinsic value of the discourse". This can cause academics to adopt pedagogy that reflects "external contingencies" (Pausigere & Graven, 2013, p. 14) "rather than focusing upon learners' understanding of disciplinary knowledge".

This raises the question as to whether the cognitive discourse in IoT engineering education has been stable historically, or whether external contingencies have been an ongoing feature? The Regional Technical College (RTC) sector was conceived to implement government policy, and has prided itself on being reactive to industry and business needs (McLaughlin, 1999), accepting of the role external contingencies have had in its direction. In considering the influence of external contingencies associated with OBE on the pedagogic discourse, the fieldwork suggests that conflicting policy aims and effects have led to manifestation of the pedagogic schizoid position. Official knowledge is, it seems, not always coherent, and, at times, Irish educational policy is at odds both with itself and with the academic discourse of engineering technician education. I have noted earlier that engineering education struggles at times to find the appropriate balance of knowledge and skills (Prados, 1992; Johnston et al, 1996; Seeley, 1999; Dooge, 2006; Heywood, 2016; Dempsey, 2017; Edström, 2018) with the more recent debate leading to the adoption of OBE. The market has always had a role in these debates, hence Bernstein's characterisation of engineering as a region. However, in this case the difficulty arises principally from the external, rather than, cognitive, interests.

These curriculum issues raise questions regarding the appropriateness of IoT technician engineering education. This issue is linked to the further impact I have observed from OBE on the structure of IoT engineering education, and I explore them together in the next section.

11.2.3 Structure of IoT Engineering Education

In describing the creation of the RTCs, and their subsequent evolution into the IoTs, I identified the importance with which technician education was, and continues to be, regarded from a national policy perspective (Hillery, 1963; OECD, 1964; GoI, 1965, 1967; Rafferty, 1968; McLaughlin, 1999; Barry, 2005; HESG, 2011; DES, 2016). The more recent refocussing of IoT engineering education towards honours engineering degrees, rather than on level 6 and 7 programmes, has contributed to concern that the IoTs are prone to 'mission drift' (OECD, 2004; HESG: 2011; Hannon, 2017) towards a replication "of the role played by the traditional research intensive Universities" (CIT, 2017, p. 2).

Mission drift, which has been a characteristic of non-university engineering education, both in Europe and the USA (Christensen, 2012; Christensen & Newberry, 2015), is associated with a variety of causes. These include: both students and academics seeking more prestigious credentials; a tendency towards the "*gentrification*" that my focus group identified; and the consequences of government funding for research. It may also be a manifestation of the pendulum effect that has been noted in engineering education which periodically emphasises and de-emphasises engineering practice (Christensen, 2012; Edström, 2018), and which was a concern of my research participants. Certainly IoT engineering education has changed quite substantially since the introduction of the NFQ, to where the majority of full-time enrolments are now on level 8 honours degrees, which, at the least, is facilitated by progression. Not all of my research participants agreed with this refocussing, in particular Thomas considered the IoTs should focus on the technician education he considered the strength of the sector, that we should "*concentrate on level 7. It's down the [...] NFQ ladder we should go, not up*".

It is important to consider the form IoT level 8 engineering education progression opportunities take. As noted earlier, consequential to EI's decision, through their interpretation of Bologna (European Ministers of Education, 1999)[38], to increase the

[38] See p. 78 and p. 137.

educational requirements for Chartered Engineer, many five year IoT honours engineering degrees were replaced by four year honours degrees: as Edwin remarked "*everybody moved to a one year add-on*". Thus, when an IoT engineering student progresses to level 8, although they *may* be moving from technician to professional engineering education, it often entails enrolling on a programme I consider better classed as a BTech degree, suitable for accreditation as associate engineer (EI, 2014). Rather than being an example of OBE influenced policy driven reform of engineering education (Hanson & Norell, 2004; Schuster & Hees, 2010; Doorsamy & Padayachee, 2019) as EI (IEI, 2001d) sought to achieve, it was instead an 'on the ground' response by the IoTs to events.

A number of my interviewees expressed concern regarding this change. For example, Henry considered that "*before I was always happy to say we're producing a student at the end of the five years who has a (professional) degree [...] different to the university student, has different abilities and we take longer to get there*". Now however, with the new four year degrees that replaced then, "*we're producing in the same amount of time*" as the universities, "*but can we really put our hand on our heart and say the student is equal but different*".

In comparison to professional engineering degrees, these new degrees, which carry the same title, Bachelor of Engineering Honours, have less emphasis on theory, and more on the application of technology, offering a route for technicians to further their education whilst maintaining their applied focus. My research participants clearly regarded graduates of such programmes as engineers rather than technicians, whether their qualifications were suitable for accreditation towards professional status or not. It is not even evident that the difference between the two types of level 8 honours engineering degrees is particularly apparent to prospective students, or employers, a point raised by Alan. This is consistent with the USA experience, where, despite the plentiful job opportunities for graduates of BTech type programmes, it is in "many ways a 'stealth' profession, existing under the radar of many prospective students, other postsecondary educators, and employers" (NAE, 2017, p. 156). However, it has been argued that industry sees little distinction between the two types of graduate in overall capability, whilst respecting their different strengths (Kelnhofer et al, 2010; Land, 2012; NAE, 2017). Indeed, in the USA graduates of such qualifications are often engaged in equivalent work to professional engineering graduates, with Land (2012) proposing that "engineering technologists are engineers" (p. 1).

Despite my concerns with regard to how the changes in curriculum and the structure of our engineering programmes have arisen, employment prospects for all engineering graduates are bright (HEA, 2017b). The knowledge economy in which Ireland is so highly invested (HESG, 2011) requires suitably qualified graduates (Skilbeck, 2003). The associated "higher value added activities that can form a sustainable basis for competitiveness" (McIver Consulting, 2003, p. 48) lead to a requirement, for both "engineers and engineering technicians", to engage with "more knowledge intensive manufacturing and logistics processes". This can lower the demand for the skills and knowledge associated with what were previously key technician activities. EI (2019d) identify that "that demand for manual skills is falling while the need for analytical thinking and innovation continues to grow" (p. 1), specifically identifying a decline in the need for "technology installation and maintenance" (p. 2).

My interviewees identified these new industry requirements, advancing it as one of the additional determining factors, alongside progression, for the changing skills/knowledge balance in technician programmes. Young (2008) argues that higher valued job opportunities need to be in place to make progression meaningful. Consideration of honours engineering graduate employment (HEA, 2017b) shows that such employment opportunities are, indeed, available, which appears to reflect an alignment of graduate capability with industry needs.

A further finding (*Figure 2-3)* is that the pattern of part-time enrolments confirms industry demand for technicians, and level 7 programmes in particular, remains strong, as predicted by government (DES, 2016), and industry (IBEC, 2015). Furthermore, HEA (2017b) indicates that, although the majority of full-time level 6 and 7 graduates go on to further study or training, for those who choose to seek employment job opportunities are readily available. Thus employers, and employees, continue to see value in contemporary level 7 technician programmes, despite my concerns regarding their reduced skills focus.

My research shows that the curriculum, and the OBE engineering education system within which it is taught, continue to serve industry requirements. However, I have argued that this continuing relevance has, to an extent, followed from unintended policy related consequences which happen to align in the direction of changing industry requirements. As I explore next, my research suggests a further enabling factor has been the resilience of IoT engineering academics approach to what constitutes engineering knowledge (de Vries, 2006; Sheppard et al, 2006; Wolff, 2013; Montfort et al, 2014; Korte, 2015; Wolmarans, 2017).

11.2.4 Knowledge

I have earlier articulated a view that knowledge is key to curriculum design (Young, 2008; Allais, 2014), particularly for engineering (Wolff, 2015; Heywood, 2016), where skills are also important. As evidenced in the fieldwork, my interviewees have maintained the engineering ontological and epistemological position of the utility of knowledge (de Vries, 2006; Montfort et al, 2014). This includes consideration of its industry and professional relevance, an important aspect of engineering educators' perspective on the purpose of education (Duderstadt, 2008; O'Byrne, 2009; Andrews et al, 2019). Although my interviewees perceive LOs as a key driver for curriculum design, significant aspects of traditional approaches remain. In particular, pre-NFQ practices for knowledge selection and acquisition are retained. The approaches the majority described seemed appropriate from my perspective as an engineering educator, allowing the identification of "appropriate forms of knowledge and ways in which they interact" (Wolff, 2015, p. 36). Additionally, as discussed earlier, the NFQ's level structure and progression seem to have inculcated a reinforcing of the hierarchical nature of much engineering knowledge, and an integrating aspect across NFQ levels for engineering practice.

