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A Phenomenographic Study of Academics Teaching on Engineering Programmes in Ireland: Conceptions of Professional Skills and Approaches to Teaching Professional Skills

A thesis submitted to Technological University, Dublin
in fulfilment of the requirements for the degree of Doctor of Philosophy

By

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Abstract

Engineers play a central role in addressing the challenges which face society. However, the influence of globalisation, disruptive technological change and socially complex problems will greatly affect the way engineers work in the future. As a result, there have been calls to embrace transformational change in engineering education, yet the literature reveals that many reform efforts have fallen short. Industry and society will therefore continue to look to Higher Education Institutions (HEIs) to better prepare engineering graduates with the new skills needed to face the challenges of the future. Notwithstanding the critical and valued role that technical engineering subjects have within an engineering programme, the literature suggests that there is a need for a greater focus on the development of Professional Skills.

A key factor in the development of Professional Skills in engineering students lies in the interaction with academics. The values and actions of the academics with whom they interact, all have a part to play in how a student understands and values the various skills they learn. Hence, focusing on academics and their approaches to teaching professional skills forms a basis for supporting reform in engineering education. However, fundamental changes to how academics teach professional skills may only result from changes to their conceptions of what professional skills are. Thus, it is critical to not only understand how academics teach professional skills, but to understand their conceptions of professional skills and how this influences their teaching approaches. This is a gap in the current literature yet is a fundamental prerequisite for supporting reform in academic practice and thus transformational change in engineering education.

This PhD study uses phenomenography to shed light on academics' experiences in regard to professional skills, with three specific objectives. The first is to better understand the variation in academic conceptions of what is meant by "professional skills". The second examines the variation in academics' approaches to teaching professional skills. Finally, the study considers if relationships exist between these two factors, how differing conceptions may influence the approaches to teaching and the implications of these relationships for practice and policy.

The outcome of this study provides a framework for describing the phenomenon of **Professional Skills** in an engineering context. Academics revealed their Conceptions of Professional Skills in six ways: Communication Skills, Technical Skills, Enabling Skills, A Combination of Skills, Interpersonal Behaviours and Acting Professionally. Academics in this study also described five Approaches to Teaching Professional Skills: Transmitting Knowledge, Practicing, Coaching, Mirror Industry Environment and Role Modelling. Finally, the findings show that there is a relationship between academics' approaches to teaching professional skills and their conceptions of what professional skills are. All outcomes are contextual to academics teaching on engineering programmes in Ireland.

This overall framework can be used in two ways. Firstly, from a top-down approach: to provide evidence for policy decisions, such as curriculum design and accreditation criteria to encourage and enhance the development of professional skills in engineering students. Policies which are multi-layered and relevant to all academic staff are more likely to be successfully implemented. Secondly, the findings can also be used in a bottom up approach: as a learning and teaching resource for engineering academics. The outcomes allow academics to reflect on their own teaching approaches and expose them to a more powerful understanding of the ways in which they can help develop professional skills in engineering students.

This study aims to give insights into the engineering academic community in Ireland and the outputs can ultimately be used to increase opportunities for engineering students to develop professional skills, resulting in a better prepared engineering graduate who can both face into and overcome the challenges of the future.

Declaration

I certify that this thesis which I now submit for examination for the award of Doctor of Philosophy is entirely my own work and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for postgraduate study by research of the Technological University, Dublin (TU Dublin) and has not been submitted in whole or in part for another award in any other third level Institution.

The work reported in this thesis conforms to the principles and requirements of the TU Dublin's guidelines for ethics in research.

TU Dublin has permission to keep, lend or copy this thesis in whole or in part, on condition that any such use of the material of the thesis be duly acknowledged.

Signed: Una Beagon

Date: 29th January 2021

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CHAPTER ONE – Introduction and Context

This chapter introduces the context of the research and my motivation and aims for this study. It begins by acknowledging the literature calling for reform in engineering education and an outline of how I arrived at this point in my career and why I wanted to undertake this PhD. The aims and objectives of the study are stated along with a summary of how the outcomes will be of use to the engineering education community to assist in educational reform. The chapter concludes with an outline of the thesis structure.

1.1 Context of Research Study

The call for reform of Engineering Education

Engineering as a profession has changed dramatically since the 19th Century and the building of the Clifton Suspension Bridge (Figure 1-1) designed by the famous Mr Isambard Kingdom Brunel (Christopher, 2006). At that time, engineers in Britain were trained under an apprenticeship system and learned at the knee of another engineer, emulating their patron.

Figure 1-1. The Clifton Suspension bridge over the River Avon designed by Isambard Kingdom Brunel and built in 1864. Reproduced with kind permission from the Clifton Suspension Bridge Trust. (CSBT, 2017)

Students learned the basics of load transfer and materials science and combined that knowledge to produce engineering solutions to infrastructural problems (Happold, 1983).

Since then, the way in which an engineer works has changed dramatically and not only because of technical advances. In Brunel's time, he acted as the Architect, the Engineer, the Draughtsman and the Resident Engineer, with perhaps the only other outside influence being the Client. Nowadays, engineers must be able to work with other people, in diverse, multidisciplinary international teams and the skills needed to succeed in this scenario go far beyond mere technical skills.

The debate on skills requirements in engineering programmes is not new. The first Journal of Engineering Education was published by the Society for the Promotion of Engineering Education in 1893 (Seely, 2005). The discourse within engineering education since, covers not only the subjects to be taught in engineering curricula, but teaching methods, research and experimental testing advances and perhaps most importantly, the skills that students assimilate through their immersion in engineering programmes. If reform of engineering education centres on teaching students new skills, it makes sense that Higher Education Institutions (HEI) have a key role to play in this reform effort. More recently there is an increased emphasis on the role of HEIs to prepare engineers for the workforce and several authoritative figures call for curricula redesign (Miller, 2015; Clarke, 2012; Seely, 2005; Vest, 2008; Trevelyan, 2019). Phrases such as "rebalancing engineering education", "reinventing the wheel" and "embracing transformational change" are all used in relation to curriculum reform (Miller, 2015; Clarke, 2012; Seely, 2005). In parallel with these calls, there have been several studies that have examined why attempts to reform engineering education are often unsuccessful, with reasons identified including a lack of faculty engagement and a lack of resources (RAE, 2012). The Royal Academy of Engineering (RAE) in their report advocating reform of engineering education notes: "The evidence in the engineering education literature suggests that successful educational reform is often associated with a combination of 'top-down and bottom up' change" (RAE, 2012, p.9).

It is important therefore to consider how an engineering education study can contribute to a balanced top down and a bottom up approach. In the first instance, top down approaches can come from governmental strategies, university policies and accreditation requirements and so providing insights which can assist in writing multi-layered policies is an important aspect. The bottom up approach emerges from academics themselves who start to change of their own accord. Understanding and connecting with academics is also recognised in the literature as a key component of enacting change within academic practice (Barrie, 2006; Borrego et al., 2010). As the overall purpose of this study is to provide outcomes to support educational reform with regard to professional skills, then it needs to deliver on contributions to initiate a top down and bottom up approach.

The rhetoric around reform of engineering education sets the context for this study, yet it is important to acknowledge attempts at reform through the introduction of new teaching pedagogies that are specifically designed to expose students to opportunities to learn by doing or emulating engineering practice. However, the student's experience within an engineering programme can be affected by many things: the ethos of the HEI, the curriculum, the opportunities for extracurricular activities, how the student engages and their initial motivation and confidence. The quality of the teaching can also be affected by class size, contact hours, lack of physical resources and the learning environment. However, these aspects are outside the scope of this study which focuses not on the student experience, but on the actions of the academic themselves. In particular, this study reveals their actions in the classroom in relation to teaching professional skills which are inherently linked to their conceptions of professional skills.

Accreditation requirements, programme reviews, industry reports and governmental policy changes can certainly influence **what is taught** in the classroom, but this study focusses on what is termed the **hidden curriculum** (Villanueva et al., 2018; Biggs & Tang, 2007; Trevelyan, 2019) or more specifically **how it is taught** by the academics in the classroom. The hidden curriculum can be defined as the "implicit attitudes, knowledge, and behaviours, which are conveyed or communicated without aware intent" (Alsubaie, 2015, p. 125). For example, if a lecturer makes light of a particular topic, the student may perceive that it is therefore unimportant and does not prioritise learning of that topic. The lecturer's actions whether performed consciously or not can affect the student learning experience and learning outcomes.

Following this assertion, previous work by Trigwell et al. (1999) shows a relation between teaching approaches and student learning. Therefore, if a lecturer values professional skills as important and this translates in their approach to teaching, it follows that the student would feel that this is an important aspect of teaching and therefore important to learn. If on the other hand, a lecturer does not value professional skills as important, the students may follow this lead and see professional skills as less important. Of course, this assertion raises several other questions. Professional Skills may mean one thing to one academic and something else to another: students or employers may consider them to be something else entirely. So how do we know that we are talking about the same thing? Furthermore, some academics, based on their conceptions of what professional skills are, may well value them as important or unimportant, and this may impact how they teach them, so finding out more about their approaches to teaching professional skills is important too. There are gaps in the engineering education literature around the understanding of what professional skills are from the views of different stakeholders and more specifically on the different approaches to teaching professional skills in an engineering programme. It is important to add scholarship in this area in order to build a knowledge base from which academics can better understand the differing (and more complete) ways of conceptualising professional skills and the differing (and more complete) approaches to teaching them. These findings can then be used in professional development programmes for academic staff. The National Forum for the Enhancement of Teaching and Learning in Higher Education in Ireland (National Forum, 2020) has recognised the importance of Continued Professional Development (CPD) for academic staff, offering funding for several projects related to curriculum design, teaching approaches and assessment practices. In particular, there are several ongoing projects which are focussed on engineering academics and include the creation of a professional development framework for engineering educators (Mac Mahon et al., 2018).

Rationale for this study - Professional Bodies and Industry Views

Whilst there is a gap in the literature with regard to understanding what professional skills are, there are many references in the literature to the lack of skills in engineering graduates. This highlights the importance of better understanding this phenomenon. The discourse about the lack of skills specifically, has been ongoing in professional bodies since 1955 (Grinter, 1955; Spinks et al., 2006; RAE, 2007; IET, 2016; ASEE, 2015). The seminal Henley Report (Spinks et al., 2006) commissioned by the Royal Academy of Engineering (RAE) specifically looked at the current and future needs of engineering graduates. They found that there were skills gaps (deficiencies) in the skills of engineering graduates available in the UK and that this had an effect on industry growth (Spinks et al., 2006). Of particular concern was a lack of ability of graduates to solve real world problems and the report encouraged HEIs to enhance curricula with opportunities for students to gain practical work experience. The Spinks report, despite being published over a decade ago has not ignited the educational reform that was intended, as there are still more recent calls from professional bodies on the lack of adequate skills in engineering graduates (IET, 2019; ICE, 2018).

Industry has a similar viewpoint to the professional bodies and several industry studies are also reported in the literature (Colman & Willmot, 2016; Kövesi & Csizmadia, 2016; Sageev & Romanowski, 2001; Husain et al., 2010; Nair et al., 2009; IOT, 2011). Employers recognise that the future is changing and as such the engineer's role is changing along with the skill set required. One industrial contributor points out that human skills will become even more important in the future as technology and automation start to replace previous engineering roles. Similarly, the role of the engineer is broadening from merely being a technical expert. Engineers will be required to undertake more management roles, and thus being able to work in a team and as an integrator becomes more important. It is perhaps surprising that industry finds these skills lacking, considering many of these are included in the accreditation processes as specific outcomes of engineering programmes (Engineers Ireland, 2014; ABET, 2019; Engineering Council, 2014). In Ireland specifically, the Institutes of Technology commissioned a study to look at the strengths and weaknesses of engineering programmes using feedback from employers (IOT, 2011). The report recommends that: "The teaching of key non-technical skills such as oral and written communication should be enhanced and further integrated into the earlier years of the engineering programmes" (IOT, 2011, p.8).

This rhetoric is not limited to the UK or Ireland. In 2013, the American Society for Engineering Education (ASEE) began a consultation process to develop a new strategy for engineering education to meet industry's needs. The purpose was to identify competencies, skills and qualities required of future graduates. The outcome was a T-shaped engineering graduate, with a broad knowledge base and ability to work within a diverse team, in addition to deep technical expertise in a particular area (ASEE, 2015). IfM and IBM (2008, p.19) define T-shaped professionals as "those who are deep problem solvers with expert thinking skills in their home discipline but also have complex communication skills to interact with specialists from a wide range of disciplines and functional areas".

Whilst the ASEE (2015) report confirmed that engineering fundamentals were still a priority, communication skills, motivation, business acumen and curious learning capacity, ethical standards, critical thinking, risk assessment and persistence were also all identified as necessary skills for the future engineer.

If the aim is to identify a "list of skills requirements" needed for graduate engineers, it is justifiable perhaps to first consider employers' views alone and many of the studies reported do just that (Colman & Willmot, 2016; Kövesi & Csizmadia, 2016; Sageev & Romanowski, 2001; IET, 2016; Husain et al., 2010; Nair et al., 2009). These studies also suggest that the views of employers are the most important consideration and it is assumed that HEIs will take those lists and implement those skills within engineering courses. The concern here of course is that successful implementation is unlikely if this is just a high level policy statement: it will require buy-in from academics (RAE, 2012). Nguyen (1998) attempted to ascertain the varying views of academics, industry and students on what the essential attributes of an engineer were, in terms of generic and specialist skills. The results of approximately 1,000 survey respondents provided an interesting insight to the different values that students, academics and industry placed on different attributes. For instance, industry and academics ranked communication skills relatively highly, but students did not, indicating there may have been a failure of academics to instil the importance of communication skills within the classroom environment. This highlights the immense influences that academics can have in the learning process and provides justification for studying academics in particular.

Graduates themselves were also interviewed in a survey involving over 700 mechanical engineering MIT graduates 10 years after starting work (Wolfe, 2004). The results showed that whilst graduates felt they had extensive technical skills, they found much less use for technical skills than professional skills, which they had to learn on the job. This outcome would suggest therefore, that although there are processes in place (accreditations, employers' feedback etc) which should ensure that students have opportunities to develop these skills, that there is a disparity between what is achieved in the curriculum and what should be achieved. This disparity requires additional research to help explain how and why this disparity occurs, whether it is related to the academics approaches to teaching in the classroom or the hidden curriculum (Villanueva et al., 2018).

Looking to the future: The Grand Challenges and the SDGs.

The skills gap in today's engineers has been acknowledged yet there is no consensus on which skills are important. The framework of the Engineering Grand Challenges and the Sustainable Development Goals (SDGs) provides an opportunity to consider the skills needed of tomorrow's engineers (NAE, 2008; UN, 2015). They also permit reflection on how the curriculum and teaching methods employed today prepare engineers for a successful career once the required skills have been determined. The ASEE (2015) compared visions of the future through various engineering professional organisations. They concluded that the organisations had similar visions of the engineer needed for the future, one with greater technical speciality and broader communication and policy skills: again, a need for more technical and non-technical skills.

The Engineering Grand Challenges and the SDGs provide a snapshot of the future and the environmental, social and economic concerns that have been raised. In the past, engineers have been accused of being technologically focussed without reference to the needs of society: forgetting the human dimension within the problem (Miller, 2015). He notes that whilst many of the previous engineering achievements did dramatically change society for the better, there were unintended consequences which were not examined in the narrow focus of the original invention. For example, the invention of the automobile has contributed to CO_2 emissions and global warming; nuclear technology can be used for good or evil and the creation of the internet has opened up opportunities for criminal activity in cyberspace. The issues of sustainability, values and ethics are highlighted here as those which engineers need to consider in their day to day work life (Miller, 2015).

Whose responsibility is it?

So the gap still exists: but whose responsibility is it to address this issue? Is it solely the responsibility of the HEI to fill this gap, or are some employers unrealistic in their expectations? There is growing recognition that the responsibility to develop these skills does not only lie with the HEI (ASEE, 2015; IET, 2016; Spinks et al., 2006). A recent review of UK engineering companies (400 employers) undertaken by the

Institution of Engineering and Technology (IET) still highlights a skills gap and attests that graduates are not work ready (IET, 2016).

Mr Glenn Bell, CEO of a large engineering consultancy in the US, in an article in Structure Magazine, attests that part of the problem lies with industry leaders as they give mixed messages to academia (Bell, 2012). On one hand, he argues:

> Employers espouse the virtues of a solid grounding in technical fundamentals and soft skills; on the other, we send recruiters to university job fairs and seek out practice-ready professionals with knowledge of the latest versions of codes and analysis software (Bell, 2012, p.50).

In his view, employers expect too much of the academic curriculum and employers must recognise their role in providing on the job training and life-long learning (Bell, 2012). Reed (2010) presents similar findings in a study on the skill sets for Environmental Engineers and where they are learned. She proposes that whilst technical skills are learned over time, through on the job application: "professional skills are developed through a combination of formal training and experiential learning from work, or through like experiences" (Reed, 2010, p. vii). Trevelyan (2019) also highlights the dissonance between HEIs and employers. He argues that on one side, government and industry advocate for universities to "produce or train job ready graduates" that can start to be productive employees straight away with "the least possible investment in training by employers". On the other side, he attests that academics consider universities to be a place where students are educated for life, a place for developing intellectual ideas and hence workplace competencies "are better learned in workplaces" (Trevelyan, 2019, p.824).

Regardless of differing views on where the responsibility lies, it is clear that the HEI (and therefore individual academics) have a role to play by exposing students to opportunities to develop the relevant skills. However, some authors query the ability of academics to teach professional skills (Miller, 2015; Pons, 2016). Some believe that industrial experience is a key factor in providing an academic with experience to teach professional skills. Gordon (2007, p.29) argues that recruiting policies and career advancement is swayed towards research and not "actual accomplishment" in the real world and furthermore, most disparagingly "Those who can, do, and those who can't teach" (Gordon, 2007, p.29). The outcome of the ASEE (2015) report also aligns with Rugarcia's view on the disjoint between faculty reward structures and the emphasis on teaching. They ask, "Who will teach engineering practice in the coming years as the number of engineering professors with industrial experience continues to shrink?" and "Can engineering education survive without such individuals?" (Rugarcia et al., 2000, p.14).

Furthermore, Miller (2015) attests that many engineering academics are not trained to teach professional skills. He proposes that teaching professional skills is more complex and nuanced than teaching technical skills which can easily be defined and measured, a view shared by Pons (2016). Industrial experience may be lauded as a necessary background for academics to teach professional skills, however, what we mean by professional skills is a question not yet answered in the literature.

Context - the researcher

At this point, it may be useful to explain my own background and how I came to undertake this study. I am a relative newcomer to engineering academia and in my previous career as a consulting engineer, I held management roles in several engineering consultancies. I became a full-time assistant lecturer in TU Dublin in 2013 and naively perhaps, I felt that I had an opportunity to bring my own experiences to the engineering programme and help students develop those professional skills that I valued as important. Whilst I made some changes within the modules for which I was responsible, such as the introduction of Problem Based Learning (PBL), I came to understand that reform in an academic institution takes much longer to achieve than the rate of change I was used to in industry. I also led a programmatic review and I realised that trying to implement change, requires not only a review of the content of a module or engineering programme, but is much more dependent on persuading the academics involved on the value of making the proposed change. It was this experience that led me to appreciate the value in better understanding academics themselves.

My experience within the programmatic review also highlighted the different conceptions and value that academics place on different aspects of the curriculum. I realised that I had different conceptions and values to other academics. It was this tension that led me to this research study and encouraged me to focus on engineering academics themselves. I realised that in order to convince academics of the value in reforming engineering education, I had first better understand academics themselves.

1.2 Aims and Objectives of the Research

This research study focusses on Professional Skills in particular and the literature presented clearly highlights the need for reform in engineering education to better develop professional skills in students. However, before we can start to advise on policies or teaching initiatives which can be used to enhance these skills, it is essential that we first understand how academics conceive of what is meant by Professional

Skills. This is a gap in the current literature yet is a fundamental prerequisite for supporting reform in academic practice.

In addition, it is crucial that we draw out the different ways in which academics teach Professional Skills, not only as a mapping exercise from a literature review, nor what might be achieved in a survey, but a much deeper analysis of how and why academics teach Professional Skills in differing ways. More specifically; what influences their approach, what is their intention and why do they teach in a specific manner? This study will critically analyse and discuss in some depth the issues around how academics conceptualise and teach professional skills. It will go far beyond mere description to allow for a depth of understanding, providing academic colleagues' unique lived experiences to be recorded and analysed.

Figure 1-2 shows the motivation for the focus of the study and the intention that in the longer term, through academics coming to know better ways of teaching professional skills, that there will be a ripple effect which can be used to enhance the engineering profession. Engineering students with improved professional skills will go on to become engineering graduates and eventual industry leaders. This enhanced skillset will enable the engineering profession to work more efficiently and to develop more socially sustainable projects which can have an impact on society as a whole.

The importance of focussing directly on academics (the key change agents) cannot be underestimated, as attempts at reform are unlikely to be successful if they do not correlate with the understanding of the academics to whom they are directed (Barrie, 2006). Hence, I attest that gaining a deep understanding of academics' Conceptions of Professional Skills and their Approaches to Teaching Professional Skills is a fundamental basis for supporting reform in engineering education.

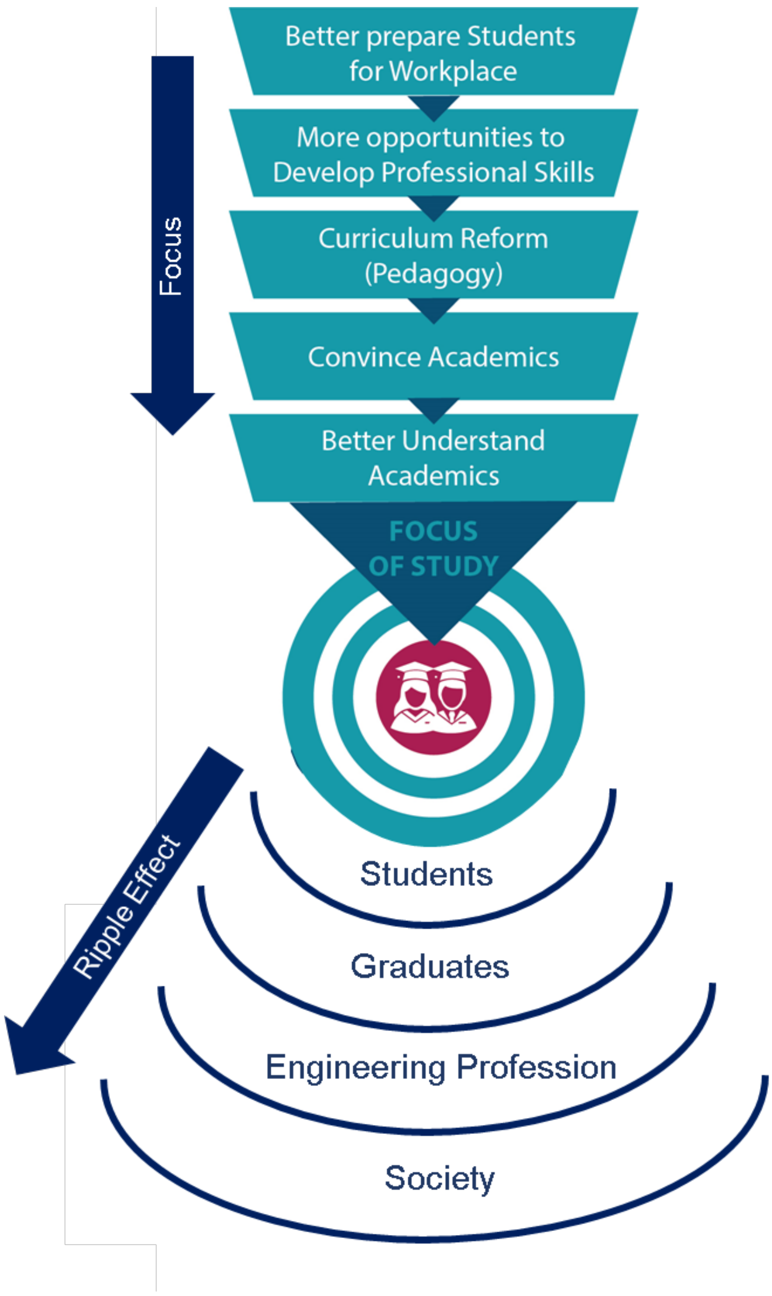

Figure 1-2. Approach to determining the focus of this study

The decision to focus on academics themselves and the intended use for the outputs of the study, led to an overall aim to better understand engineering academics' conceptions and approaches to teaching professional skills on engineering programmes in Ireland. Specifically, there are three objectives of this research study:

They are:

- To understand how academics teaching on engineering programmes in Ireland conceptualise the term **Professional Skills**.
- To examine the different ways in which academics teach **Professional Skills** in engineering programmes in Ireland.
- To investigate if there is a relationship between how academics teach Professional Skills and their Conception of Professional Skills.

The first aim of the study, to better understand academics' Conceptions of Professional Skills includes questions such as:

- What do academics think professional skills actually are?
- What is included in their (definitions leading to) conceptions and what is not?
- Are they important/not important for engineers?
- Why are they important/not important?
- What has influenced their conceptions?
- Where do they think engineers learn those skills?
- How do they believe they developed their professional skills?

This study will critically analyse and outline in some depth the issues which influence how academics conceptualise and teach professional skills. In order to gain this deep understanding, I will examine the academic's experiences and draw findings from their descriptions of those experiences. The outcomes will present more than a mere description and will show detailed aspects of the structure of the conceptions or approaches to allow for a greater depth of understanding.

1.3 Outcomes of the study

The outcomes of this study aim to add important scholarship to support the reform of engineering education. If the aim is to change the way academics approach teaching professional skills, or even how they integrate it into the curriculum, first, it is important to understand what they currently do and think, and why. Without this knowledge, it is not possible to develop effective strategies to change. This is a principle of the constructivist learning theory, that people build new knowledge based on previous knowledge hence, it is critical to first investigate their current understanding of a particular phenomenon that we wish to change.

Kember and Kwan (2002) propose that recommendations for change to approaches to teaching will only come about if they are consistent with the associated conception of teaching. This makes the case that it is important therefore not only to educate academics about the different approaches to teaching professional skills but also to educate them in the more complete conceptions of what professional skills are. Fundamental changes to how academics approach teaching professional skills many only result from changes to their conceptions of professional skills.

The outcomes of this research therefore aim to add a deeper understanding of the phenomenon of Professional Skills and to support reform of engineering education in two ways.

First, by better understanding how Professional Skills are conceptualised by academics, HEI or accreditation policies which aim to encourage education reform can be written in a multi-layered way. In this way, they will be of more relevance (and thus more likely to be enacted) by academics with differing conceptions and with differing teaching approaches (Barrie, 2006).

Second, providing an outcome which shows that there are different conceptions of and approaches to teaching professional skills can be used as a resource to enable academics to reflect on their own understanding and teaching practice. It is expected that such a resource which shows a wider range of approaches to teaching can provide inspiration to academics in ways in which they can incorporate alternative (and perhaps better) teaching approaches in the classroom.

The insights from the research outcomes can help in planning learning experiences within the classroom, in informing policy development and finally, in helping us better understand how we can achieve engineering education reform through the actions of academic themselves.

1.4 Outline of thesis

This chapter provided the context for the research in relation to the call for reform of engineering education to better prepare engineers to solve the challenges of the future. It advocated that academics play a key role in supporting the reform effort through their actions in the classroom and provided the justification for making academics the focus of the study. The aims of the research were highlighted to show how the outcomes could add to the scholarship informing engineering education reform, both from a top-down and bottom-up approach.

Chapter 2 presents the literature review which supports the research study by identifying the gap in scholarship in relation to academics' conceptions of and approaches to teaching professional skills in engineering programmes. It concludes with a summary of some educational theories which serve as a background to learning and teaching approaches and highlights some specific studies which are relevant to this research work.

The research design for the study is presented in Chapter Three. Phenomenography as a research methodology is proposed as the most appropriate strategy of inquiry to answer the research questions and the theoretical and methodological assumptions associated with this tradition are presented along with the epistemological and ontological assumptions brought to this study. Each stage of the research design is outlined in this chapter.

Chapter Four is the first of two results chapters. It begins by describing how the interviews were analysed: the steps taken to identify, extract and present the relevant quotations which informed the outcome for each research question. The chapter then describes in detail each Conception of Professional Skills revealed. It concludes with the results being presented both in tabular and pictorial form to highlight the relationships between each Conception of Professional Skills.

Chapter Five presents the outcomes for Approaches to Teaching Professional Skills and describes each approach in detail. The chapter also presents the results in tabular and pictorial form to show relationships between each approach. It concludes with a discussion on the approaches to teaching revealed in this study in comparison to existing literature.

All the findings of the study are compared in Chapter Six which also includes a discussion on the relationship between Conceptions of and Approaches to Teaching Professional Skills. It concludes the thesis with a discussion of the new scholarship offered by the study and recommendations for further work in this area.

CHAPTER TWO – Literature Review

This study aims to advance knowledge in two key areas of engineering education scholarship and thus the literature review is presented in two main parts: Professional Skills and Learning and Teaching.

The first part begins by presenting literature and studies in relation to professional skills in engineering education and studies of relevance external to the engineering education field. More specifically the literature considers stakeholder views on why professional skills are important and proposes that academics are a key driver to enhance skills within the engineering curriculum. Studies which have attempted to list and prioritise which skills are important are discussed to highlight the lack of consensus on the meaning of this term.

The second part of the literature review focuses on learning and teaching. It begins by summarising relevant learning theories which have informed teaching approaches through the lenses of behaviourism, constructivism and humanism. Focus then turns to two areas of research and scholarship in particular: Experiential Learning Theory and Approaches to Teaching. These areas are of particular interest as they can be compared to the approaches to teaching Professional Skills revealed in this study, to ascertain if there are particular aspects of each theory which are revealed in the findings within this study. The literature review concludes by referencing Bloom's Taxonomy Affective Domain which also provides a basis for discussion of the study outcomes.

2.1 Professional Skills

Previous studies on specific skill requirements

Despite not wishing to simply create a definition for what professional skills are, this literature review would not be complete without acknowledging the previous studies which have focused on specific professional skills and their importance. These typically fall into two categories.