Furthermore, in recognising the social nature of curriculum design, my interviewees ensure that curriculum design remains a department level activity, building upon the expertise of engineering faculty as a group. This is epitomised by Bill's comment, when discussing programme design, that, although he may not be an expert on all topics, he is assured of the overall integrity of a programme because "the knowledge is in the department", suggestive of the screening approach to curriculum design (Furst, 1958; Heywood, 2008, 2016).

As Young (2008) states, "the content and forms that the curriculum takes are not and should not be static; new curriculum forms and content will always emerge" (p. 89). The approach to knowledge and curriculum described by my interviewees seems to reflect the practicalities of engaging with the new system for "labour-market orientated 21st century engineering education" (Wolff, 2015, p. 82), whilst retaining the existing practices for knowledge acquisition they recognised as effective. Allais (2014) puts forward the view that it is centres of academic strength and excellence that are required to provide meaningful education, rather than programmes designed using LOs. I believe this strong approach towards engineering knowledge that I have observed in the fieldwork has been a key factor in enabling the relevance of our engineering education and graduates to be maintained.

11.2.5 Contributing to the Debate Regarding Engineering Curriculum

I have earlier questioned whether the stratification of engineering into professional engineering and technician career paths is necessary, and it is clear that is has at least partially arisen, and to an extent is maintained, through societal influences (Dempsey, 2017, 2018). However, the professional engineering/engineering technician dichotomy has been effective (McLaughlin, 1999), and, as I have shown, in the case of the RTC engineering education system, arose through a policy development and implementation process that involved detailed consideration of the implications for proposed actions.

I consider that the changes I have observed in IoT engineering education consequent to OBE have not had the benefit of a similar level of forethought and follow-through. Educational policy regards a supply of level 6 and 7 technician graduates as important for our economy (DES, 2016), as supported by industry requirements (IBEC, 2015). Clearly there has been a recognition that what technicians do has changed and that reforms in higher education need to be harnessed to ensure that enough technicians are educated and that they are educated appropriately (DES, 2019; EGFSN, 2013; EI, 2019e; McIver Consulting, 2003). However, not only has much of the change I have observed, as a consequence of policies which were designed to achieve this, been contingent, rather than fully planned, more worryingly it is not necessarily either fully in the direction intended, or coherent from a disciplinary perspective. As Henry said, in discussion of the structural effect of OBE on IoT engineering education, "*we haven't sat back and said 'what kind of engineer do we want to produce'*".

The challenges faced by engineering educators tend to persist across the decades (Edström, 2018). Although the practical skills, the theoretical knowledge, and the application of technology are different, in some respects the pressures identified in the *Training of Technicians in Ireland* report (OECD, 1964) are still with us. However, the debate and investigation evident in the 1960s to decide what that education should constitute appear somewhat less well developed in these contemporary times, and, as I have argued, are overly focussed on the perceived benefits of OBE. However, the earlier debate did not just begin with policy makers, but, my research shows, was associated with concern amongst educators, business interests, and civic authorities, supported by the technical education sector of the time (Warren, 1961, Latchford, 1962). IoT engineering education as a sector needs to contribute to contemporary debate, to help define what our engineering education should be (Edström, 2018) in these neoliberal times (Pawley, 2019), and I would hope, this research forms part of the effort that is required.

11.3 The Effectiveness of the NFQ

My research also speaks to the overall effectiveness of the NFQ and other similarly configured qualification frameworks (Raffe, 2009). QQI are quite positive about the benefits that stakeholders perceive the NFQ has brought to Irish education (QQI, 2017). However, my practitioner-centred findings are somewhat in contrast to their policy level perspective, and, to begin with, I make further use of the tension between the learner centred and skills focussed facets of the NFQ to provide a focus for my concerns.

I have noted earlier that transparency, a fundamental value of the NFQ, in common with other NQFs (Allais, 2014), and which is enabled through the use of LOs, can be regarded as contributing to learner-centeredness (Attard et al, 2010). However, a recent QQI Green Paper paints a complex picture of LOs, stating that “writing LOs is an art. The statements must be comprehensible at an appropriate level to learners, to teachers, to members of the discipline’s wider communities of practice and to other key stakeholders” (QQI, 2018, p. 50). It is very difficult to see how LOs can be constructed with the multi-layered meaning required in order make them accessible to the different groups listed above. I would have to agree that if it were possible it would, indeed, be an ‘art’. Take, for example, a LO from a mechatronics programme “analyse, design, communicate, reflect and critically evaluate technology and resource choices”. This would carry significant meaning for a mechatronics academic, but the proposition that any student in the early years of study could read it and get real meaning from it is quite questionable (Cort, 2010; Young, 2011).

This concern was apparent in the fieldwork, where John described the process of trying to teach students on the basis of LOs, asking them “*do you know what a programme LO is? What is a module LO?*", but found a complete lack of awareness. John still persevered with using LOs to engage with the students as part of his pedagogy, but realised that, rather than LOs being transparent to them, he had to explain each in detail.

To investigate transparency for prospective or current students further, I used readability analysis (Reck & Reck, 2007) to examine programme outcomes of a number of engineering Higher Certificates mapped to the NFQ, and also an EQF programme, (see *Appendix C*). The resultant readability indices represent how understandable the programme outcomes are in terms of the number of years of educational attainment required to easily comprehend them. The results suggests a high degree of educational attainment, college graduate and beyond, would be required, consistent with LOs being constructed by experts, using a complex and domain-oriented terminology. However, it is not consistent with LOs assisting in qualifications being transparent to prospective or current students, particularly in the earlier years of study. This brings into question the claim that transparency "has made it easier to evaluate qualifications for [...] study" (QQI, 2017, p. 16).

A further concern I raised earlier was whether LOs even have the same meaning for all engineering academics (Heywood, 2016). However, the fieldwork shows that transparency can be regarded by engineering academics as a valuable tool to help them compare and benchmark awards. The focus group considered that, when used in combination with Bloom's taxonomy, anyone "*who has written a programme or course knows what you are talking about*", with the use of LOs making programmes transparent across different HEI's.

Transparency is a fundamental value of the NFQ, but it appears overly ambitious to believe it fully useful to students and prospective students, even if it has value for experts in the field.

A further area of digression from QQI's positive view of the impact of the NFQ is with regard to the significance of the use of the nomenclature of the NFQ. Collins et al (2009) identified that the NFQ "would introduce a new language and set of concepts including the levelling of qualifications, learning outcomes and award-type descriptors" (p. 9) and that "*the language of learning outcomes and Levels*[39] creates common reference points for identifying and assessing non-formal and informal learning" (p. 28). More recently QQI (2017) noted that a number of stakeholders agreed that "the NFQ is now part of the infrastructure and language of Irish education" (p. 13), similar to the South African experience (Tuck et al, 2004). The fieldwork revealed more than just the use of the nomenclature associated with the NFQ and EI's accreditation processes, where I observed the phenomena of the language of levels in use

[39] My emphasis

by my interviewees, and myself, as a language of engagement with the regulative discourse, and also in the instructional discourse of our academic practice.

I have earlier contended that this language of levels acts to emphasise progression for my research participants, but it is pervasive in the pedagogic discourse on academic matters, through which it has become part of our disciplinary terminology as engineering educators. The significance can be considered through the concept of learnification, which raises concern of the side-lining of knowledge in the modern curriculum by languages of learning (Biesta, 2005, 2014, 2015) rather than of education, such as that associated with LOs (Biesta, 2014).

A key question is whether such a language of learning rather than of education, where the curriculum emphasises skills and competences as opposed to, and at the expense of, knowledge of the field, is sufficient to represent educational concepts of "content, purpose and relationships" (Biesta, 2015, p. 76). Given that the ontology of engineering disciplines is reflected in their terminology (Moses, 2008; Heywood, 2011), it may not be compatible with generic LOs terminology (Young, 2010), such as is represented by the language of levels. For example, the focus group recognised that the language of levels was not useful in an international engineering education context. Furthermore, Heywood (2016), as discussed earlier, reported on differences in interpretation of LOs between lecturers, and between lecturers and students, suggesting both ontological (between academics) and epistemological (between academics and students) discord.