The first includes systematic literature reviews or meta-analyses which were carried out to identify the most important skills that engineers need. Markes (2006) carried out a literature review on employability skills in engineering which highlighted the different skills considered important to employers. Rather than clarifying the required skill set for engineering, Markes reports that the extent of literature published merely confused the definition and the outcome of the work concluded that further research is required to define “graduate skills for employability” (Markes, 2006, p.648). Similarly, Passow and Passow (2017) aimed to provide a comprehensive list of generic engineering competencies along with their relative importance. Four categories of competencies were identified: apply technical foundations, collaborate with others, engineer within constraints and manage own performance. However they report that the variation in understanding of the terms which were used proved troublesome in the review.

Other studies provide lists of predetermined skills in survey form to ascertain which are most important. These include surveys distributed to engineers working in the field (Male et al., 2011; Passow, 2012; Le & Tam, 2008) and to employers (Husain et al., 2010; Kovesi & Csizmadia, 2016; Colman & Willmot, 2016; Nair et al., 2009).

There are a multitude of skills lists, some of which use similar terminology for different meanings.

Towards a better understanding of Professional Skills

Many terms are used to describe the list of skills that engineering graduates should have upon graduation. These include: graduate attributes, soft skills, employability skills, key skills, transferable skills, generic competencies, generic skills, professional skills, non-technical skills and transversal skills (Barrie, 2007; Pons, 2016; Litchfield et al., 2016; Shuman et al., 2005; Male et al., 2011; Winberg et al., 2018; Iborra et al., 2014; Fernandes, 2014; Dacre Pool & Sewell, 2007; Markes, 2006; Husain et al., 2010; Iqhal Khan et al., 2014; Craps et al., 2017). These examples demonstrate a lack of consistency in terminology and interpretation conceptually, yet are often used interchangeably in the literature.

Some authors use a combination of terms such as the subset of knowledge, skills and attributes used in the ASEE large scale study entitled: "Transforming Undergraduate Engineering Education" (ASEE, 2015). Other authors use the term professional skills to mean teamwork, motivation and communication (Van Petegem et al., 2016); communication, teamwork, project management, leadership and self-awareness (Gilbuena et al., 2015) or often include "people skills: that represent attitudes, behaviors, skills, and motivations and not just knowledge" (Miller, 2015, p.6).

For clarity, the term **Professional Skills** is used in this study.

The National Science Foundation funded a project to develop a taxonomy of keywords for engineering education research (Finelli et al., 2016). The taxonomy has 454 terms arranged in 14 branches under 6 levels which was validated by undertaking a keyword analysis of engineering education articles. Attention is drawn to Branch 8 which relates to Outcomes and which is reproduced in Figure 2-1.

This taxonomy proposes that Professional Skills is given an equal hierarchal level to outcomes such as: Communication, Critical Thinking, Ethics and Teamwork for example. The hierarchy suggests that Professional Skills do not therefore include these aspects, but is something different, something synonymous with soft skills.

8. Outcomes

- 8.a. Communication
  - 8.a.i. Audiences
  - 8.a.ii. Communication skills
    1. Nonverbal
    2. Verbal
       - a. Listening
       - b. Oral presentations
       - c. Speaking
    3. Visual communication
       - a. Engineering graphics
       - b. Illustrations
    4. Visualization [syn: Spatial skills]
    5. Written communication
       - a. Argumentation
       - b. Reading
       - c. Writing
  - 8.a.iii. Foreign languages
  - 8.a.iv. Technical communication
- 8.b. Competence
- 8.c. Computing skills [syn: Computing knowledge]
- 8.d. Creativity
- 8.e. Critical thinking
- 8.f. Engagement
- 8.g. Engineering standards
- 8.h. Entrepreneurship
- 8.i. Ethics
  - 8.i.i. Academic dishonesty [syn: Academic integrity
    1. Plagiarism
  - 8.i.ii. Social justice
  - 8.i.iii. Social responsibility
- 8.j. Information literacy [syn: Information fluency]
- 8.k. Innovation
- 8.l. Intercultural competence [syn: Global]
  - 8.l.i. Cultural schemas
- 8.m. Leadership
- 8.n. Lifelong learning
- 8.o. Problem solving
- 8.p. Professional skills [syn: Soft skills]
- 8.q. Scientific literacy
- 8.r. Student perception
- 8.s. Student experience
- 8.t. Teamwork [syn: Team skills]
- 8.u. Reflection
  - 8.u.i. Critical reflection
- 8.v. Systems thinking

Figure 2-1: Hierarchal content of Branch 8 of the EER Taxonomy project, relating to outcomes, (Finelli et al., 2016).

One of the most influential publications in relation to professional skills are those listed as outcomes in the ABET engineering criteria (ABET, 2019). There are six outcomes which are commonly termed Professional Skills (Miller, 2015; Mutalib et al., 2013) and Shuman et al., (2005, p.41).

They include:

- an ability to function on multidisciplinary teams
- an understanding of professional and ethical responsibility

- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context
- a recognition of the need for, and an ability to engage in lifelong learning
- a knowledge of contemporary issues

This list is also at odds with the EER taxonomy in relation to the hierarchal position of lifelong learning, communication, ethical responsibility and teamwork.

This thesis does not attempt to synthesise all the skills, explain the differences between the terms used nor produce a definitive list of skills as that is not the focus of this study. However, this summary is produced to highlight that all these studies focus on which skills are important and they give a background on how Professional Skills are currently defined in the literature. Yet, none have attempted to reveal the fundamental understanding of how academics conceive of the term Professional Skills; what they actually are, what is included and what is not, how important they are, where engineers learn those skills and so on. This question is one of those to be answered in this study and it is crucial that we understand the foundation of what academics conceptualise of Professional Skills before we can successfully attempt to improve how Professional Skills are taught.

Previous studies on Conceptions of Professional Skills

It is important to state at this point a differentiation between Professional Skills and Professionalism. There have been several studies which relate to the concept of professions and professionalism which date back to the seminal study on professions by Carr-Saunders and Wilson (1933) and Cogan (1955). These papers attempt to describe what constitutes a profession in a socially constructed sense. More recently, the concept of professionalism within engineering education has also been discussed (Johansson & Ohlsson, 1993; Wang et al., 2005), however, "professionalism" is not the focus of this study, but rather the skills needed to be a professional engineer, what is termed Professional Skills.

Focussing on previous research studies in relation to the concept of Professional Skills, it is worthy to note that there are no studies within an Irish context which describe how Irish academics conceive of this term. Furthermore, there was only one study (Gilbuena et al., 2015) related to investigating the term Professional Skills in an engineering context, with the aim of providing a list of skills. However, it is also important to show that the gap in knowledge is worthy of being filled and hence there are several studies presented which provide evidence of the interest in this topic (Barrie, 2007; Gilbuena et al., 2015)

Gilbuena et al., (2015) undertook an ethnographic study within an engineering context which involved discourse analysis of teacher-student interactions in a capstone project as the teacher (whose role was that of a coach) gave feedback to the students. One of the research questions focussed on "What types of professional skills are addressed?" in an effort to define Professional Skills. The analysis of the audio recordings of coaching sessions revealed five types of professional skills categories; communication, experimental documentation, teamwork, economic impact of engineering solutions and project management (Gilbuena et al., 2015). The authors accept that the professional skills identified were only a subset of those found in the literature and were contextually bound but can be commended on their observational and qualitative approach. The researchers observe three implications for their research one of which is that "research is needed to provide an understanding of what professional skills entail" and should identify the knowledge and understanding that engineering educators have of professional skills (Gilbuena et al., 2015, p.29).

Moving away from engineering education literature specifically, Barrie (2007) sought to investigate the term "Generic Graduate Attributes". Whilst Barrie's study focussed on Generic Graduate Attributes, as opposed to Professional Skills and is not within engineering education, the results are still worthy of note and comparison with this study. His phenomenographic study was carried out amongst multiple disciplines in various universities in Australia. The work concluded that not only did academics have a variety of conceptions of the term graduate attributes but that they had differing understandings of how these attributes were taught and learned. Barrie (2007) produced an outcome which shows relations between academic conceptions of what generic graduate attributes are and how generic graduate attributes were developed, an example of relational phenomenography. Four hierarchal conceptions of generic graduate attributes were identified as;

- **Precursor Conception** (necessary basic precursor skills but irrelevant as they are a prerequisite for university entry)
- **Complement Conception** (Useful skills that complement/round out disciplinary learning)
- **Translation Conception** (These are the abilities that let students translate, make use of or apply disciplinary knowledge in the world)
- **Enabling Conception** (They are enabling abilities that infuse university learning and knowledge)

(Barrie, 2007, p.441)

Six Categories of Description were identified as to how students develop these attributes:

- Remedial: **Not** usually part of university teaching
- Associated: Generic attributes are **taught as a discrete subset** of the teaching in university courses
- Teaching Content: Generic attributes are **taught in the context of** the teaching of disciplinary knowledge
- Teaching Process: Generic attributes are **taught through the way** the course disciplinary knowledge is taught
- Engagement: Generic attributes are **learnt** through the way students **engage** with the **course's learning experiences**
- Participatory: Generic attributes are **learnt** by the way students **participate** and engage with all the **experiences of university life.**

(Barrie, 2007, p.445)

The conceptions identified above were taken from the range of transcripts that were collected from the interviewees. These results in themselves provide a unique understanding of the different conceptions that academics have in relation to generic graduate attributes. However, Barrie (2007) then reviewed the transcripts again, this time to identify relationships between both categories in each interviewee transcript. For example, how did an interviewee with a Translational Conception of what generic graduate attributes were, conceive of how students were meant to develop those attributes? This work enabled him to present outcomes showing the different approaches to teaching generic graduate attributes.

The different approaches to teaching generic graduate attributes were:

- Approach I: Additive outcomes taught in a teacher-focused way in a supplementary curriculum.

- Approach II: Transformative outcomes taught in a teacher-focused in an integrated curriculum.

- Approach III: Transformative outcomes taught in a learner focused way in an integrated curriculum.

(Barrie, 2007, p.453).

The outcome of Barrie's work allows academics to identify and then reflect on their own conceptions of generic graduate attributes and to see other (perhaps better) ways of conceptualising what they are and other (perhaps better) ways of teaching them. The aim of this PhD study is comparative yet is focusing specifically on Professional Skills and in an Irish engineering education context.

The literature review was conducted by searching a range of academic data bases (Science Direct, Academic Search Complete, ERIC, Australian Education Index and EBSCO Host) using search terms such as Professional Skills, Graduate Attributes, Employability Skills and Soft Skills. As such, this part of the literature review has highlighted the dearth of research which has been undertaken to better understand what is meant by Professional Skills, particularly in an engineering context. This highlights a gap in the literature relating to the Conceptions of Professional Skills.

This section finishes with literature to show why it is important to fill this gap in knowledge. Seely (2005) attests that motivation for reform generally comes from issues which people consider are important. It holds therefore that in order to influence an academic to change, the initiative for change must align with the academic's own view of what is important or what they find relevant. That view is acknowledged by better understanding their conception of a particular issue. Barrie (2006, p.219) argues that system wide implementation of initiatives are not successful if they do not reflect individual's understandings, "even if there are shared common features to these understandings". Gilbuena et al. (2015) supports the effort to gain more insight into what professional skills means to engineering educators in the implications of her study for future research work:

> Research is needed to provide an understanding of what professional skills entail. Research could help identify the facets of the professional skills discussed here, as well as other professional skills that were not explicitly elicited in this context. Research should identify as Allie et al. (2009) describe the "tacit knowledge and understandings" engineering instructors have of professional skills in their respective discipline (p.29).

Furthermore, the literature review did not reveal any studies in an Irish context. In order to provide evidence to assist in policy development or accreditation (or simply programmatic review on a local basis), it is important to consider the views, values and beliefs of academics teaching in Ireland where the political and social climate can colour their views on the conceptions of and therefore value of professional skills. This study aims to do just that.

2.2 Learning and Teaching

The literature review turns now to focus on literature relating to learning and teaching. It begins by outlining some learning theories and relevant studies which have influenced teaching practice and then summarises previous work on Approaches to Teaching.

Learning Theories

This section of the literature review summarises some of the educational theories which are relevant to how academics teach, highlighting specific theorists of interest. Three learning theory categories are described as an introduction; behaviourism, constructivism and humanism (Aubrey & Riley, 2018). Behaviourist theories assume that behaviour can be predicted, measured and controlled and learning is simply a matter of stimulus and response (Wallace, 2008). Key behaviourists include; Watson, Pavlov and Skinner (Aubrey & Riley, 2018).

Constructivism can be described as a theory in which it is considered that knowledge and understanding is actively constructed by learners and cannot be learned just by listening passively to a teacher. Constructivism assumes that students build on previous knowledge and expand and change their conceptions when they learn more. The analogy of a jigsaw is often used to describe constructivism: where new pieces of information are added to an existing knowledge bank and a new picture begins to emerge. Cognitive constructivism refers to theories which concentrate on the internal processes within the brain, theories advocated by Dewey, Piaget and Bruner. Social constructivism reflects the influence of the outside world on the learning process and Vgotsky, Freire and Bandura added to scholarship in this field. (Aubrey & Riley, 2018). Dewey advocated that students learned by active experimentation and social interaction: that they learned through experiences (Apple & Tietelbaum, 2001). Situated in social constructivism, Vygotsky also argued that the child builds knowledge through social and cultural interaction in their environment and with others. Vygotsky also coined the term Zone of Proximal Development (ZPD), (Scott, 2008; Bates, 2019). It is described as “the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky, 1978, p.86). Vygotsky was more interested in the potential of what a child could do with assistance rather than what they could do on their own. The term “scaffolding” has emerged as a way of a teacher supporting the child’s learning to solve problems beyond their competence so that upon success, they are then confident to attempt tasks on their own (Bates, 2019). Scott (2008, p. 87) describes scaffolding as “a form of guidance in which the novice engages with the expert to solve a problem or carry out a task. The zone of proximal development refers to the gap between the novice and the expert and scaffolding is used as a way to bridge the gap”.

Social learning theory (later renamed as social cognitive theory) is a theory that people learn and repeat behaviours that they have observed (Bandura, 1999). Whilst Bandura agrees with the concepts of behaviourism he considers that people do not only act in a certain way as a result of reward or punishment. He argues there are two additional factors; that behaviour can be learned through observing the environment and that a mediation process occurs between stimuli and response (McLeod, 2016).

Humanism centres around the individual and is based on the belief that the learner is free to make their own choices and in doing so they are more likely to learn if the subject matter is directly relevant to their own life. In humanism, the instructor acts as a facilitator, directing the learner, rather than specifically teaching concepts or giving instruction (Bates, 2019). Contributors to this learning theory include Knowles, Montessori, Rogers and Maslow (Aubrey & Riley, 2018). Similar to Dewey's ideas on self-directed learning and the role of the teacher as a facilitator, Knowles recognised this as a key element for adult education for "helping adults to learn", not by transmitting fact and figures, but by guiding the learner. This view is shared by Carl Rogers, who attests that "we cannot teach another person directly; we can only facilitate his learning" (Rogers, 1951, p.389). In fact, Rogers also proposed that learners learn by experience, through building relationships and in Knowles' opinion the best educational experiences are enclosed within a co-operative learning climate with guided interactions between the teacher and learners (Knowles, 1980; Blondy, 2007).

The different learning theories discussed offer alternative ways to consider how academics conceive of the learning process and hence how that is enacted in their actions in the classroom. To that end, they provide a basis for discussion of the approaches to teaching professional skills which form an output from this study.

The final part of this section of the literature review highlights some studies which set the scene for learning. They have influenced how people learn and how educators teach and hence are presented here as relevant to this thesis.

Experiential Learning Theory

David Kolb is American psychologist and educational theorist known for Experiential Learning Theory (ELT): a theory that proposes that there are methods whereby experiences can be turned into knowledge. He describes learning as "the process whereby knowledge is created through the transformation of experience" (Kolb, 1984, p.38). Piaget's concept that learners construct knowledge through interaction with the environment, and then use that to reshape and reform their knowledge for a new situation, also aligns with the idea of the cycle of ongoing learning (Aubrey & Riley, 2018). Kolb's theories differ from some of the educational theorists described earlier because he concentrates not on the learning processes of the child, but the adult and focusses on workplace scenarios, rather than the classroom. His work is presented here as being specifically applicable to engineering education and professional skills, as in the main, engineering education refers to adults and the aim is to prepare them for the workplace.

Kolb created a model of the learning cycle which presents a more holistic approach than just that of behaviourism (Pavlov and Skinner) or cognitive theories (Dewey, Piaget, Bruner or Vygotsky) or in fact just on the importance of reflection (Rogers). His theory supposes that people learn best when they are engaged in first hand experiences and have the opportunity to reflect on that experience in order to inform the future. His work also builds on the concept of action research and the importance of considering feelings and emotions in the reflective process (Lewin, 1948, as cited in Dennick, 2015). Kolb has more recently created an Educator Role Framework to assist lecturers in what he terms a "dynamic matching model" of teaching. Educators can complete an inventory online to identify their own teaching role preferences and skills, which helps them reflect upon how they teach. The framework describes four educator roles which are summarised as:

- **The Facilitator role:** When facilitating, educators help learners get in touch with their personal experience and reflect on it. They create personal and trusting relationships with learners.

- **The Subject Expert role:** In their role as subject expert, educators help learners organise and connect their reflections to the knowledge base of the subject matter. This knowledge is often communicated through lectures and texts.
- **The Standard-Setter/Evaluator role:** As a standard-setter and evaluator, educators help learners master the application of knowledge and skill in order to meet performance requirements. They create performance activities for learners to evaluate their learning.
- **The Coaching role:** In the coaching role, educators help learners apply knowledge to achieve their goals. They assist in the creation of personal development plans and provide ways of getting feedback on performance.

(Kolb and Kolb, 2018, p.13).

Kolb's learning cycle has received some criticism, namely that is its too simple to include the influence of the social and interaction or the impact of emotions (Illeris, 2018) and highlights the importance of educators being aware of this aspect of cognition in students. The role of the educator as highlighted in Kolb's Educator Role Profile advocates that the lecturer must firstly become aware of the different roles available before they can introduce them to the classroom at appropriate times, depending on the context. So far, the literature review has summarised some theories of learning and teaching: next it focusses on practical application in the classroom, academics' approaches to teaching.

Some view that engineering academics are not best placed to teach professional skills, since they were hired for technical expertise and not their professional skills (Miller, 2015; Pons, 2016). However, there is evidence to show that many innovative educators are redesigning their curricula and using alternative teaching approaches to expose students to opportunities to practice these important skills. A wide range of teaching approaches are used including that of an experience-led curriculum (RAE, 2010). This includes closer collaboration with practitioners, to bring real-life situations to student projects, work experience and industrial simulation. This reflects the apprenticeship system of the British training model and the idea that students learn by practicing. The benefits of using current students who have already gained experience in industry to mentor other students is also discussed in Davies and Rutherford (2012) whilst the benefits which can be gained from extracurricular activities such as being an Engineering Ambassador is presented in Anagnos et al., (2014).

Problem or Project based learning is also proposed in a significant number of studies (Fernandes, 2014; Musa et al., 2011; Gavin, 2011; Ahern, 2010; Savin-Baden, 2000; Jollands et al., 2012; Warnock & Mohammadi-Aragh, 2016) as is case-based teaching (Newson and Delatte, 2011) and the Conceive-Design-Implement-Operate (CDIO) initiative is gaining traction (Crawley et al., 2011; Larsen et al; 2017; Andersson & Andersson, 2010). It is lauded as a way to combine both the technical fundamentals and the teamwork skills required of an engineer. "Graduating engineers should be able to conceive-design-implement-operate complex value-added engineering systems in a modern team-based environment" is the key premise of the CDIO Syllabus (Crawley et al., 2011, p.2).

In 2012, the National Academy of Engineering (NAE) commissioned a report to provide exemplars of engineering programmes that have implemented Real World Experiences within their programmes (NAE, 2012). The activities range from good examples of capstone programmes, co-op experiences and service learning through to curricular and ex-curricular programmes. It appears therefore, that whilst there are specific examples of individual initiatives within engineering educational literature, there has not been any research at a higher level about the ways to (or approaches to) teaching professional skills in engineering programmes. The next section describes a study (and survey instrument) which relates to Approaches to Teaching in a general context but not specifically Professional Skills (Trigwell & Prosser, 2004).

Studies on Approaches to Teaching

Initially it is important to define some terms in relation to the Trigwell and Prosser studies (Trigwell & Prosser, 1994; 1996; 1999). **Conceptions of Teaching** can be defined as the beliefs that teachers have about teaching; what they consider its purpose. **Approaches to Teaching** describe the strategies that teachers adopt in the classroom: how they actually teach (Postareff & Lindblom-Ylänne, 2008). In addition to the learning theories presented to date, early research into learning and teaching focused on approaches to teaching: (Trigwell & Prosser, 1996) and the importance of constructive alignment (Biggs & Tang, 2007). These research studies took a first-order approach, that of the perspective of an observer.

Marton and Saljo (1976) and Biggs' (1993) work concentrated on student learning. Relations between how students approached their learning and the resulting learning outcomes were found. The terms surface and deep learning were identified by Marton and Saljo (1984) from a phenomenographic study as two qualitatively different approaches to students' learning. Further studies in different contexts confirmed this finding (Biggs 1978; Entwistle & Ramsden, 1983). Furthermore, higher quality learning outcomes were consistently linked to those students who undertook a deep approach to learning (Marton & Saljo, 1997; Trigwell & Prosser, 1991; Ramsden, 1992). The approach to learning was composed of two components: a strategy (what the student does) and an intention (what the student is trying to achieve), both of which merited consideration.

Approaches to Teaching

Trigwell, Prosser and Waterhouse (1999) also used this finding in a different context, considering it from a lecturer's viewpoint. If students' approaches to learning were affected by both intention and strategy, then could a lecturer's approach to teaching also be influenced by both factors? Their research investigated the links between teacher intention and strategy and between the teachers approach to teaching and the students' approach to learning within that class. The aim was to prove that teachers using a student focused strategy would be more likely to encourage students to adopt a deep learning approach compared to teachers who adopted a teacher-focused approach. The outcomes were intended to be used to enhance teacher training. There were three phases of the study as shown in Table 2-1:

Table 2-1. Summary of Trigwell and Prosser research studies.

Phase	Type	Aim	Reference
1	Phenomenographic study of first year university physical sciences teachers.	To investigate different approaches to teaching.	Trigwell, Prosser and Taylor (1994)
2	Development of Approaches to Teaching Inventory based on phenomenographic analysis in Phase 1.	To enable large scale data collection and provide statistical analysis for reliability.	Trigwell and Prosser (1996) and later Trigwell and Prosser (2004)
3	An empirical study between different approaches to teaching and different approaches to learning.	To provide empirical evidence to show relations between teaching approaches and student learning.	Trigwell, Prosser and Waterhouse (1999)

Trigwell et al. (1994) started with investigating the experiences of first year university science teachers to attempt to link the strategies used in the classroom to the intentions of the teachers. The analysis yielded five qualitatively different approaches to teaching. Table 2-2 portrays the five approaches to teaching which were determined from the study and the logical relations between intention and strategy.

Table 2-2. Approaches to teaching (Trigwell, Prosser and Taylor, 1994)

	Strategy		
Intention	Teacher-focused	Student/Teacher Interaction	Student focused
Information transmission	A		
Concept acquisition	B	C	
Conceptual development			D
Conceptual change			E

Approach A: A teacher-focused strategy with the intention of transmitting information to students.
Approach B: A teacher-focused strategy with the intention that students acquire the concepts of the discipline.
Approach C: A teacher/student interaction strategy with intention that students acquire the concepts of discipline.
Approach D: A student-focused strategy aimed at students developing their conception.
Approach E: A student-focused strategy aimed at students changing their conceptions.

The research came with a proviso because of the relational nature of the work, that the outcomes indicated here were most relevant in the context of first year university science teachers and that other disciplines may differ. They proposed in fact, that even the same teachers teaching non-first year students may differ in approach. The next step was to use the phenomenographic data to create an inventory which could be used as a large-scale data collection method and the Approaches to Teaching Inventory (ATI) was born (Trigwell & Prosser, 1996). It was later revised and published in Trigwell and Prosser (2004).

Trigwell and Prosser (1996) proposed that the teaching approaches identified, reflected to some extent the student approaches to learning and the final phase of the study investigated the link between the teacher's approach to teaching and the student's approach to learning (Trigwell et al., 1999). The study involved quantitative analysis of data collected from 46 first year science teachers and 3,956 students within those classes. The teachers completed the ATI (Trigwell & Prosser, 1996) and the students a modified version of the Study Process Questionnaire (Biggs, 1987). Cluster analysis was carried out on the data collected which enabled the researchers to examine each class individually and compare the teacher's report of their approach to teaching to the students' approaches to learning. The results showed that an Information Transmission/Teacher Focussed (ITTF) approach to teaching was strongly associated with surface approaches to learning. Similarly, a Conceptual Change/Student Focused (CCSF) approach by the teachers resulted in students using a deep approach to learning, although less strongly correlated. The results showed the link between teachers' approaches to teaching and students' approaches to learning. Trigwell et al., (1999) make the case that the results can be used to enhance academic training. However, the authors again highlight the importance of linking teacher intention and strategy. Academic training in best practice teaching strategies alone, is insufficient. Teachers with an intention to transmit information will not be able to implement student focused strategies in the way they intend. For example, the suggestion to use a demonstration in class as a student focused approach, could result in just another way to transmit information or could be used to challenge previous conceptions of the task, depending on the intention of the teacher. In 1999, the original five sub scales (Table 2-2) were reviewed and a two-factor subscale was now proposed, representing two fundamentally different approaches to teaching:

Information Transmission/Teacher Focussed (ITTF) and Conceptual Change /Student Focussed (CCSF).

Kember and Kwan (2002) found that six dimensions were necessary to capture the range of variation in approaches to teaching. Their qualitative study included 17 lecturers in three university departments. The authors proposed approaches based on one motivation dimension and five strategy dimensions. However, these are distinguished within two broad categorisations, which they term "Content-Centred" and "Learning-Centred" teaching, conceptually both very similar to the CCSF and ITTF categories. One focuses on students and what they are learning, while the other emphasises teachers' performance and the teaching materials produced.

Postrareff and Lindblom-Ylänne (2008) identified the limited scope of studies such as Kember and Kwan (2002) and Lindblom-Ylänne et al., (2006). They wanted to examine more deeply the approaches to teaching and conceptions of teaching from a large range of multidisciplinary teachers. The hypothesis was that they would find more aspects of teaching than the two broad categories previously identified as a result of the large population (69 teachers) and range of disciplines involved. However, upon analysis, only two broad categories emerged from the data in this study which they termed "the learning-focused approach" and the "content-focused approach", again terms with meanings conceptually similar to those above (Postrareff & Lindblom-Ylänne, 2008). The researchers identified 10 aspects of teaching which were grouped under four broad themes; teaching process, learning environment, conception of learning and pedagogical development and this they proposed gave a more complete description of approaches to teaching. Each of the ten aspects were identified within both the learning and content focused approaches.

Regardless of the different positions taken by the researchers mentioned and the different approaches uncovered, there is a clear distinction between two broad approaches to teaching in general: that of the Information Transmission/Teacher Focused and the Conceptual Change/Student Focused approaches to use the Trigwell and Prosser terminology (Trigwell et al., 1994).

Bloom's Taxonomy

The final study of interest refers to Bloom's taxonomy classifying the processes of thinking and learning (Bates, 2019; Forehand, 2010). He proposed three domains of learning: the cognitive domain, the affective domain and the psychomotor domain. His main contribution to educational scholarship, however, was the development of the cognitive and affective domain taxonomies. The psychomotor taxonomy followed later and was published by others (Dave, 1975; Wilson, 2016; Forehand, 2010). Figure 2-2 summarises the terms used in each domain.

The cognitive taxonomy proposed six progressively more difficult levels of cognitive complexity as a way to help educators create tasks and learning objectives to align with levels of attainment (Forehand, 2010; Bates, 2019). The six levels were termed: remember, understand, apply, analyse, evaluate and create.

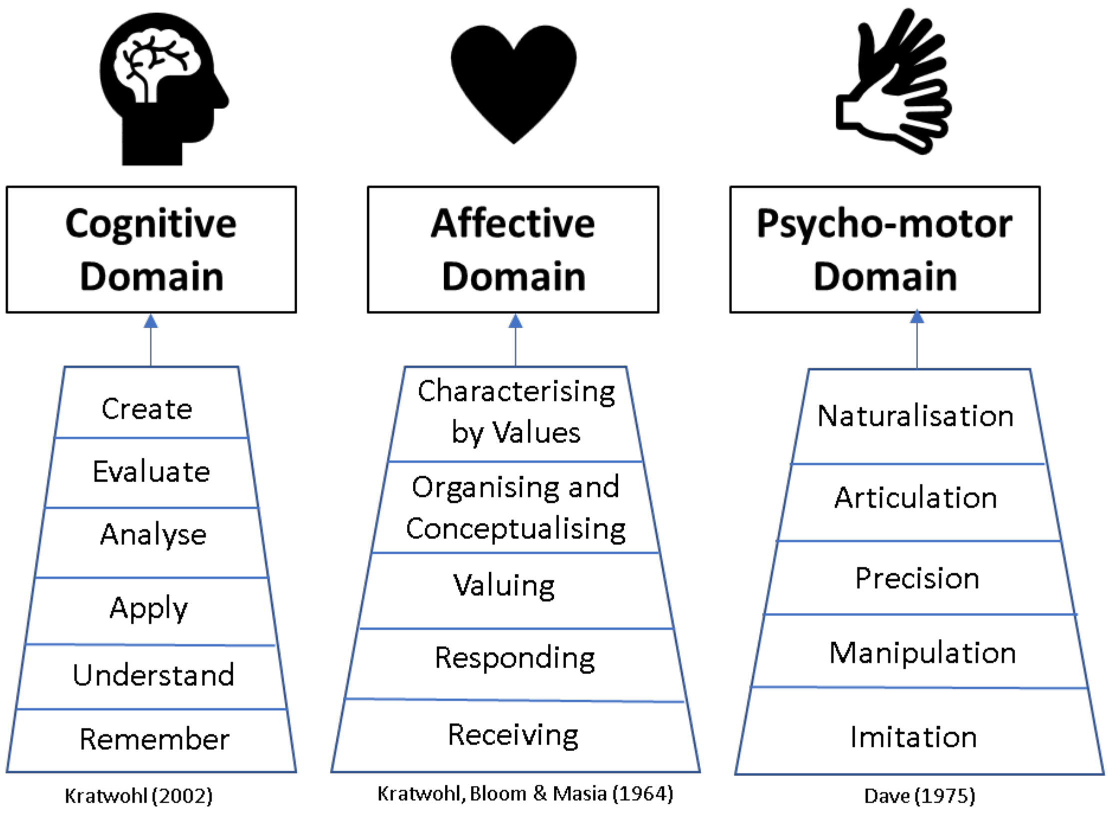

Figure 2-2: The Cognitive, Affective and Psycho-motor Domains

The affective domain taxonomy outlines the concept of how people deal with emotions, values and motivations (Krathwohl et al., 1964). Five levels are proposed as part of the affective domain: receiving, responding, valuing, organizing and conceptualising, characterizing by values. These terms merit more explanation. In relation to how people deal with attitudes and emotions, receiving refers to taking in the environment, whereas responding references how one would take responsibility to find out and respond to a situation. To value something is to recognise that something is worth doing. To organise and conceptualise recognises that a person will have their own way of responding to a situation, dependent on their values. The top tier recognises that individuals will take into account the whole situation, they will bring together their responses and ideas, which are dependent on their values and beliefs and then respond appropriately. Mourtos (2003) offers examples of how these can be achieved in engineering education:

- Level 1: Receiving (a stimulus). Students go to class, participate in class activities.
- Level 2: Responding (to a stimulus). Students study for their courses, carry out assignments.
- Level 3: Valuing (an object or a behaviour). Students are committed to their education, have positive attitudes about their coursework.
- Level 4: Organization (of values into a system). Students balance their responsibilities effectively; begin to formulate a systematic approach to learning.
- Level 5: Characterization (by a value complex). Students work independently and diligently, practice cooperation when working in teams, act ethically. Their value system reflects consistently in their behaviour.