In considering the impact of OBE on the pedagogy of IoT engineering academics, my research highlights issues of more general impact across higher education. QQI (2018) quite correctly regard assessment and LOs as fundamentally interlinked. In their 2017 survey (QQI, 2017), involving government, learners/employees, higher education institutes, further education, employers, schools, and educators, they report positive benefits the NFQ has brought to assessment. 64% of respondents agreed that "the LOs Approach of the NFQ has Improved Teaching and Learning Practice" (QQI, 2017, p. 24), and nearly 70% of respondents agreed that "the LOs Approach of the NFQ has Improved Assessment Practice" (QQI, 2017, p. 25). However, it is difficult to see how QQI can claim success on this matter. The NFQ was bound to have an impact on teaching and learning, but my research shows that the National Qualifications Authority of Ireland (NQAI), which later subsumed by QQI, at the least did not set out what it was to be, and, perhaps, had not considered it at all.

QQI's measure of success seems to be a circular argument that OBE promotes assessment, to which I respond that my research suggests that where previously we assessed what we taught, now we teach what we assess. QQI (2018) do raise the criticism that "teaching to the test" (p. 13) may arise, where academic integrity is compromised through academics overly focus on teaching what is to be assessed. However, surely this is a consequence of LOs, which emphasise the role of assessment over teaching, where QQI consider that when "assessment in all its dimensions is healthy it is likely that teaching and learning are also healthy" (p. 9).

I have already shown that NFQ's skills focus has not been fully effective in its influence on my research participants. However, QQI (2017) reports strong evidence of the NFQ being effective in matching employer skills requirements to qualifications, based upon an employer survey related to higher and further education and training (HEA, 2015b). Closer analysis reveals a significant proportion of employers (31%) were unaware of the NFQ, and only 36% referred to it during recruitment. Allais (2017), in a contemporary study, similarly reported on limited employer awareness of the NFQ, and this was highlighted by Rudolf in the fieldwork. This suggests, as HEA (2015b) acknowledges, that respondents to the employer survey may have been self-selecting. Given the skills emphasis, it is hardly surprising that, for those employers aware of the NFQ, the matching of their requirements to the skills focus of qualifications on the framework is apparent. However, the level of employer awareness casts further doubt on the effectiveness of the NFQ's skills focus.

11.4 OBE and the Relationship between IoT Engineering Education and Society

In considering the pivotal relationship (HEA, 2012) between engineering and society (Heywood, 2016: Pawley, 2019), a concern I share is that the neo-liberal skills emphasis of OBE could have a detrimental effect not just on engineering education, but on the society it serves (Matos et al, 2017). However, for my interviewees, our education system, whilst maintaining its industry relevance, has not become more skilled focussed under the influence of OBE. IoT engineering education has been an effective instrument of government educational policy, and its ongoing socio-economic focus, from the outset (Christensen & Newberry, 2015), and it is possible that alignment with the more recent neoliberal emphasis of government educational policy is not a major re-orientation. Reflecting the utilitarian turn in engineering education with which Heywood (2016) is concerned, it may be that we "unwittingly indoctrinate students into neoliberalism as the only possible mode of economic development" (Pawley, 2019, p. 6).

A broader issue relates to the strengthening of participation in our democracy associated with the IoTs (Department of Education and Science, 2001; Fleming & Harfords, 2014). However, a challenge to this success is the influence of OBE, which is targeted towards producing a workforce who will be compliant with the needs of industry rather than educating a citizenry with the capacity to engage in democratic debate (Rata, 2014; Pawley, 2019). The distribution of knowledge in engineering education, and the power and control issues associated with it (Akera, 2017; Edström, 2018), reflect wider societal hierarchies (Bernstein, 2000). When I consider the performance pedagogy approach I have observed, and the impact this might have on the disposition of our graduates, I consider it does not inculcate the development of the reflective capacity which is an aspect of the ability to engage not just in effective engineering practice, but also in the democratic process (Bernstein, 2000; Nudelman, 2018).

The IoT's are particularly associated with access to education, and a key societal benefit that it is proposed will accrue from an NQF is further improvement in this regard (Carney & Schweisfurth, 2018; O'Reilly, 2018), with HEA (2015a) linking equity of access to what is good for society *and* the economy. Improved access and diversity is necessary for engineering (JEE, 2006), with EI's registrar urging "students to consider all routes into an engineering sector full of job opportunities" (Owens, 2016b). However, engineering has much to do to improve diversity and access (Dempsey, 2017; EI, 2017c; Pawley, 2019), and I consider EI's role in the restructuring of Irish engineering education through Bologna has acted in opposition to this.

The international and Irish experience is that there is little evidence to support claims that any major positive change regarding access and diversity has resulted from OBE (Young, 2003, 2005). Lynch (2018) argues that "equality of opportunity in education" (p. 21) cannot overcome fundamental socio-economic inequalities, and Clancy (2015) writes it terms of "access to what" (p. 303) in considering equity of access to more prestigious higher education courses. Furthermore, there are concerns that the NFQ might have led to a devaluing of vocational qualifications (Allais, 2017). However, the fieldwork provided evidence that access is regarded as important by my interviewees, who consider the NFQ's level structure, and progression, act to counter elitism, which is emphasised for them through the pervasiveness of the language of levels in the pedagogic discourse. Furthermore, my research does point towards improved access to degree level engineering education for tradespersons. Fleming et al (2017), in considering the overall success of the access agenda in Irish higher education, remark that “progress has been patchier and slower than policymakers hoped” (p. 3), and the progress revealed through my research is clearly not the major success that it was anticipated would result from the NFQ. Nevertheless, progression has raised the awareness of this important matter for my interviewees and provided them with new structures within which to advance the access agenda. Consequently, some students have benefited through educational opportunities that would not otherwise have been available.

The engineering professional bodies have a larger role, where, as communities of trust (Beck & Young, 2005; Young, 2008), they mediate between engineering education and society with regard to engineering qualifications (EI, 2018b; Engineering Council, 2020). EI promote their relevance to society and the economy, and consider OBE based accreditation a core activity (EI, 2017c) in maintaining this. In recognising the importance of EI accreditation, my interviewees regarded it as a sectoral imperative, a ‘must have’ (Klassen, 2019, p. 21) to keep up with competitors, although they did not all consider that accreditation is fully relevant for all graduate engineers. However, accreditation has a prominence with Irish engineering educators (Homan, 2020), including my research participants, who recognise it as an important benchmark for our programmes. Rather than being unaccepting of EI’s societal role, the views of a number of my research participants suggest that, instead, they were concerned that it was not sufficiently effective and relevant for their engineering fields.

11.5 Reflection on the Use of the Pedagogic Device

In the preceding discussion the complexity of what I have observed and conceptualised concerning the impact of OBE on IoT engineering education is apparent. Bernstein (1977) considers that “Curriculum, Pedagogy and Evaluation form a whole and should be treated as a whole” (p. 73). To this I would add the dispositions of the academics who construct, teach, and assess the curriculum, the academic structures within which they are situated, the policy drivers that shape them, and the wider societal context. In providing a theoretical model which seeks to “explain the entire environment of pedagogic discourse” (Halliday, 2014, p. 32), the pedagogic device offered a heuristic through which I could regard IoT engineering education, and which I consider may be of wider use to my peers. Utilising the pedagogic device in my conceptual framework required a synthesis of my personal positioning as an engineering educator within the field of inquiry, alongside socio-historic accounts of the development and evolution of IoT engineering education since the 1960s, and the more recent transition to an OBE engineering education system. This served as a perspective to build upon the fieldwork to develop the understanding I sought.

A key issue I addressed in applying the theoretical framework was establishing the distributive rules of the pedagogic device, which Bernstein (2000) refers to, as I have noted earlier, as "who may transmit what to whom and under what circumstance" (p. 31). In my reading of the literature to gain understanding of the application of the pedagogic device I noted that authors were often quite clear in their discussion of the recontextualising rules of the educational context they were considering. However, whilst the distributive rules were generally acknowledged, this was often without any significant elaboration (Smithwick, 2001; Wolff, 2015; Klassen, 2019), although in suggesting a role in determining access to education and knowledge they seemed to me quite critical

Wheelahan (2005) gave the distributive rules more consideration, where in discussing their role in the context of vocational education and training, she related them to policy level issues related to access to education and knowledge. Further research suggested an interpretation of the distributive rules as a means to represent overarching aspects of educational policy (Kwok, 2017; Lim, 2014). This offered a heuristic through which to advance my research, where I chose to interpret the distributive rules as associated with the policy debate around the formation and development of RTC/IoT engineering education, and the later consequences of OBE for the sector. This was critical to my research, allowing me to situate the socio-historic context as it related to policy formation within the distributive rules of the device, which in turn influenced my establishment of the recontextualising rules. I consider I used this to useful effect, and I suggest it as a way forward for others.

A further important consideration was how to represent EI's role. The engineering professional bodies are part of the community of trust for engineering education (Young, 2008), and could be regarded as contributing to the instructional discourse of the pedagogic recontextualising field (PRF). However, through their decisions and positioning they often have an influence more consistent with being part of the regulative discourse (Homan, 2020). My research suggested EI's role pertaining to OBE aligned with the extension of official knowledge to encompass the engineering professional bodies (Klassen, 2018; Moodley, 2014). However, this may not reflect every situation, and it may be appropriate to revisit this in the application of the pedagogic device in other engineering education contexts, allowing a role for the professional bodies in both the regulative and the instructional discourse.

The pedagogic device of IoT engineering education, as revealed through consideration of the fieldwork, is presented in *Figure 11-1.* A key influence on the distributive rules is educational policy (Kwok 2017; Lim 2014) promoting a skills agenda in higher education, in which the NFQ plays a key role. EI, as the engineering professional body also contribute to the distributive rules through their accreditation requirements, including their interpretation of Bologna.

The discourse of the PRF is seen through the analysis of the fieldwork, for the selection of engineering academics I interviewed, to be shaped by the following.

- The use of LOs, which has been established as a core part of the pedagogic discourse;
- Progression has become an important consideration in pedagogy and course structure and design, and influences the balance of skills and knowledge taught to students.
- The language of levels, which has emerged from the NFQ, is used by engineering academics in their engagement with the ORF, i.e. with the policy discourse on higher education. It has become part of the terminology of their everyday academic practice, part of the pedagogic discourse that shapes recontextualisation.

The evaluative rules determine the pedagogic practice in the field of reproduction. The analysis has shown that, for my interviewees, pedagogy follows a performance approach (Bernstein, 2000), focussed on assessment. Bernstein (2000) used the pedagogic device in applied research into particular educational contexts, adapting it where appropriate to particular situations. The pedagogic device incorporates, through the concept of the PRF, the disposition of those engaged in teaching. In considering the implication of our focus as engineering academics on assessment in the theory of instruction, I propose that the field of reproduction has become oriented more towards being a field of evaluation.

The pedagogic device can be used in conjunction with fieldwork to assist in the understanding and explanation of particular educational systems, as in my research and others (Bernstein, 2000; Wolff, 2015). Kelly (2013) proposed the pedagogic device can be used to inform policy development through comparing pedagogic approaches in different educational contexts. The pedagogic device also offers the potential for the effect of change to be anticipated, and I suggest it may also serve as a tool to allow more informed decisions to be made with regard to the development of educational policies and their implementation.

Field of Production

Sites for creation of new knowledge

Field of Recontextualisation

The IoT Engineering Education Sector as a site where knowledge from the field of production are selected, re-arranged and transformed to become pedagogic discourses. This pedagogic discourse includes programme and module design, and also the selection of pedagogy to be used in teaching in the field of reproduction

Field of Reproduction (Evaluation)

The IoT Engineering sector as sites of teaching and learning

Recontextualising rules

Distributive rules: skills and competencies as what is to be taught to new generations of students can be seen as the consequence of the dominant influence over the distributive rules by government policy promoting a skills agenda in higher education

The NFQ promotes the teaching of skills in higher education, in line with government policy.

EI's accreditation requirements increase vertical stratification in engineering education.

The Discourse of the Official Pedagogic Field

The ***ORF*** is formed from the influence and prescription of the NFQ, and also EI's accreditation requirement, i.e. by Official Knowledge

Aspects of this discourse include:

Government Policy, in particular the skills driven knowledge economy and related economic imperatives

Transparency, a key under-pinning of the NFQ, manifests as use of learning outcomes, leading to new course design requirements

The nomenclature of the framework, which manifests as a *Language of levels,* is part of the policy *discourse,* helping to communicate policy and shape implementation.

Progression is foregrounded

Engineers Ireland require learning outcomes for accreditation, and also influence structure of engineering education, increasing stratification

The Discourse of the Pedagogic Recontextualising Field

The ***PRF*** incorporates the cognitive interests of academics

Learning outcomes have become an established part of the PRF

Concept of progression has become a consideration in pedagogy and course structure

Pedagogic identities of academics are being re-shaped by the **ORF**

Language of levels has become part of the pedagogic discourse

- Part of the discourse regarding knowledge
- part of the pedagogic principles that shape recontextualisation

Evaluative rules

Teaching is focussed on assessment. The field becomes oriented towards being a ***field of evaluation*** rather than a ***field of reproduction***

Identity of new graduates is being formed, but technician identity is being weakened in comparison to pre-NFQ technician education

Figure 11-1 The Pedagogic Device of Engineering Education in the IoT sector as Revealed through the Analysis, adapted from Bernstein (2000)

11.6 Conclusion

In this discussion I have considered the complexity of causes for, and effects of, the impacts I have observed on IoT engineering education since the transition to OBE. The views of my research participants suggest there are conflicting educational policies at play, particularly associated with tension between the employability and learner centred facets of the NFQ. These manifest in our pedagogy; in how we balance the impact of progression vs. the skills oriented education agenda; and in the problematic nature of transparency.

I discussed my findings regarding the pedagogy of my interviewees, the curriculum they offer, and overall structure of IoT engineering education through an EER lens, which allowed me to contextualise my research in the contemporary debate on what should constitute engineering education. I was quite questioning of the impact of OBE as revealed through the fieldwork. However, my research highlighted my interviewees' enthusiasm for being better engineering educators, their student focus, and their strong approach to what constitutes engineering knowledge, which I believe have all been factors in ensuring the continuing relevance of our engineering education. I articulated concern that the changes I observed have been largely unplanned and contingent, and that IoT engineering educators need to take a more prominent role in debate as to what constitutes Irish engineering education.

Of more general relevance to the application of OBE, I highlighted areas where my practitioner oriented research perspective digresses from QQI's policy level outlook. This includes consideration of the effectiveness of the skills focus of LOs and the validity of the concept of transparency. I also discussed implications of the usage of the language of levels, which goes beyond the adoption of the nomenclature of the framework that was intended.

In discussing how my findings illuminated the relationship between engineering and society I acknowledged the role of the neoliberal drivers for OBE and highlighted: the impact on the democratic project; the relationship to the commitment to diversity and access in engineering education; and EI's role as a mediator between engineering education and society.

In my reflection on the use of the pedagogic device as part of my conceptual framework to assist in my understanding of the complex field I have described, I suggested that it may of use to my peers as a means to consider related engineering educational contexts, and I highlighted particular challenges I faced, and how I resolved them.

Chapter 12 Conclusions

This is not to say that the challenges of curriculum in the contemporary age cannot be adequately met, but that we should become understanding of the nature of the challenges before us.
Ronald Barnett and Kelly Coate (2005, p. 9).

12.1 Introduction

When I began this research into the impact of outcomes based education (OBE) on the Institute of Technology (IoT) engineering education system that I, and my colleagues, have made a career, the changes in our approach to curriculum, consequent to OBE, appeared to me so substantial that I felt sure it was a research area that required attention. From the outset, I had a feeling that our approach to pedagogy would have been impacted, and my early readings into the field suggested there might be change to how we regarded knowledge. These considerations coalesced into my research question of considering what effect the introduction of outcomes based education (OBE) has had, and is having, on engineering educators and engineering education in the Institutes of Technology (IoT) sector in Ireland, and for which, through my research, I have provided the answers presented in this thesis.

In order to achieve this, I adopted a qualitative approach for my research, opening up avenues of inquiry to address that I consider I would just not have visited otherwise. For example, the highlighting of progression, initially by Bill, in the fieldwork, led me, through careful consideration of the literature and the fieldwork, to the realisation that profound related change has occurred in our education system. My conceptual framework may have only fully developed as I moved towards the later stages of my research, but important issues that it highlights including: the stratification of knowledge; whose knowledge it is that is selected in the curriculum (Young & Muller, 2014); and the factors exerting control over our engineering education system, became apparent, if not fully conceptualised, quite early in the fieldwork.