(Mourtos, 2003, p.2).

The final domain (which was not completed by Bloom) refers to the psychomotor domain and can be described as that which refers to practical or physical skills. These can be physical skills such as building a wall or skills associated with arts performance (to draw, to throw, to weld) (Aubrey & Riley, 2018, p.95; Wilson, 2016).

Each domain was created in order that the change in behaviour of the learner could be measured. The cognitive domain is the most commonly recognised of the three domains, and is used by teachers to design curricula, learning and teaching plans and assessment techniques. However, the affective domain, which refers to peoples' attitudes and behaviours in a variety of situations also has value in a learning experience (Pierre & Oughton, 2007). Of course, the difficultly lies in how to assess those attitudes and beliefs. Zimbardo & Leippe (1991, cited in Pierre & Oughton, 2007) offer suggestions which include role modelling, the use of positive reinforcement and practice;

> Effective attitude instruction should involve the learner emotionally, and demonstrate the required behaviors that is consistent with the desired attitude and when positively reinforced can bring about the desired changes. Humour, fun, delight, surprise, and even confusion (dissonance) can all have a place in students' affective progress. Finally, instruction that provides learners with an opportunity to express or act out the target attitude, and responds to that expression with positive reinforcement will move them towards changed behaviour (p.5)

The importance of teaching students appropriate attitudes and behaviours is also raised by Hammer (2000) who advises that there are three influences which effect student behaviours and attitudes. They are "the values and behaviours that students bring into professional programs, role models in the professional and academic environments and the environments themselves" (Hammer, 2000, p.457). Bloom's taxonomies provide a framework to allow academics to reflect on how they teach through different levels of complexity in each domain.

Chapter Summary

The literature review has presented a summary of previous work in relation to professional skills (lists of skills) and has highlighted the lack of in-depth studies to ascertain fundamental knowledge about what we mean by professional skills. Previous work on the terms Generic Graduate Attributes was presented to show the importance of undertaking research work in this area. The second part of the literature review focussed on Learning and Teaching and presented theories which have shaped teaching practice and which are relevant to the outcomes of this study. These included: Behaviourism, Constructivism, Humanisim, Experiential Learning Theory, Approaches to Teaching and Bloom's Taxonomies.

Much of the research associated with teaching in higher education has been to search for new knowledge in order to improve teaching. The research however has principally been concerned with pedagogy, ways of teaching or specific interventions which enhance the development of skills in engineering students. There is value in this aspect, but there has been little focus on the academic conceptions of what the term Professional Skills means and the different ways in which academics teach professional skills in particular.

The literature review has highlighted aspects of the field of knowledge that touch upon the phenomenon of Professional Skills and the influence that academics can have on developing these skills within students. In doing so, I have shone a light upon a need for further research into both the current conceptions of professional skills and the different approaches that academics use in teaching these skills within the classroom. There are two proposed enquiries therefore, in simple terms: "What are academics

Conceptions of Professional Skills?" and "How do academics approach teaching Professional Skills?"

This study outcome will show detailed aspects of the conceptions or approaches to allow for a greater depth of understanding of both research questions. The outcomes will not only fill the gap in knowledge highlighted by the literature review but will add to engineering education scholarship by providing a fundamental knowledge of what academics conceive of professional skills and the differing ways in which they are taught.

CHAPTER THREE – Research Design

Researchers all bring background experiences and biases to the research work they undertake, particularly so in an individual research project such as a PhD. Therefore, the objective of this chapter is twofold. First, it aims to communicate to the reader the theoretical assumptions which influenced the choice of research approach, the aims of the study and the research questions themselves. Second, it considers the nature of the research questions and describes a research design which aims to provide an appropriate method to answer the research questions. A conceptual framework is presented to showcase the interweaving concepts which led to the research questions and the use of variation theory is also described as a contributing factor to the research design. Phenomenography was selected as the most appropriate strategy of inquiry to answer the chosen questions and included within this section is a description of phenomenography as a research approach.

The second part of the chapter describes the overall methodology for carrying out the data collection which was undertaken in two phases: an online survey and in-depth interviews. The survey was primarily used to select interviewees for the main body of the study, in addition to setting the context and informing the interview questions, thus a detailed description of the survey is not included in this thesis, as it is published elsewhere (Beagon & Bowe, 2018a;2019b).

The chapter concludes by describing how the work was conducted in an ethical manner in order to protect those who kindly participated in the study.

3.1 Theoretical Perspective

For a research study to have quality and coherence there should be alignment between the nature of the phenomenon being investigated, the research question that is asked and the research method that will be used to answer this question. As a structural engineer, my educational training and industrial background was centred on an objective quantitative stance where I undertook numerical analyses and compared these with experimentally determined material properties. Hence when I moved into educational research, a positivist approach such as a quantitative research study, would have built on my previous experience.

However, undertaking an engineering education research study must start with a review of the question that the researcher wishes to answer. This is influenced by the theoretical assumptions that the researcher makes. The epistemological stance (what can we learn from this study and how should we go about it) influences how the research questions are phrased, and the data collection and analysis methods used.

In this study, I want to gain a deep understanding of a particular phenomenon. To achieve this, I will investigate individual experiences of academics in relation to a phenomenon, the phenomenon being Professional Skills. I intend to use this data to provide a deep analysis of the different ways in which academics conceptualise what professional skills are and the different ways in which they teach professional skills. I am attempting to interpret what they say when describing their experiences so that I can draw comparisons and contrasts from individual accounts. Therefore, for this study, it is important to place value on individual experiences (to showcase similarities and differences) and a qualitative research approach to draw out those personal experiences is most appropriate.

I realised therefore that an interpretive research methodology would align with the epistemological stance required for this study and hence the next step was to determine the specific research questions I wanted to answer and the appropriate strategy of inquiry. Cohen, Manion and Morrison (2011) highlight how the strategy of inquiry is inherently tied to the ontological and epistemological beliefs of the researcher.

> Ontological assumptions (assumptions about the nature of reality and the nature of things) give rise to epistemological assumptions (ways of researching and enquiring into the nature of reality and the nature of things); these, in turn, give rise to methodological considerations; and these, in turn, give rise to issues of instrumentation and data collection (p .3).

There are several ontological and epistemological assumptions that I bring to this research which have informed my research design and which I declare here:

- From a philosophical viewpoint, I believe that we make our own meaning of things and we do this through our interaction with the world. Our reality is not out there as an objective reality to be discovered: it is created as a result of our interaction with it.
- I consider that we as individuals experience all social phenomena in different ways. It is contextual: it depends on whether we are initiating it, receiving it, observing or researching it. It depends on our mood at that time, our previous experience of the matter and with what attitude we approach the issue.
- I believe that people learn to do things in different ways, some better, some worse and through an increased awareness of the different ways of doing something, they can be encouraged to enhance their practice, whatever that may be. This is what learning means to me: to see things in a new light and to be aware of better ways of doing things.

- If I want to effect change in a social phenomenon, it is more important to look at how people interact with the phenomenon, rather than a distanced view of what the phenomenon entails. I am interested therefore in peoples' experience of the situation, how they handle it and I intend to interpret their conceptions from their description of their experiences.
- In this study, I want to better understand how a person views a particular phenomenon, through their eyes, not as an observer on the side.

These beliefs led me to approach this research study with an interpretivist ontological position and a constitutional epistemological perspective, a perspective which is built on the constructivist perspective. Guba and Lincoln (1994, p. 105) define a paradigm as "the basic belief system or worldview that guides the investigator, not only in choices of method but in ontologically and epistemologically fundamental ways". The next section summarises the key concepts associated with ontology and epistemology.

Ontological position

Ontology stems from the greek "ontos" meaning being. It is concerned with the nature of reality; how things come to be. Ontology also considers how things are connected; "relationships between people, society and the world" (Savin-Baden & Major, 2013, p. 57). My ontological position for this research is that of interpretation. I want to be able to explain how people conceptualise the term professional skills and their approaches to teaching professional skills. Therefore, it is not to define what the term professional skills is; but to describe how people experience it, which I believe I can interpret from listening to their experiences.

Epistemological position

Epistemology stems from the greek "episteme" meaning knowledge and is concerned with how we come to know reality; how we develop knowledge. Whilst there are many competing paradigms for researchers to consider, this text focusses on constructivism and constitutionalism as being appropriate to this research study. Constructivism came from several cognitive approaches that thought of knowledge as being constructed rather than discovered and several of these have been presented in the literature review. It is based on the ontological assumption that there are multiple realities, formed in the human mind as a result of experiential and social constructions (Marton & Saljo, 1976). Although some of these realities may be common across a group of people, they are personal to each individual. In the opposite sense of a positivist viewpoint, constructions are not either correct or incorrect: each one is valid in its own right. Guba and Lincoln (1994, p. 111) assert; "Constructions are not more or less true in any absolute sense, but simply more or less informed and/or sophisticated." Findings from a constructivist investigation are created by the interaction between the object and the researcher and constructions are refined and elicited usually through dialectical interaction between the two.

At this stage it is appropriate to introduce constitutionalism, a further development of constructivism. The key difference in constructivism and constitutionalism is the difference between dualistic and non-dualistic assumptions. "There is a dualistic assumption underlying constructivism: thinking takes place in an inner subjective world, divorced from the outer objective reality and knowledge is constructed there by the individual through material and mental acts" (Marton & Neuman, 1989, p. 37).

Dualistic assumptions refer to beliefs that there are two separate entities, the world and human knowledge whereas non-dualism assumes that objects and events exist only as they are experienced. Richardson (1999) claims that this is not a genuine ontological assumption as it assumes that there are two types of entities in the world; those objects and events that are currently being experienced and those which exist and which are not currently being experienced. Marton and Booth (1997) acknowledge however that natural objects in the world may exist independent of humans.

> This is not to say that if humankind disappeared then the sun, the Hudson river, and wombats would necessarily disappear as well. The point we wish to make strongly is this: We cannot describe a world that is independent of our descriptions or of us as describers (Marton & Booth, 1997, p. 113).

Perhaps the popular philosophical question "When a tree falls in a deserted forest, does it make a sound?" can be used to explain this assumption of dualism which underpins constructivism. A dualistic assumption is that the tree falls in the deserted forest causing the air around it to move, and independently and removed from the act, the person can make assumptions about what may or may not have happened. The thinking takes place in an inner subjective world. Whereas in a non-dualistic world, the emphasis is on the interaction of the human with the experience. Sound is a human experience and hence we can only describe what happens through the human description of what they heard, the unity of the object and the experience – a sound. It is the interaction and the description of this interaction that is of importance. As Guba and Lincoln (1994, p. 106) propose: "Human behaviour, unlike that of physical objects, cannot be understood without reference to the meanings and purposes attached by human actors to their activities". According to Marton and Neuman (1989) it is this non-dualistic approach to research which is more appropriate to investigating people's experience of phenomena and this they term constitutionalism.

> While Piagetian constructivism has a clear psychological orientation, the constitutional framework—to which phenomenography clearly belongs—is more easily reconciliable [sic] with didactic considerations. While the emphasis in constructivism is on acts—material or mental—constitutionalism has the unity of the act and that which is acted upon as its point of departure (Marton & Neuman, 1989, p. 40).

Therefore, considering the value that I place on individual experiences, it is with an interpretivist ontological position and a constitutional epistemological perspective that I approach this research study.

Object of interest

The review of the literature dealing with professional skills presented in the preceding chapters revealed varied literature on the importance of developing professional skills in undergraduate students, on industry's attestations about the lack of skills in graduates and work relating to good pedagogical approaches to teaching. In engineering education literature, there are studies which link different pedagogical approaches to teaching and students' understanding, but mainly on a technical level, with specific concepts in mind. These studies have provided arguments to enhance learning and teaching in specific contexts. However, there are more limited studies which investigate those skills which are non-technical, and it is this aspect which I am particularly interested in and which initiated this research study.

Ultimately, I would like this study to effect change in how professional skills are taught in engineering programmes so that engineering students, graduates and the engineering industry as a whole, are better equipped to solve the myriad of problems which society will face in coming years. In particular, I want to influence the change agents (academics) and to do this I want to draw out academics' own values, beliefs and practices, their conceptions and approaches of teaching professional skills. Aligned to the ontological position, I want to go to the heart of the matter, by talking to those people who can make it happen. I want to investigate the varied experiences of academics themselves and articulate this in a way that can be used to inform teaching practice and policy development in this context.

Conceptual Framework

Savin-Baden and Major (2013) highlight the importance of a conceptual framework to set out how the researcher has been influenced and how the study will be undertaken. They define a conceptual framework as a "collection of general but related concepts from the literature that serve as a partial background for the study and that support the need for investigating the research question" (Savin-Baden & Major, 2013, p. 138). The initial conceptual framework which framed this study is presented in Figure 3-1. The study is context bound in three ways:

- The people whose experiences interest me are those academics teaching on engineering programmes in Ireland only.
- The Theoretical Framework should describe how the findings of the study can be used to meet the overall aim of the study – how can outputs be of use to inform teaching practice and policy development?

- The object of interest is Professional Skills. I am interested in how academics conceive of what Professional Skills are and how they currently teach Professional Skills.