My conceptual framework called for the generation of detailed socio-historic accounts to help me understand the context in which my research was situated. Initially these comprised material on the genesis and early development of engineering education in Ireland; and the later development of the RTC/IoT engineering education system. As I moved to consider the development and implementation of the national framework of qualifications (NFQ), and the adoption of OBE for engineering accreditation, I began to describe events in which I myself had participated: where the changes I described had a direct effect on me, and, I, in helping implement them, on others. I used my insider status to these events to useful effect in identifying and teasing out issues, and it provided me with, at times, access to important, but not readily accessible, literature, and opinion from my peers.

A limitation of my study is that I have chosen to focus the changes in IoT engineering through the lens of OBE. As Allais (2017) remarks “analyzing qualifications frameworks is complicated; impact analysis of most education and training policies are contested and complex” (p. 2). I have considered other influences, but only in so far as they directly relate to the introduction of the NFQ and Engineers Ireland’s (EI’s) learning outcomes (LOs) based accreditation process. This does, however, mean that my research goes beyond describing the impact of the NFQ and EI’s accreditation as perceived by my research participants, in that their views were situated in the totality of the political, economic and social pressures on engineering education, and the subsequent impact that they have experienced.

The application of knowledge and skills in practice lies at the core of engineering. OBE provides a means for engineering educators to teach them together, where the LOs focus should lead to an emphasis, for students, on the importance for engineers of achieving tangible, useful, effects. However, as my research reveals, OBE oriented educational policies and associated factors, as they seek to achieve their intended impact, interact with the cognitive interests of engineering educators to produce other, and at times contradictory, contingent changes.

The next section presents the contributions of my thesis to the literature with regard to the impacts I have observed, analysed and conceptualised in my research.

12.2 Contributions of my Research to the Literature

This thesis contributes to engineering education research (EER) into engineering faculty, examining the consequences, for engineering educators, and the education they offer, of the use of OBE. My literature review revealed this to be an under-researched, but important, aspect of the field. It is the first research study of the experience of IoT engineering academics of the use of OBE, and of the effect on the education they offer. Using a qualitative methodology, and drawing from a theoretical perspective on social realist, EER literature, and other critique of OBE, it allows the voices of my research participants to speak with regard to how they themselves, and the engineering education they offer, have been affected by OBE under the dual influence of the NFQ and Engineers Ireland (EI), and related policies. In doing so I offer a practitioner perspective, rather than a policy led perspective, on the impact of OBE on IoT engineering education. My contributions to the literature relate to the effect of OBE on engineering education and educators in the IoTs, the effectiveness of OBE as a policy instrument, and the representation of IoT engineering education as a pedagogic device.

An overarching contribution of my research to the literature is to the national policy discourse on engineering education, where I have set out a critical view of the effects of OBE on the technical engineering education sector in Ireland. This is in contrast to QQI's (2017) review of the impact of the NFQ, which was largely positive with regard to the benefits they perceive it has brought to education in Ireland, and EI's similarly positive view of LOs (EI, 2014).

I have shown that, for my interviewees, the 'official knowledge' of the NFQ alongside Engineers Ireland's (EI's) accreditation requirements has exerted a dominance over the pedagogic discourse of IoT engineering education. This includes: in the recontextualisation of knowledge and the balance of knowledge and skills in the curriculum; on our pedagogy; in the impact of progression; and on the overall structure of engineering education. My research provides evidence, through the fieldwork, of the influence of EI, as a community of trust (Tuck, 2007; Young, 2008) in the engineering region (Bernstein, 2000), in establishing the credibility of LOs with IoT engineering academics (Brent & Felder, 2003; Heywood, 2005, 2016).

A key contribution to the literature is to demonstrate the manner in which my research participants have given a positive, if at times qualified, acceptance to OBE. They regard it as effective: impacting positively on their pedagogy; serving as a useful framework for curriculum design; facilitating communication; and improving access to education. However, I set out a critique of the pedagogy they appear to have adopted as a consequence, question the appropriateness of the language of levels that has emerged in the pedagogic discourse, and raise concerns about the impact on the structure of engineering education.

My research reveals, through analysis of the available records, that the pedagogical basis of the NFQ received little attention during its development (NQAI, 2001a, 2001b, 2002c, 2003a). Through the fieldwork, I provide qualitative evidence, supported by related studies (Rami, 2012, Muller, 2004a), for the contention in the literature that a potential consequence of the use of LOs is a move to performance pedagogy (Deacon & Parker, 1999; Havnes & Prøitz, 2016; Muller, 1998; Torrance, 2007).

Kenny (2006), in exploring the impact of policy on contemporary higher education in Ireland, reported that “LOs, as a new discourse, are embedded in the academic language and programme content of HE” (p. 201). In providing qualitative evidence to support this, a further contribution to the literature is to suggest, through the voice of the interviewees, the emergence of a *language of levels* consequent to the introduction of the NFQ, as is proposed will result from the use of qualification frameworks (Allais, 2010b; Raffe, 2011), and the NFQ in particular (Kenny, 2006, Collins et al, 2009). My research describes the manner in which this is used by engineering academics, in their engagement with policy discourse and also in their everyday academic lives, consistent with Biesta’s (2015) concept of learnification. I question whether the use of this language of levels, in displacing the terminology of the discipline, is fully appropriate, whilst recognising the utility of this language that my research participants identify, and the necessity they feel for engaging with it and through it.

My research shows the strong influence OBE has exerted over the instructional discourse of my research participants through the use of LOs in curriculum design. Although this influence was particularly apparent in the recontextualisation of knowledge in the curriculum, my research participants showed they had maintained effective practices regarding engineering knowledge. Furthermore, my research provides qualitative evidence that the NFQ has facilitated the presence of hierarchically organised discourses (Bernstein, 1999) of engineering knowledge, as has been proposed for national qualification frameworks (NQFs) (Baynham, 2012; CEDEFOP, 2017). This allays a concern raised in the literature (Allais, 2014), and by one of my research participants (Ayah) that LO’s reduce curriculum to the transmission of information rather than the teaching of knowledge. A further contribution to the literature (McLaughlin, 2001; ABET, 2006; Heywood, 2016, 2005; Owens, 2016a) is to provide qualitative evidence of the overarching influence of EI’s OBE accreditation requirements on IoT engineering curriculum design.

A finding revealed the NFQ as a policy tool in the re-orientation of Irish higher education towards a skills focussed emphasis. The NFQ is regarded as a key enabler for the knowledge economy through its promotion of knowledge and skills *together,* as part of life-long learning (HESG, 2011). However, the literature suggests that NQFs downplay knowledge and emphasise a skills based education (Heywood, 2000; Corbell, 2014; Allais, 2014). Through the use of Corbell's (2014) methodology to analyse NQAI (2003a), my research confirms this skills emphasis in the case of the NFQ, which is seen as supporting the national requirement for a continuing supply of level 6 and 7 technicians (DES, 2016).

However, my research revealed the dramatic change in full-time enrolments in IoT engineering over the period 2008-2017. Whereas previously higher certificates and ordinary degrees (level 6 and 7) were the most popular, by 2017 the majority of students were enrolled in honours degrees (level 8). A finding from the fieldwork is that, influenced by the principle and consequences of the NFQ concept of progression (NQAI, 2003a), alongside other factors, my interviewees now regard level 6 and 7 programmes as preparatory programmes for level 8 degrees, leading them to emphasise theory over skills. There are two implications, the first of which is in providing qualitative evidence, in the specific case of IoT engineering, of the use of OBE leading to the weakening of boundaries between vocational and academic education (Young & Muller, 2010; Allais 2010a; Shay, 2012). The second is in providing qualitative evidence to support earlier research (Llorens et al, 2014) that suggests level 7 engineering programmes are becoming precursors to level 8 degrees rather than paths to employment.

Despite the skills emphasis of the NFQ, my interviewees held somewhat conflicting views of the correct balance of knowledge and skills in curriculum. I argue this is related to dual influences from the NFQ as a policy instrument, simultaneously promoting a more skills-based education, (HESG, 2011; DES, 2016), whilst, my research has shown, progression encourages the opposite, leading to a diminishing in the skills focus of technician programmes. I suggest that, consequent to these opposing pressures, Bernstein's (2000) pedagogic schizoid position is manifest in the differing attitudes of IoT engineering academics to the level of skills that should be taught.

A contribution to the literature, from the vantage of 2020, is to confirm McLaughlin's (2001) prediction that EI's interpretation of Bologna would have an impact on the structure of IoT engineering education, with many of the five year IoT engineering degrees, suitable in principle for accreditation towards Chartered status, being discontinued. These were replaced with four year programmes suitable for accreditation as associate engineer. I have argued that the changes I have observed in IoT engineering education consequent to OBE have, to an extent, been contingent, rather than planned, and it is not clear the educational implications were always fully considered, with Edith relating "*we did it half-heartedly because we didn't think it was right*". However, there appears to be an alignment of graduate capability with employer requirements, and I propose that this continuing relevance is maintained through the strong engineering knowledge base of IoT engineering academics, and their understanding of industry requirements.

QQI (2017) makes strong claims with regard to the effectiveness of the NFQ value of transparency (NQAI, 2001b), but my research indicates the broadness of QQI's claims to be problematic. In particular my research shows that readability analysis (Reck & Reck, 2007) applied to programme outcomes of curriculum mapped to the NFQ and the EQF supports the contention that transparency cannot be fully achieved through LOs (Cort, 2010; Young, 2011). However, the fieldwork indicates that the principle of transparency is of value if regarded in a more limited fashion, in particular for communication between academics.

Consistent with the international experience of NQFs (Fernie & Pilcher, 2009; Allais, 2010a; Havnes & Prøitz, 2016), a contribution the literature is to suggest that the NFQ, and associated policies, leads to contradictory policy positions. In the case of the NFQ these are particularly associated with the tension between the learner centred facet of the NFQ and the parallel employability emphasis. The NFQ promotes more skills, but progression, alongside other factors, inculcates a more theoretical approach; pedagogy is not specified, but a performance pedagogy appears contingent, at odds with the competency model that would be associated with student-centeredness; the NFQ value of transparency, from which it follows that LOs should be accessible to all stakeholders, is shown to be problematic.

From a methodology perspective I show the applicability of the pedagogic device (Bernstein, 2000) to assist in the consideration of the impact, from the perspective of a selection of engineering academics, of OBE on IoT engineering education. I further propose that, in considering the resultant pedagogic device, under the assessment emphasis of OBE the field of reproduction of the device has become oriented towards being a field of evaluation. A contribution to the field of EER is in suggesting the pedagogic device has the potential for a wider application in research into engineering education systems.

12.3 Future Directions

A limitation of my research is that, as opposed to using a quantitative approach, it does not provide for definitive conclusions to be taken from the findings (Donmoyer, 2008). In considering future research direction, the research could be expanded to allow for more definitive findings regarding the impact of the use OBE in IoT engineering education. For example, the impact on pedagogy could be further examined to confirm the extent and modalities (Bernstein, 2000) of the performance pedagogy approaches. My qualitative research could form the basis for a mixed methods research methodology (Creswell, 2011), informing the design of survey instruments to be used to gather quantitative data for a statistically representative sample of IoT engineering academics.

A further future research direction could be to expand the research to examine the impact in other academic areas. In particular, academic disciplines could be chosen that did not have professional bodies with the same influence as EI, or, indeed, might have associated professional bodies that had not moved so wholeheartedly to embrace LOs. The research question, in this case, would examine the role of professional bodies in the take up of OBE.

My research shows there to have been structural change, under the influence of OBE and other factors, to IoT engineering education. The views of my interviewees suggest that technician programmes have become more theoretical, in preparation for progression, for most students, to honours degrees. Other causes identified by my interviewees included the reduction in government funding for third level education, and changing industry requirements, as also identified in the literature (EI, 2019; McIver Consulting, 2007). I believe a debate is necessary, which the technical education sector should lead, in order to decide what is meant by contemporary engineering technician education in Ireland, to ensure it is aligned with our country's requirements. The stratification of engineering into technician and professional engineering should form part of that debate (Dempsey, 2017, 2018), including revisiting an earlier proposal for a parallel Chartered Engineering Technologist path (IEI, 2005a).

This leads me to future developments related to the NFQ. I was encouraged, in reading QQI (2013), by the importance which it ascribed to the influence of communities of practice in helping determine the shape of educational programmes. There was an acknowledgement that LOs are not in themselves complete descriptors, leaving space for the disciplinary expert. The ascendancy of LOs within the NFQ was diminished in that it was described as LO referenced as opposed to based, and that "not everything that matters can be expressed using LOs.” (QQI, 2013, p. 17). There was a recognition that different types of educational institution will produce different types of graduates, albeit their programmes may be mapped to the same NFQ level, which acknowledges the importance of established centres of disciplinary excellence, and the differentiation between them. In order to consider whether a programme meets the standard to which it aspires, it is not just the compliance of the programme documentation with the QQI standards that is important, but also the institutional disciplinary capacity, i.e. “textual analysis is not a sound basis for comparing standards” (QQI, 2013, p. 17). However, more recent publications make clear that LOs will continue to be in the ascendency (QQI, 2017, 2018), and, indeed, QQI are bound by statute to implement the NFQ (Irish Statute Book, 2012). However, I believe my research acts as a counterpoint to some of their claims for the NFQ, and will inform policy makers in this regard.

I believe reducing the journey to becoming an engineer to achieving a series of LOs misses the substantial, critical, point, which I raised earlier in *Chapter 2*, that it is what we learn on the way to achieving those outcomes that is important, allowing us to develop the engineering mind-set. If OBE is to be the effective educational approach its protagonists claim, we need to use it within an appropriate educational model, where we integrate what Heywood (2016) refers to as “content knowledge and understanding, theories of learning” and “a defensible theory and philosophy of assessment” (p. xiii). The literature points a way forward: Bowe and Duffy (2010), Clark and Andrews (2014), Heywood (2016) regarding educational models for engineering education; Heywood (2016) regarding assessment; Shay (2012), Wolff (2015) regarding technician vs. professional engineering education; Barnett and Coate (2005), Heywood (2008), Wolff (2015) regarding curriculum design; Muller (1998), Heywood (2016) and Deacon and Parker (1999) regarding pedagogy; and Allais (2014, 2017), Maton and Moore (2009), Young and Muller (2010) on broader issues associated with NQFs.

I believe this perspective can be inculcated in my fellow engineering academics through taking advantage of the interest identified by my research participants in training as educators. If I consider this from the vantage of a Head of Department of engineering in TU Dublin, I would be in a position to address this through the facilitation of a series of workshops where, working with my colleagues, we considered what OBE means to us as engineering educators, what type of engineering graduate we intend to educate, and whether we feel we are achieving this in our current programme structures. Further workshops would focus on particular pedagogical approaches, where we explore, for example, the applicability of constructive alignment, reflective practices in engineering education, and how the problem based learning activity within my department contributes to our students' identity formation.

I believe it will also be of benefit to my fellow engineering education researchers to publicise my work, and, through communities of practice such as the UK-Ireland Engineering education Research Network (EERN, 2021), TU Dublin's CREATE (2019) group, and SEFI (2021), I will seek to disseminate my research and engage in debate with regard to it.

12.4 Final Reflection

As I move to conclude this thesis, a final finding is my realisation of just how influenced I am, as an engineering academic manager and leader, by government policy, of yesteryear and today, and by EI's positioning as a professional body. In leading the implementation of the OBE approach for engineering programmes within my IoT I helped to bring about other, related changes, the consequences of which I question, and with regard, in particular, to pedagogy, I am quite critical. In my role as head of department (HoD) I had to engage with the move to OBE, but I consider I became overly focussed on operational issues. In my defence, the move to the NFQ was initially presented as a re-packaging exercise for our existing programmes, and, indeed, that was what it was to begin with. Over the years, under the dual influences of the NFQ and EI, we have, however, experienced quite radical change in terms of the engineering education we offer.

In retrospect I should have been conscious of the need to question the claims that were made for OBE, and query the effects its introduction might have, in order to guide and support my colleagues appropriately. My research provides me with the perspective, and the opportunity, to provide more appropriate support and leadership to my colleagues going forward, to encourage them to develop and use their engineering expertise to deliver an engineering education relevant to our students and society.

The fieldwork was carried out in 2016, 4 years before the thesis was completed. The moves within our sector to consolidate IoTs into technological universities has led to creation of Technological University Dublin, where I am now employed. This changing landscape for technical education in Ireland will no doubt have an impact on the education we offer and on us as educators. At time of writing, although TU Dublin has been formed for over 2 years, the impact on academics, the programmes we offer, and our students, has as yet been quite minimal. However, the adoption of a TU Dublin strategic plan, an impending radical change in our organisational structure, and the development of an educational model for the University will bring significant change across all levels of the engineering education we offer. My research, informed by the views of my research participants, places me in an advantageous position to contribute to the impending changes for the positive benefit of my colleagues, our students, and the industry and society in which they will find careers.