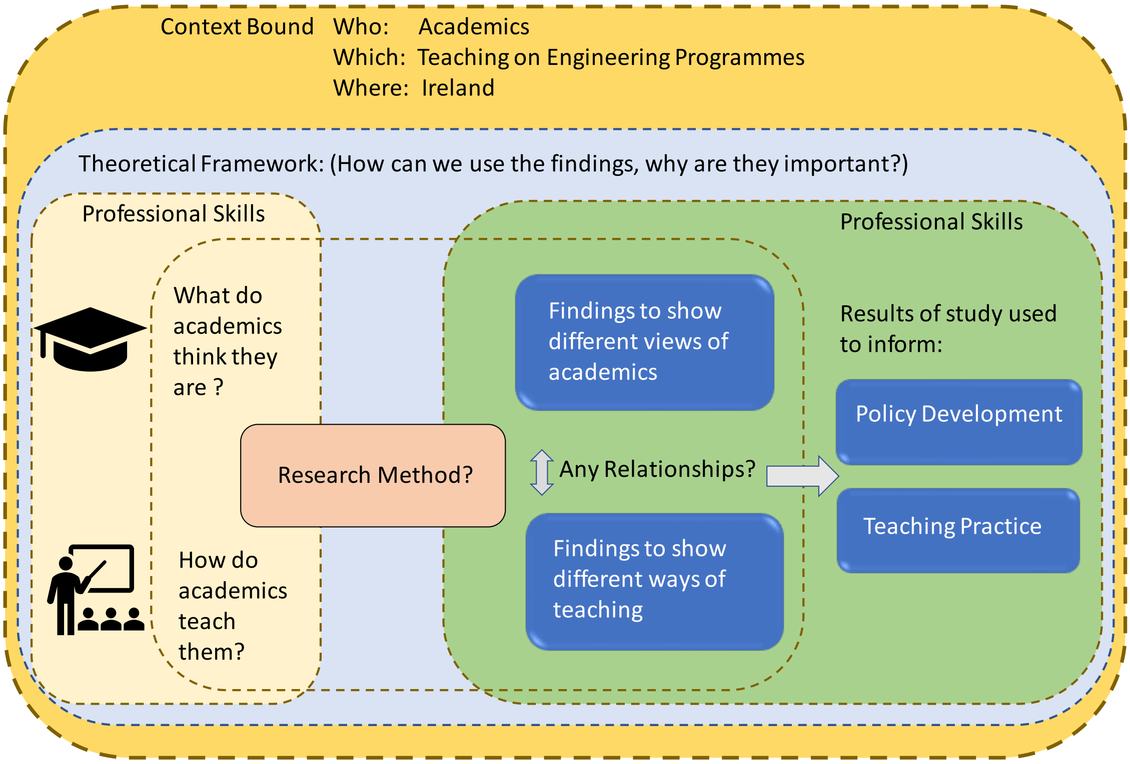

Figure 3-1: Initial Conceptual Framework outlining ideas for research study

- It is imperative that we build a better understanding of the way in which academics conceptualise and teach professional skills because if we want to change how professional skills are developed and taught we must change the way academics understand and view professional skills.
- To that end, it is crucial that we first build a knowledge base by uncovering the current conceptions of professional skills which are held by academics and their current approaches to teaching them.
- This study will provide a deep understanding of how academics conceptualise professional skills, how they currently teach professional skills and it aims to identify any relationships between these outcomes.

- The outcomes of the study will be used as a tool to assist in the reform of engineering education from a top down (policy) and bottom up (teaching practice) approach.

Study Objectives

In order to produce outputs which can be used to inform teaching practice and policy development in relation to teaching professional skills there are three key objectives of this study. They are re-stated here for reference:

- To understand how academics teaching on engineering programmes in Ireland conceptualise the term Professional Skills.
- To examine the different ways in which academics teach Professional Skills in engineering programmes in Ireland.
- To investigate if there is a relationship between how academics teach Professional Skills and their Conception of Professional Skills.

The first aim of the study, to better understand academics' Conceptions of Professional Skills includes questions such as:

- What do academics think professional skills actually are?
- What is included in their (definitions leading to) conceptions and what is not?
- Are they important/not important for engineers?
- Why are they important/not important?
- What has influenced their conceptions?
- Where do they think engineers learn those skills?
- How do they believe they developed their professional skills?

This study will critically analyse and outline in some depth the issues which influence how academics conceptualise and teach professional skills. In order to gain this deep understanding, I will examine the academics' experiences and draw findings from their descriptions of those experiences. The outcomes will present more than a mere description and will show detailed aspects of the conceptions or approaches to allow for a greater depth of understanding. A deep and detailed study was required to show this depth of understanding, rather than a survey type data collection method which may provide breadth, but not depth.

Research Methodology

The aim of the study is to build an understanding of academics' conceptions of and approaches to teaching professional skills. It is crucial that we build this knowledge base to help us understand and therefore influence academic practice. I needed a descriptive method of enquiry that allows for discovery and not verification. There were a range of methods to choose from, which had varying levels of description, interpretation, explanation or action. Each option ensures that the voices of the individuals are heard, but each with varying degrees of interpretation by the researcher (Dunkin, 2000).

I considered two research approaches appropriate for my study: phenomenology and phenomenography. These approaches seek to study peoples' experiences of different phenomena, usually in the form of in-depth interview, however the focus, outcomes and uses of each of these studies differs. Phenomenology seeks to find the common perspectives from a group of people in order to describe a phenomenon, what is termed the **essence** of the phenomenon. A phenomenographic study seeks to identify the range or **variation** of experiences within a group.

Figure 3-2 aims to show the differences between the focus of each approach in graphical form. In phenomenological studies the researcher looks for commonality by interpreting experiences within a range of interviews (interviews are represented by circles), and the aim is to reveal what is common about those experiences, or what is the essence or core of the phenomenon (represented by the red dot in the centre). Conversely, in phenomenographical studies, the researcher first considers the qualitatively different ways of experiencing a phenomenon, termed **Categories of Description**. Hence extracts from interviews are initially grouped together to form a Category of Description, or one way of experiencing the phenomenon. An interviewee may reveal several ways of experiencing a phenomenon within the one interview. However, the Categories of Description are not the only outcome of a phenomenographical study, it is the description of the variation between each of the ways of understanding that is also of interest, indicated in Figure 3-2 by the red arrows.

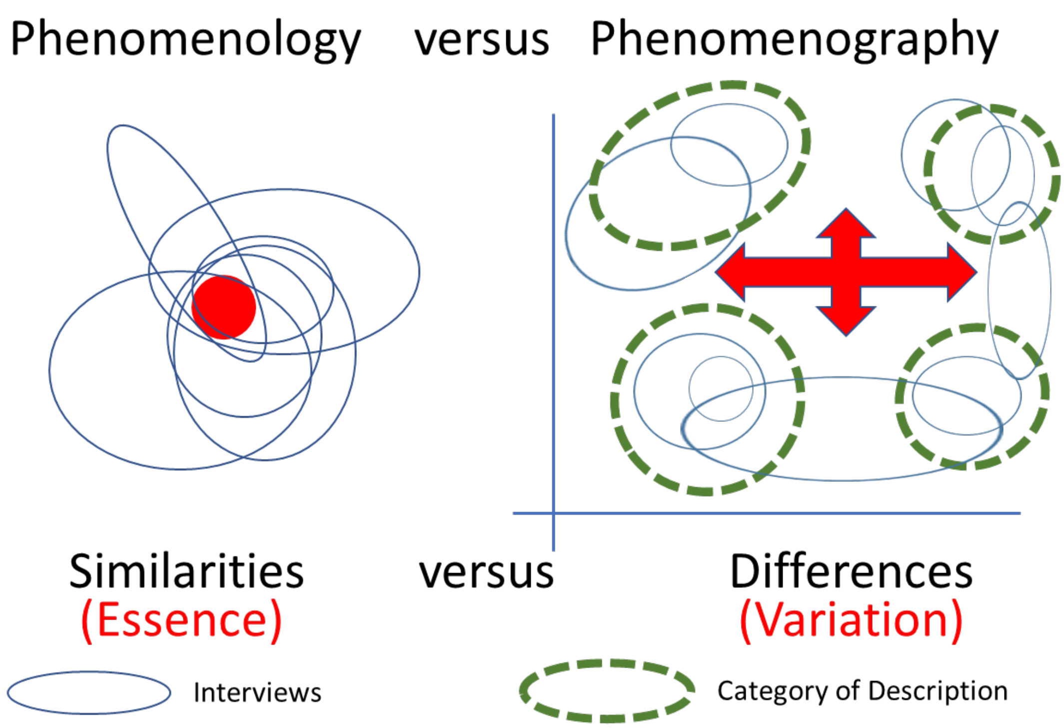

Figure 3-2: Comparison of Phenomenological and Phenomenographical studies

As may be expected, with different outcomes from each research methodology there is also a difference in how one might use the outcomes of each type of study. Larsson and Holmstrom (2007) give a useful account of a comparison between a phenomenological and a phenomenographical research study. Their study centres around interviews with anaesthesiologists about their work and they carried out both a phenomenological and a phenomenographical analysis of the interviews. The aims, findings, outcomes and uses for each approach are summarised in Table 3-1.

Table 3-1: Summary of outcomes from Larsson & Holstrom (2007)

	Phenomenographical Study	**Phenomenological Study**
Research Question	What do experienced anaesthesiologists think about what anaesthesiology is?	What is the essence of the anaesthesiologist's work?
Findings	Four categories of description describing how anaesthesiologists see their work.	A statement describing the essence of being an anaesthesiologist.
Outcomes	Certain ways of understanding are more powerful than others and are probably linked to more efficient ways of acting in clinical work.	The description of being an anaesthesiologist, what it involves - the essence of the profession.
Uses	As a learning and competence development tool.	To help people grasp what it really means for a person to live with this work. This could generate discussion on working conditions, and how to remain healthy in this demanding profession.

Another key difference between the two approaches lies in the sample size. Since phenomenology looks to the essence of the phenomenon, the researcher seeks to investigate a deep and rich experience, which may only require a few participants, in theory one participant could be sufficient. In phenomenography, variation is the driver and so a range of interviews will take place to ensure the researcher uncovers the maximum variation in the experiences of the phenomenon (Åkerlind, 2005b; Trigwell, 1999).

Returning to the objectives of this study allows for consideration of both research methods. The first study objective (Conceptions of the term Professional Skills) could have been answered by both methods, but with varying outcomes. A phenomenological study would provide a definition of the term, the essence of what academics believe Professional Skills means (the common understanding). On the other hand, a phenomenographic study provides outcomes which show a range of understanding, or a range of conceptions.

The second objective specifically looks to describe the different ways in which academics teach professional skills and this question could not be answered in a phenomenological study. Describing differences or variations is more appropriate to a phenomenographic study. The final study aim seeks to investigate relationships and it follows therefore that the previous two objectives should produce outcomes which can be contrasted. This is also more appropriate to phenomenographic outcomes (showing variation) than a singular description of a phenomenon, typical in a phenomenological study.

The final consideration which led me to choose a phenomenographic methodology was the intended use of the outcomes. As described earlier, it is hoped that the outcomes of this study can be used in two ways. A better understanding of how academics conceive of what professional skills are will assist in producing effective policies which are multi-layered and thus relatable to all academics with varying views. Secondly, an outcome which describes the varied ways in which academics teach professional skills can facilitate academics to reflect on their own practice. In this way, it is intended that the outcome is used as a learning and teaching tool, or for competence development as noted by Larsson and Holstrom (2007). Similarly, Entwistle (1997) explains that the value of phenomenography in a learning and teaching context is that it can support educational change and enhance learning. "In higher education, we are generally intending to encourage the development of conceptual understanding in students, so a method which so vividly portrays differing conceptualisations must have direct relevance to teaching and learning" (Entwistle, 1997, p. 129). In a learning and teaching scenario of enhancement to academic practice, the academic becomes the student. It was therefore determined that a phenomenographic study would best answer the study aims.

What is Phenomenography?

This section explains phenomenography in detail, beginning with the history of how it emerged and the key assumptions associated with the approach. Aspects of validity and reliability and the use of Variation Theory as a theoretical framework are also presented in this section.

Phenomenography was first pioneered by Professor Ference Marton and his research colleagues in Göteburg University in Sweden in the 1970s and the term "phenomenography" was coined in his seminal paper: "Phenomenography - Describing Conceptions of the World Around Us" (Marton, 1981). "Phenomenography is a research method adapted for mapping the qualitatively different ways in which people experience, conceptualise, perceive, and understand various aspects of, and phenomena in, the world around them" (Marton, 1986, p. 31).

Marton (1986) attests that Piaget's early work in child development followed a similar methodology, that of describing qualitatively different ways in which children, at different stages of development, experienced aspects of the world. He claims, however, that the focus of Piaget's studies, was to understand the general phenomenon of mental processing within the child at certain ages so that they could explain the more general phenomena – how the human minds develops. He argues that the purpose of the Piagetian studies had a different focus than that of phenomenography which maps the distinctly different ways that people understand different phenomena, what he defines as "the hidden human world of conceptions" (Marton, 1986, p. 145). Marton (1986) proposed that this was valuable as a specialisation in itself and this he termed, **Phenomenography**.

The work carried out in Göteburg was a marked departure from previous educational research which focussed on **how** students study (Saljo, 1975; Dahlgren, 1975, all cited in Marton & Saljo, 1976); this new point of departure explored students' **experience** of studying. A key finding from this research is the differentiation between surface and deep learning (Marton & Säljö, 1976), terms used in the general discourse in learning and teaching ever since (Biggs, 1999).

Phenomenography is an empirical research method used to investigate the variation in conceptions of a particular aspect of the world around us. It is based in a non-dualist, second order perspective. The researcher explores the relationship between a person and a phenomenon: how that person experiences it. The role of the researcher in a phenomenographic study is to take the place of the individual, as Marton & Booth (1997, p. 121) put it "trying to see the phenomenon and the situation through her eyes, and living her experience vicariously". Marton (1981) describes the first order perspective as being orientated towards the world: gathering data on a phenomenon so we can make statements about the world or a particular phenomenon. First order perspectives are typical of research in the natural sciences where a researcher describes things as they are, typical of a positivist stance (Reed, 2006). However, the second-order perspective is orientated towards people. In other words, we are not reporting on the phenomenon itself, but rather on people's experiences of that phenomenon. We collect information on how people think about the world or how they experience aspects of the world (Marton, 1981).

Phenomenographers seek qualitatively different, but logically interconnected descriptions that a group of people experience in relation to a particular context (Marton, 1994). Marton and Booth (1997) relate action and experience. It follows that if we want to understand how people **handle** certain problems, situations or the world, we need to investigate how they **experience** those problems, situations or the world. "A capability for **acting** in a certain way reflects a capability **experiencing** something in a certain way. The latter does not cause the former, but they are logically intertwined" (Marton & Booth, 1997, p. 111).

Phenomenography aligns with a subjective ontology, where the researcher interprets the outcome of interviews. It is accepted that people will construe the world in different ways, as opposed to there being one truth. In fact, in phenomenography, researchers do not make any assumptions about reality, nor do they intend that their research outputs represent the **truth**. The findings of a phenomenographic study are presented in **Outcome Spaces**; hierarchically ordered sets of **Categories of Descriptions.** Categories of Descriptions is the term used to explain the qualitatively different variations of experience of the phenomenon. Researchers aim to present outcome spaces that reflect the phenomenon, but as Åkerlind (2005a) posits, researchers can only provide more or less complete outcomes, not right or wrong outcomes.

Phenomenographic theoretical perspective

Svensson (1997) attests that in phenomenography, the research object is not the phenomenon itself, but the relationships between the people (subject) and the phenomenon (object). Phenomenographers consider that it is the differences in descriptions (and thus meaning) that are most important. Svensson (1994) also suggests that, in instances where there is less generality of meaning, then the description of individual cases becomes more important in order to distinguish the variation across the group. Hence, description of experiences and the meaning behind them are of utmost importance.

Piaget (1964) proposed that knowledge is constructed by a person through their acts and interaction with the world, what is termed **constructivism.** As discussed earlier, constructivism assumes a relationship between the inner (mind) and the outer (acts or behaviours), but it does view the inner individually constructed world and outer real world as two separate entities (Marton & Booth, 1997; von Glasersfeld, 1988). Marton and Booth (1997) situate phenomenography in a set of epistemological beliefs termed **constitutionalism**. Although similar to constructivism, that in which meaning is not discovered, but constructed by the individual, constitutionalism recognises that the world we deal with is a world experienced by people. It is this internal relationship between the individual and the world which is **constituted** between them and which phenomenography seeks to explore.

Variation Theory

Phenomenography grew out of a shared empirical approach to describe peoples' conceptions of different phenomena undertaken by various researchers (Svensson, 1997). However, it lacked a theoretical base for its approach and attracted some early criticism (Säljö, 1996; Säljö, 1997; Richardson, 1999; Pang, 2003). **Variation theory** (sometimes referred to as **new phenomenography**) was therefore proposed as a theoretical foundation for phenomenography (Pang, 2003). Bussey et al., (2013) posit that whilst the initial phenomenographic studies were able to identify and describe a range of experiences of a phenomenon, phenomenography alone could not explain **why** that variation existed. Variation theory, which may be thought of as a theoretical extension of phenomenography aims to do just that.

It is through variation in experience that people discern which features are important or valued and those that are unimportant. Specifically, individuals' experiences are different depending on what aspect of a phenomenon they are focussing on at a particular time. It is these differences in experiences that equate to critical variation which is the differentiator in phenomenographic Categories of Description. Bussey et al., (2013) explain it simply:

> According to variation theory, there are a limited number of features of a given phenomenon to which we can pay attention at any given time. Our experience of that phenomenon depends on the specific features to which we direct our attention. Two individuals who experience the same phenomenon may focus on different features and, thus, come to understand the phenomenon differently (p. 9).

The example of banana ripeness is used to explain critical and non-critical variation and is presented here as an example, prompted by Bussey et al., (2013) and Daniel (2015). Bananas have many aspects that may vary: colour, taste, size, softness, smell. We have learned by experience that the colour of a banana is a good indicator of ripeness. Green bananas are under ripe, yellow bananas are ripe and brown bananas are usually over ripe. This variation in experience acts as a reference for future banana selection and is a critical variation with regard to ripeness. Through experiencing the ripeness of different banana colours (See Figure 3-3) the next time we choose a banana, we will take colour into account.

Size on the other hand, whilst also on a variable scale is not a critical variation with regard to ripeness. The size of the banana is not related to the ripeness: both small and large yellow bananas may be equally ripe.

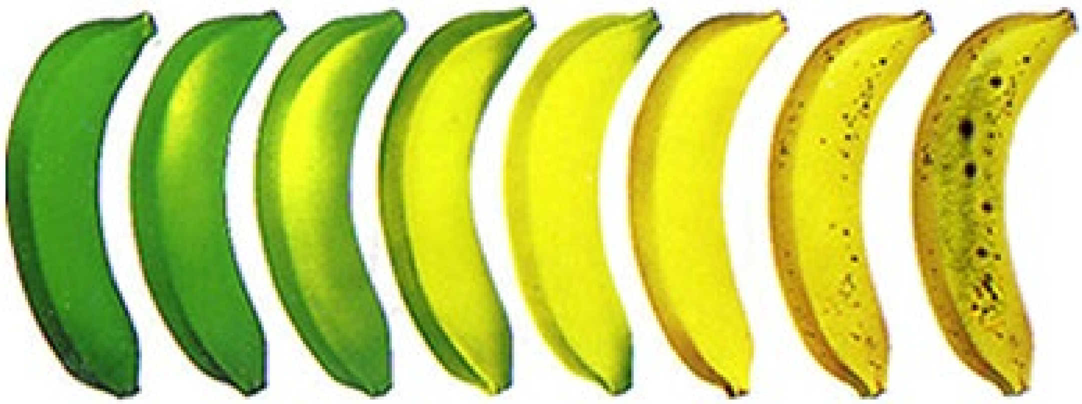

Figure 3-3. The variation in banana colour. Adapted from image downloaded (15th Jan 2017). *http://healthimpactnews.com/wp-content/uploads/sites/2/2013/10/banana_ripe4_n.jpg*

It is through experience therefore that an individual learns to discern what critical features of a banana relate to ripeness and this will be different for different people. Take for example a person who is colour blind and therefore cannot discern ripeness by colour (Daniel, 2015). This individual may consider only softness and the number of black dots on the banana as critical variation. In variation theory this is referred to **simultaneously in focal awareness (or figural or central)**, whereas colour, which is not in focal awareness at this point is "relegated to the very limits of awareness (i.e. **they recede to ground**)" (Reed, 2006, p. 4).

Marton and Booth (1997, p. 1) explain that people do things differently and to do it differently “they must have learned to do it differently – some better, some worse”. The process of learning therefore requires the ability to see variation and to be able to distinguish between different aspects (Trigwell, 1999). The importance of discernment and variation is also highlighted by Bowden and Marton (1998):

> To discern an aspect is to differentiate among the various aspects and focus on the one most relevant to the situation. Without variation there is no discernment. We do not think in a conscious way about breathing until we get a virus or walk into a smoke-filled room. Learning in terms of changes in or widening of our ways of seeing the world can be understood in terms of discernment, simultaneity and variation. Thanks to the variation, we experience and discern critical aspects of the situations or phenomena we have to handle and, to the extent that these critical aspects are focused on simultaneously, a pattern emerges. Thanks to having experienced a varying past we become capable of handling a varying future (p.7).

Taking this example a step further: imagine that you met a banana connoisseur who attests that colour, softness, smell and number of black dots determine ripeness (Daniel, 2015). Their experience of banana ripeness is a combination of all these aspects of critical variation. In variation theory, this would be described as **all of these aspects of critical variation being simultaneously within her focal awareness**. This way of experiencing banana ripeness is more comprehensive than experiencing ripeness by colour alone, or by softness and number of black dots alone. Neither way of experiencing it is wrong: one way is more comprehensive and the others are only partial ways of experiencing it.

Finally, you meet a biochemist who is undertaking research in what makes bananas ripe. She tells you that the outcome of her research shows that the following factors relate to ripeness: colour, softness, smell, number of black dots, biochemistry, pH value and so on. Here again is a more comprehensive experience of the phenomenon of banana ripeness.

Figure 3-4 shows what the outcomes from a study on banana ripeness might look like in hierarchal graphical form based on the example above. Perhaps you never knew that the number of black dots or the smell of a banana was an indicator of ripeness. Now that you have been made aware of that, your choice of banana in the future may change. Through awareness of variation and discernment, you have just learned something. This serves to show that as a person is made aware of the differences/variations in a phenomenon, they have an opportunity to learn or to have a more comprehensive understanding of a phenomenon.

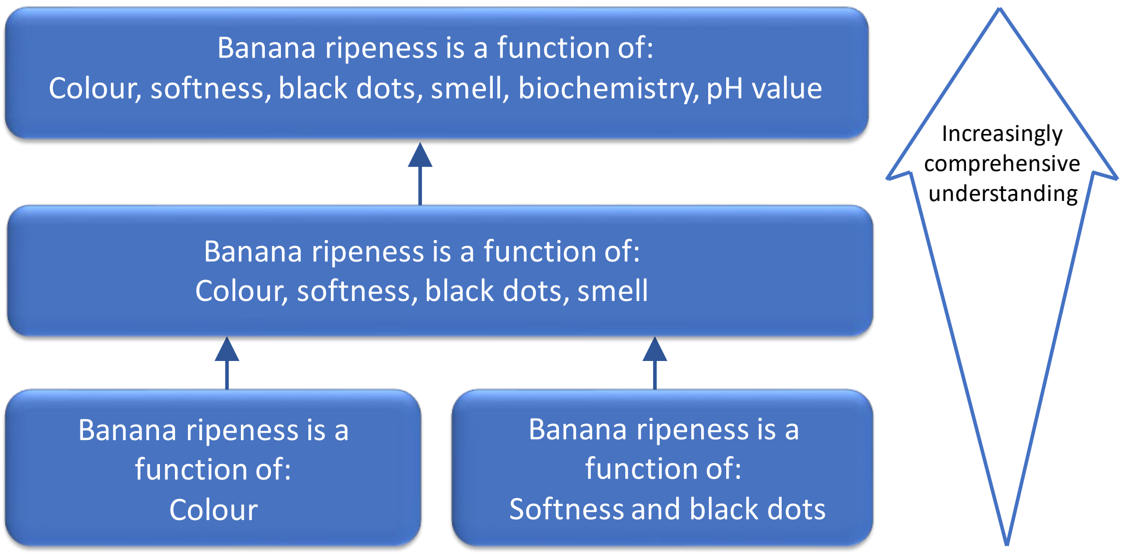

Figure 3-4. A hypothetical (graphical) outcome for banana ripeness (Adapted from Daniel (2015))

In conclusion, phenomenography describes the qualitatively different ways in which a person experiences something and variation theory provides a framework to explain why that is the case.

Phenomenographic Research Methodology

Bowden (2000) explains that initial studies into how students learn, sought to inform teaching pedagogy and he terms this **developmental phenomenography**. This contrasts with Marton's (1986, p. 38) description of **pure phenomenography**, where the phenomena are more general, and not necessarily based in an educational setting. The purpose in **pure phenomenography** is to understand the variation in ways people conceptualise a particular phenomenon, not necessarily to effect change with that knowledge. The purpose of this study is to enact change in engineering education and hence it can be described as developmental phenomenography.

Green and Bowden (2009) provide good direction on how to carry out phenomenographic studies in relation to a developmental approach. This includes how to set a research question, from whom to collect data, and both analysing and interpreting the data itself. Marton (1986) and Reed (2006) also describe methodologies for analysing the interview transcripts. Marton (1986, p.153) suggests the first phase is a review of the transcripts looking for **criteria of relevance** as he describes, "**utterances which are found to be of interest in relation to the question being investigated"**. The isolated utterances themselves are not the focus, the researcher must ensure that they continuously relate back to the context in which the utterance was made. The selected quotes make up a data pool from which the researcher then turns away from referring to individual subjects and attempts to determine the meaning embedded in the utterances themselves. Quotes are grouped into categories which are based on similarities between quotes, with boundary cases being highlighted in each group. During this process, the researcher must reverberate between the quote and the interview, so that the context of the quote and thus the meaning embedded within in it is **faithful**. Through an iterative procedure, the researcher determines the criterion for each **Category of Description**, where each Category of Description is differentiated from another with respect to its differences to others. The iterative procedure continues, with quotes being re-examined and rearranged until what Marton (1986) describes as a decreasing rate of change and a stabilised system of meanings.

Outcome Spaces

The research outputs of a phenomenographic study are called **Outcome Spaces**. The term conception is sometimes used to refer to individuals' ways of experiencing a specific aspect of reality (Reed, 2006). As Säljö (1996, p. 25) explains, "categories of description are intended for describing conceptions". The Outcome Space is a logically related set of Categories of Description, each of which describe a qualitatively distinct way of experiencing the phenomenon. Each successive category of description should provide an in-depth description of how the phenomenon was experienced. Åkerlind (2005a) describes this as a **Theme of Expanding Awareness**, a framework which describes the relationships between the Categories of Description. Each theme recurs in different categories, described in different ways. Phenomenography is not simply focussed on determining the variations in experiences but the relationships between the different experiences. It is how the experiences vary from one another that is the focus of such a study. The variation in experiences facilitates discernment allowing for a more complete understanding.

It is important that the researcher develops the categories with three criteria in mind:

- The categories of description must be logically related.
- The categories must be parsimonious, i.e., the researcher must strive to create the minimum number of categories that fully describe the variation.

- Each category must be distinctly different from the others; qualitatively different. (Marton and Booth, 1997, p. 125).

The ultimate aim of phenomenography is to reveal the variation in ways of experiencing the phenomenon, and this description of how each category differs is the key output of phenomenographic study.

One of the research objectives of this study is to investigate if there is a relationship between two outcome spaces in relation to one phenomenon, what is termed **relational phenomenography**. Biggs' (1978) study which linked students' study processes with the quality of learning outcomes and Trigwell et al., (1999) study relating teachers' approaches to teaching and students' approaches to learning are both examples of relational phenomenography.

Quality and Rigour

Quality and rigour in phenomenography is often a contentious issue (Sandberg, 1997; Trigwell, 2006; Cope, 2004). Marton (1986) attests that reliability as replicability is not appropriate for phenomenography. The researcher discovers the Categories of Description and thus this **discovery** is not replicable, however, it is possible that once these categories have been found, it is reasonable to suggest that other researchers would be able to agree on them. Marton (1986) provides a good example to explain this concept, in the form of two botanists who visit a desert island to discover flora and fauna. It is conceivable, even likely that within a specified time, each botanist will discover different flora and fauna, and thus this discovery is not assumed to be the same for each botanist. However, through describing the varied types of flora and fauna, a third botanist, should be able to identify the same flora and fauna on another visit, and perhaps come up with a few new discoveries too. As in phenomenography, the ways in which these varied discoveries are described is the key to understanding.

This approach to reliability appears to have been a method used in several studies. Sandberg (1997, p.205) also argues for interjudge reliability and defines this as "a form of replicability in the sense that it gives a measurement of the extent to which other researchers are able to recognise the conceptions identified by the original researcher through his/her categories of description".

Whilst interjudge reliability can be used to assess agreement with the original researcher's classification, Sandberg (1997) also points out that this does not address the researcher's procedures for obtaining faithful accounts of the experiences of the individual. He suggests that the researcher may find it difficult to separate their own pre-concepts of the phenomenon and thus the original Categories of Description may be flawed, but still attain a high agreement rate from other researchers. Bowden et al., (1992) provides an alternative way of maintaining reliability, where the researcher is asked to defend their Categories of Description by other researchers who are familiar with the data. Through testing, probing and discussions, consensus around the Categories of Description can be attained by all researchers.

The issue of **bracketing** is discussed in Bowden and Green (2005) and Ashworth and Lucas (1998. p.422) who highlight the temptation for researchers to become "distracted by immediate reactions to students comments and the need to immediately make sense of them in terms of one's own understanding". Furthermore, the researcher must be aware that they cannot be objective, as Kinnunen and Simon (2012, p.202) explain "the researcher strives actively to be aware of his/her subjectivity and how that might affect the interpretation he is doing". Dunkin (2000) gives an honest account of her experience of undertaking studies about organisational change. In one study, she had the assistance of a phenomenographer/challenger, in the other she worked alone. She highlights the difficulty in sustaining the level of self-discipline required to bracket her previous knowledge:

> As the researcher immersed in the literature, I slipped into the well-worn categories of approaches and leadership styles that characterise that literature. The immediate demand by someone, less familiar with the literature's categories, to know the source of the data for category assertions, was helpful. This immediacy became, then, an added force of rigour (Dunkin, 2000, p. 147).

3.2 Phenomenography Frameworks for Analysis

So far, I have introduced phenomenography as a research methodology, and the theoretical assumptions that set it apart from other research methodologies. I have also described the outcomes of a phenomenographic study: Categories of Description, Outcome Spaces and the concept of Theme of Expanding Awareness. This section describes in more detail some of the theoretical terminology associated with the analysis process in a phenomenographic study and summarises some of the different assumptions made by other researchers.