Government policy and the engineering professional bodies may dictate an OBE approach to this education, but within that we should strive to develop our students' identities as future engineers and technicians (Nudelman, 2018) rather than educate them to be level '6, 7, 8 and 9' graduates. As engineering educators, rather than emphasising assessment, we need to reinvigorate our focus on the identity formation process of educating the next generation of engineers, asking ourselves "*what would you like to see in an engineer*" (Thomas). Our academic expertise, our pedagogic identities, the curriculum we offer and the structure of our programmes must be aligned to allow us to inculcate in our students the engineering view of knowledge as that which is useful, along with the associated body of expertise, know-how and skills they need to usefully apply themselves in engineering practice. We must be aware of the pressures on our engineering education system as we undertake this important task. Change should be driven by, and accepted for, the betterment of engineering education and the society it helps shape, rather than come about through the unintended contingency that may result from educational reforms that have not been fully thought through.

In adopting a social realist influenced conceptual framework for my research, it is necessary to acknowledge that the description and understanding of the impact of OBE on IoT engineering education I have developed in this thesis is only one way to analyse the consequences of these educational reforms (Sayer, 2000). I offer my findings not as a definitive position but as a reasoned account (Smit, 2016) of the impact I have observed. I hope the reader agrees that this perspective, which I arrived at through the assistance of my research participants, offers insight, and where appropriate, explanations, into the impact that OBE has had on engineering educators and education in the IoT sector.

Appendices

We have finished the job, what shall we do with the tools?

Haile Selassie, as quoted in Ambrosia and Small Beer, Marsh E and Hassall C, (1964, p. 160).

Appendix A Level Indicators for the NFQ for Levels 6 to 10

Table A-1 Level Indicators for NQF Levels 6-9 (NQAI, 2011)

	Level 6	***Level 7***	***Level 8***	***Level 9***
Knowledge *Breadth*	Specialised knowledge of a broad area	Specialised knowledge across a variety of areas	An understanding of the theory, concepts and methods pertaining to a field (or fields) of learning	A systematic understanding of knowledge, at, or informed by, the forefront of a field of learning
Knowledge *Kind*	Some theoretical concepts and abstract thinking, with significant underpinning theory	Recognition of limitations of current knowledge and familiarity with sources of new knowledge; integration of concepts across a variety of areas	Detailed knowledge and understanding in one or more specialised areas, some of it at the current boundaries of the field(s)	A critical awareness of current problems and/or new insights, generally informed by the forefront of a field of learning
Know-How & Skill *Range*	Demonstrate comprehensive range of specialised skills and tools	Demonstrate specialised technical, creative or conceptual skills and tools across an area of study	Demonstrate mastery of a complex and specialised area of skills and tools; use and modify advanced skills and tools to conduct closely guided research, professional or advanced technical activity	Demonstrate a range of standard and specialised research or equivalent tools and techniques of enquiry
Know-How & Skill *Selectivity*	Formulate responses to well-defined abstract problems	Exercise appropriate judgement in planning, design, technical and/or supervisory functions related to products, services, operations or processes	Exercise appropriate judgement in a number of complex planning, design, technical and/or management functions related to products, services, operations or processes, including resourcing	Select from complex and advanced skills across a field of learning; develop new skills to a high level, including novel and emerging techniques
Competence *Context*	Act in a range of varied and specific contexts involving creative and non-routine activities; transfer and apply theoretical concepts and/or technical or creative skills to a range of contexts	Utilise diagnostic and creative skills in a range of functions in a wide variety of contexts	Use advanced skills to conduct research, or advanced technical or professional activity, accepting accountability for all related decision making; transfer and apply diagnostic and creative skills in a range of contexts	Act in a wide and often unpredictable variety of professional levels and ill-defined contexts
Competence *Role*	Exercise substantial personal autonomy and often take responsibility for the work of others and/or for the allocation of resources; form, and function within, multiple, complex and heterogeneous groups	Accept accountability for determining and achieving personal and/or group outcomes; take significant or supervisory responsibility for the work of others in defined areas of work	Act effectively under guidance in a peer relationship with qualified practitioners; lead multiple, complex and heterogeneous groups	Take significant responsibility for the work of individuals and groups; lead and initiate activity
Competence *Learning to Learn*	Learn to evaluate own learning and identify needs within a structured learning environment; assist others in identifying learning needs	Take initiative to identify and address learning needs and interact effectively in a learning group	Learn to act in variable and unfamiliar learning contexts; learn to manage learning tasks independently, professionally and ethically	Learn to self-evaluate and take responsibility for continuing academic/professional development
Competence *Insight*	Express an internalised, personal world view, reflecting engagement with others	Express an internalised, personal world view, manifesting solidarity with others	Express a comprehensive, internalised, personal world view manifesting solidarity with others	Scrutinise and reflect on social norms and relationships and act to change them

Appendix B Sample Focus Group Exercise

Progression

The table below shows where the interviewees had views on progression.

	Progression		
	Progression to Level 8 viewed as the Aspirational Target for Students	Influence on Technician Education	The Higher Certificate
Interviewee			
Isambard			
Ayah			
Kees			
Rudolf			
Vitruvius			
Bill			
Thomas			
Gordon			
Edwin			
George			
Edith			
Henry			
John			
Alan			
Grace			

The old Certificate and Diploma technician qualifications have been replaced with new level 6 and 7 qualifications:

- *Are they equivalent?*
- *Or has the skills focus has been downgraded in favour of a more analytical, theoretical, education*
- *Or do you teach in a manner more consistent with the claims for the knowledge economy, i.e.* ***knowledge and skills*** *together?*

Are the new level 6 and 7 qualifications becoming merely pre-cursors to professional engineering qualifications (level 8)?

What has happened to the Higher Certificate? Is this due to progression, or other factors?

Appendix C Readability Analysis of Programme Outcomes

One of the claims associated with qualification frameworks is that they promote transparency with regard to qualifications (Cort, 2010). This can be taken to mean that a prospective student should be able to read the programme LOs, and understand them sufficiently well to make an informed decision with regard to whether the programme in question is one they would pursue (Lindholm, 2009). However, my research suggested that this claim is aspirational, and, in fact, the language of levels and LOs provided by qualification frameworks is largely opaque to such prospective students (and others) (Cort, 2010).

In order to investigate this I applied readability analysis (Reck & Reck, 2007), using an online tool (Online-Utility.org, 2017), to the programme outcomes of a number of NFQ level 6 awards, and to an EQF award (level 6). The utility takes text as input, and applies a number of algorithms to assess the text's readability at an initial reading. As can be seen from the results below, in each case the algorithms calculate that many more years of formal education are necessary in order to be able to easily understand the programme outcomes. Assuming someone commences college at age 18, having started primary school at 5, they would have, at that point 13 years of formal education, whereas the average number of years of formal education required for easy readability of the programme LOs, in, for example, the case of the ITB Mechatronics Higher Certificate, is 19 years. This is equivalent to someone having spent enough years in education to not be pre-college, but to already have received a bachelor's degree and master's (and even possibly a PhD). In one case (the EQF mapped Air Traffic Control Engineer) the readability analysis implies that the text is largely incomprehensible (at first reading).

This strongly suggests that programme outcomes, as written, do not provide prospective students with the transparency related to the qualification that is expected from the use of qualification frameworks.

This is supported by the following fieldwork interview extract, discussing the use of LOs with students "I'll try to convert them into [...] everyday language" (Rudolf). The interviewee recognises the difficulty of expecting students to understand learning outcomes, and instead explains them to the students in terms of more accessible terminology.

ITB Mechatronics Higher Certificate Readability Analysis, level 6 NFQ

Programme Outcomes

Display a knowledge and understanding of the mechatronic engineering discipline and the fundamental science, mathematics and technologies underpinning this discipline.

Demonstrate knowledge of the integration of the various mechatronics disciplines and relevant codes of practice.

Demonstrate proficiency in the use of workshop, laboratory and computer equipment used in the construction and testing of mechatronic products

Be able to select and apply mathematical formulae and scientific techniques to solve mechatronic engineering problems and communicate the results in an appropriate format.

Apply the knowledge and skills learned to plan and produce mechatronic engineering projects, reports and assignments, within a specified time-frame.

The ability to work both independently and as part of a team to plan, manage and organise mechatronic engineering assignments and projects.

Reflect on and evaluate the quality of his/her own learning. Knowledge of the importance of continuing professional development.

Show awareness of the significance of the wider ethical, environmental and business contexts within which engineering operates and to participate in engineering activities in a responsible manner

Readability Analysis.

Indication of the number of years of formal education that a person requires in order to easily understand the text on the first reading	
Gunning Fog index :	21.52

Approximate representation of the U.S. grade level needed to comprehend the text :	
Coleman Liau index :	19.09
Flesch Kincaid Grade level :	17.28
ARI (Automated Readability Index) :	18.06
SMOG :	17.75

CIT Electrical Higher Certificate, level 6 NFQ

Programme Outcomes

A knowledge of areas of electrical circuitry and practice, installation and equipment. A knowledge of mathematics, ICT, design, business and engineering practice relevant to the electrical engineering technician.

The ability to apply knowledge of electrical science, practice and design, to the solution of well-defined electrical engineering technology problems

The ability to use basic electrical engineering techniques, skills and modern computer-based engineering tools and packages necessary for engineering practice.

The ability to assist in the design of an electrical facility, component or process to meet specified needs and to contribute to the assessment of the technical performance of the system.

The ability to contribute to the solution of common engineering technology problems in electrical engineering.

The ability to work autonomously and safely and as a member of a multidisciplinary team in well-defined work settings.

The ability to identify and address learning needs within a structured learning environment and an awareness of the need for continued professional development.

An appreciation of the wider social, political, business and economic contest within which engineering operates and the need for high ethical standards in the practice of engineering, including the responsibilities of the engineering profession towards people and the environment

Readability Analysis

Indication of the number of years of formal education that a person requires in order to easily understand the text on the first reading	
Gunning Fog index :	22.22
Approximate representation of the U.S. grade level needed to comprehend the text :	
Coleman Liau index :	17.67
Flesch Kincaid Grade level :	19.03
ARI (Automated Readability Index) :	18.68
SMOG :	19.09

Air Traffic Control Engineer, Level 6 EQF

http://ec.europa.eu/ploteus/en/content/air-traffic-control-engineer-rai

Programme learning Outcomes

To obtain knowledge about air traffic services and organisation in accordance with the national, EU, ICAO and EUROCONTROL regulations as well as to obtain knowledge about meteorology, aircraft and navigation;

To acquire skills in management and control of air traffic, communication with the air crews about meteorology, equipment operation and flight planning, to use the data of the IT management systems for the choice of safe, efficient and rational flight routes;

To acquire skills necessary to use radio electronic and automated satellite systems for air traffic control and to manage the work of emergency, search and rescue services;

To develop a competence in air traffic control by studying the binding regulations, assuring flight security and efficient work of air traffic control service.

Readability Analysis

Indication of the number of years of formal education that a person requires in order to easily understand the text on the first reading	
Gunning Fog index :	57.65
Approximate representation of the U.S. grade level needed to comprehend the text :	
Coleman Liau index :	16.16
Flesch Kincaid Grade level :	54.43
ARI (Automated Readability Index) :	65.32
SMOG :	33.00

Appendix D, HEA Data on Engineering Enrolments

Table D-1 Enrolments in Full-Time Engineering Programmes in the IoT Sector, Based on Analysis of Data from HEA (2021).

Year	No of Level 6&7 Enrolments	No of Level 7 Enrolments	No of Level 6 Enrolments	No of Level 8 enrolments in the IoT sector	Level 6/7 as a percentage of total	Total enrolments in engineering in the IoT sector
2008-09	8418	7399	1019	3581	70	11999
2009-10	8021	6927	1094	4907	62	12928
2010-11	7582	6487	1095	4831	61	12413
2011-12	6737	5942	795	4759	59	11496
2012-13	6381	5688	693	4325	60	10706
2013-14	6148	5457	691	4278	59	10426
2014-15	5772	5176	596	4478	56	10250
2015-16	5569	5005	564	4942	53	10511
2016-17	5047	4539	508	5223	49	10270
2017-18	4705	4,283	422	5703	45	10408

Table D-2 Enrolments in Part-Time Engineering Programmes in the IoT Sector, Based on Analysis of Data from HEA (2021)

Year	No of Level 6&7 Enrolments	No of Level 7 Enrolments	No of Level 6 Enrolments	No of Level 8 enrolments in the IoT sector	Level 6/7 as a percentage of total	Total part-time enrolments in engineering in the IoT sector
2008-09	2110	785	1325	272	89	2382
2009-10	1738	956	782	340	84	2078
2010-11	1194	1013	181	313	79	1507
2011-12	1503	1057	446	390	79	1893
2012-13	1667	1098	569	508	77	2175
2013-14	1704	907	797	388	81	2092
2014-15	1848	950	898	434	81	2282
2015-16	2027	951	1076	481	81	2508
2016-17	1308	799	509	388	77	1696
2017-18	1360	904	456	413	77	1773

Appendix E The Bologna Process

The Bologna process began with the Sorbonne Declaration (Ministers of Education France, Germany, Italy and UK, 1998), which, linked to moves to reform the education systems of the initiating countries (Huisman et al, 2012), formally established moves to create an EHEA, and invited other countries to participate. The Bologna declaration (European Ministers of Education, 1999) marked the expansion of this to 29 countries, including Ireland. It sought to establish a system where degree’s awarded in the EHEA could be easily compared, in order to promote employability and international competitiveness. It advocated a credit transfer system, such as the ECTS, to aid in mobility and in lifelong learning, and promoted semesterisation. It had as an objective the promotion of mobility of students, teachers, researchers and administrative staff. It promoted the concept of a common European view of higher education, alongside associated quality assurance processes.

It initially established a two-cycle degree process (an undergraduate and a graduate cycle), with a third (doctoral education) added in the Berlin Communiqué (Ministers Responsible for Higher Education, 2003) as part of continuing bi-annual ministerial meetings (Huisman et al, 2012). The Berlin Communiqué also committed the signatories to the use of OBE at a national level, in the context of an overarching European qualification framework.

Ireland and the NFQ played a role in this adoption of a qualification framework approach, e.g. through its influence on the earlier Copenhagen seminar (Bergan, 2003), which set out that “an overarching qualifications framework for the European Higher Education Area is a *conditio sine qua non* to the setting up of a European Higher Education Area”. A series of meetings following the Berlin Communiqué (Joint Quality Initiative Informal Group, 2004b), culminated in the agreement of the Dublin descriptors (Joint Quality Initiative informal group, 2004a). The report setting out the Dublin descriptors makes explicit reference to the influence of the NFQ, and notes the participation of representatives of the NQAI, HETAC and the IoTs. The Dublin descriptors differentiate between the different degree cycles through outcomes specified in terms of knowledge and understanding, applying knowledge and understanding, making judgements, communication, and learning skills. This served as a defining moment in the development of the Bologna framework, in that the Dublin Descriptors enshrined the use of LOs in the Bologna process (Feeny & Horan, 2016).

The Bologna Framework (ECA, 2020), formally designated the Framework for Qualifications of the European Higher Education Area is, essentially, the three cycles agreed under Bologna, implemented using the Dublin descriptors, and was officially announced in the Bergen Communiqué (European Ministers Responsible for Higher Education, 2005). This communiqué also agreed the desirability of compatibility with the developing EQF, as later established by the Bologna Follow-Up group (BFUG, 2005). Indeed the EQF was required to build upon the achievements of the Bologna process (CoEU, 2002).

The compatibility of the NFQ with the Bologna framework was determined in 2006, and compatibility with the EQF was certified in 2009 (NQAI, 2009). This was hardly surprising given the degree of influence of the NFQ in the development of the European frameworks. See below for a comparative table of the levels of the Bologna framework, the EQF and the NFQ.

Table E-1 Comparison of the Bologna Framework, the EQF and the NFQ (FIN, 2017)

EQF Levels	Bologna Framework	Irish NFQ Levels	Irish Major Award-Types
1		1	Level 1 Certificate
		2	Level 2 Certificate
2		3	Level 3 Certificate, Junior Certificate
3		4	Level 4 Certificate, Leaving Certificate
4		5	Level 5 Certificate, Leaving Certificate
5	Short Cycle within First Cycle	6	Advanced Certificate*, Higher Certificate
6	First Cycle	7	Ordinary Bachelor Degree
		8	Honours Bachelor Degree, Higher Diploma
7	Second Cycle	9	Masters Degree, Postgraduate Diploma
8	Third Cycle	10	Doctoral Degree, Higher Doctorate**

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