Cope (2004, p.10) proposes that the best way to ensure a reliable and valid study is when "all aspects of the research have been underpinned with the analytical framework of a structure of awareness". The structure of awareness is the conceptual framework that provides an explanation of how a person is aware of a phenomenon or an aspect of phenomenon. In phenomenography, we aim to describe a phenomenon, (i.e. describe its structure) and in order to describe its meaning, it is important to allow a person to discern the phenomenon from its background. So, a phenomenon has both structure and meaning, or as Marton and Booth (1997, p.87) attest "The two aspects, meaning and structure, are dialectically intertwined and occur simultaneously when we experience something". Returning to the example of the underripe or ripe banana, the structure of the phenomenon would include colour, texture, smell and biochemistry, whereas the meaning explains how they differ. So for example, green, yellow or black within colour; firm or soft within texture and so on.

The first two competing paradigms are those of the "what/how" framework and the "structural/ referential framework" (Harris, 2011). The unit of description in a phenomenographic study must be broken into smaller parts for the purposes of analysis. The what/how framework and the structural /referential frameworks are two options to describe the way in which the description is broken down and are considered frameworks as they "frame" the research design and analysis process (Harris, 2011).

Both frameworks had their origins in studies about learning, with the "what/how" framework first being employed in Pramling's (1983) study on children's conceptions of learning. She conceived of two aspects to the child's learning: the first being, "what" the child perceives to be learning and "how" that learning comes about. She explained that theoretically any combination of the "what" and "how" categories were possible, but there were correlations which linked the two aspects (Pramling, 1983, as cited in Harris, 2011). Marton (1988) was also exploring conceptions about learning and argues that there is a connection between both the "what" aspect and the "how" aspect. He also used the terms "structural" and "referential" to describe the outcomes of learning. "Structure refers to how the outcome is arranged, and reference refers to what the outcome is about" (Marton, 1988, p.64).

Some authors add a level of additional complexity to these frameworks at a second level. In the what/how framework, the second level involves terminology such as the act, direct object and indirect object, whereas in the structural/referential framework, the second level includes the internal and external horizon.

Marton and Booth (1997) coined the terms Act, Direct Object and Indirect Object to explain their findings on their study on learning. In relation to learning, the experience of learning includes two aspects, "what" is learned and "how" it is learned. The outcome of learning (Direct Object) is the "what" is learned, whereas Marton and Booth (1997) propose that the "how" of learning includes both an Act and an Intention (The Indirect Object) in this case. Cope and Prosser (2005) propose a structure of awareness drawing on Gurwitsch's (1964) model of human consciousness which suggested three domains: Theme, Thematic Field and Margin. (Harris, 2011; Gurwitsch, 1964 as cited in Cope and Prosser, 2005). Figure 3-5 is adapted from Cope and Prosser (2005, p.350) and shows the relationship between the Gurwitsch (1964) model and the Marton and Booth (1997) descriptions of internal and external horizons.

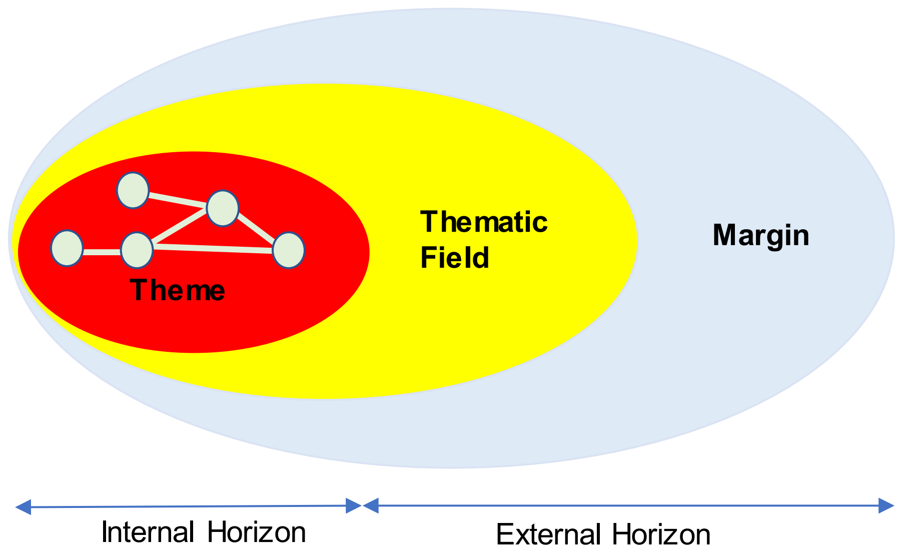

Figure 3-5. Theme, Thematic field and Margin in relation to Internal and External Horizons (Adapted from Gurwitsch (1964), Marton and Booth (1997), Cope and Prosser (2005))

This figure explains that people, when asked to describe an experience, can be simultaneously aware of many things. Some aspects of the phenomenon which are being focussed upon come to the fore and form the theme. They represent the object of focal awareness or become figural or central. All those aspects which relate to the phenomenon, which are simultaneously in mind, but are not being focussed upon make up the thematic field. Other aspects of awareness, other things which are not being focussed on are relegated to the margins (or recede to the ground). Marton (1994) refers to the terms internal and external horizon, where the internal horizon describes the parts that make up the phenomenon and the external horizon refers to the context in which this phenomenon exists.

The concepts described here are best illustrated by an example. Let us refer back to the example of fruit. Imagine at breakfast, a person decides to choose a ripe piece of fruit from the fruit bowl to have with their cereal. At the beginning the person focusses on what fruit is available in the bowl: apples, oranges and bananas. This aspect would contribute to the thematic field "fruit to have with breakfast". The person is also able to discern a piece of fruit from other foodstuffs and hence it forms part of the external horizon. Let's assume they decide upon choosing a banana, then the awareness of other pieces of fruit in the bowl recede to the ground. They now bring into focal awareness the "theme", aspects of choosing a "ripe banana". At this point, they become aware of the different bananas in the bowl; their colour, their smell, the number of black dots which they can see and so on. It is the inter relationships between these aspects that make up the theme or the internal horizon, which forms the structure of the phenomenon.

Finally, in addition to whatever fruit they are choosing, they are simultaneously aware of the noise of the radio in the background and the smell of toast. These are not in focal awareness during fruit selection and are not part of the theme or thematic field, these aspects of awareness are within the external horizon or the margin. To conclude, Cope and Prosser (2005) describe how to use these concepts in order to adequately describe a particular phenomenon:

> A description should incorporate a structural component (the nature of the internal and external horizons), and a referential component (the meaning inherent in the structure). The detail of the structural component should include the aspects of the phenomenon simultaneously present in the internal horizon, the way each aspect is conceptualised, the existence and nature of relationships between aspects, and the nature of the boundary between the internal and external horizons (p.350)

Rationale and use of phenomenography in this research

This study aims to produce outcomes which can be used to educate academics in more complete ways of conceptualising and teaching professional skills. This ambition aligns well with the origins of phenomenography based in an educational setting. Prosser (2000) argues that previous research studies in science education have sought to develop prescriptive solutions to problems in teaching and learning and that this is not effective, that descriptive results are much more powerful. The outcomes will constitute research output in a descriptive form and will allow academics to reflect critically on their own practice, which can account for their own individual conceptions. They can then use this knowledge and awareness of more complete ways of doing things to enhance practice and enact change in the classroom.

Specific Research Questions

Bearing in mind the study aims and the use of phenomenography as a research methodology, the three research questions can now be presented as:

- What are the qualitatively different ways that academics **conceptualise what is meant by professional skills** in engineering?
- What are the qualitatively different **approaches to teaching Professional Skills** that academics use in engineering programmes in Ireland?
- How do academics manifest their conceptions of professional skills through their approaches to teaching professional skills?

The initial conceptual diagram presented in Figure 3-1 is updated in Figure 3-6 as the finalised Overall Framework to indicate the relationships between the context, theoretical framework, research method and outcomes described in this section.

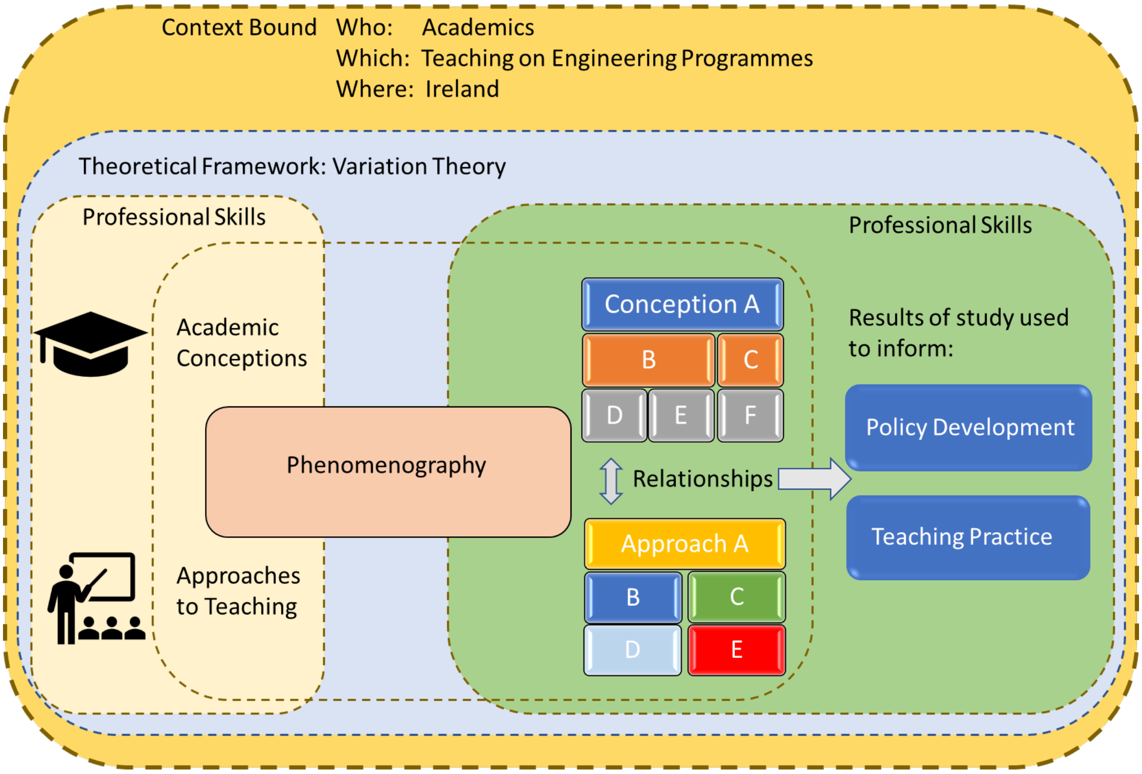

Figure 3-6. Overall Framework of research study

3.3 Overall methodology for study

Marton and Booth (1997) propose that phenomenography is not a method itself but a research approach, where the methods are subordinate. Hence it is intended that this research study employs two phases of data collection: both an online survey and in-depth interviews. Figure 3-7 shows the methodology used to design and carry out this study.

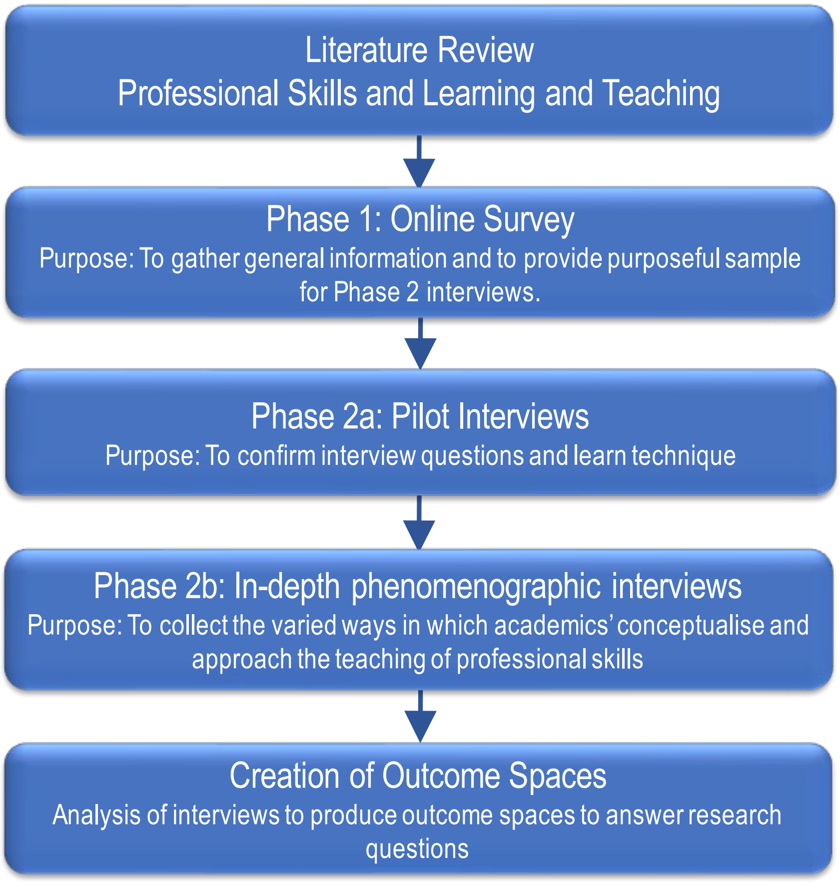

Figure 3-7. Overall Methodology for this study

Phase 1 Online Survey

A phenomenographic study relies on gaining a wide selection of participants in order to maximise variation. To this end, an online survey was created and circulated to the entire data pool of academics teaching on engineering programmes in Ireland (n=942 +/- 60) and gained a response rate of n=321 (34%). With initial data cleansing this reduced to n=309 and by the end of the survey, n=273 (29%) respondents had answered all questions. This provided a bank of 273 academics from which interviewees were chosen.

The survey collected data relating to gender, age, HEI, extent of industrial and academic experience and qualifications. In addition, the survey included a version of the Approaches to Teaching Inventory (Trigwell & Prosser, 2004) described in the literature review as a way of assessing how an academic approaches teaching generally, albeit in the context of a specific module. Finally, respondents were asked to indicate opinions on provocative statements and the importance of specific skills. The purpose of the questions was to create a mechanism to choose respondents who are atypical in order to maximise variation within the interview pool.

Gender is also an important consideration in choosing research participants for interview, and it is important to note that the cohort of academics teaching on engineering programmes in Ireland is predominantly male, at approximately 88% (Beagon and Bowe, 2019b). However, in a phenomenographic study, the aim is not to provide an outcome which is representative of the group, but to provide an outcome which shows maximum variation. Considering gender in research is becoming increasingly important, not only in relation to the gender of academics who are carrying out the research but to the influences of gender on the research itself. Funding bodies in Ireland now require that research proposals include consideration of gender equality in the research (IRC, 2013). As part of 7th Framework Programme (EU Research and Innovation Funding 2007 - 2013) the European Commission funded a project to create a Toolkit to assist researchers in integrating gender considerations in their work (EU, 2013) and this justified the attempt to gain a 50/50 split between male and female interviewees in the study. In relation to phenomenography, Reed (2006, p.6) describes how it is important to select interviewees who offer “the best opportunity of manifesting the full extent of the various ways of experiencing the phenomenon”. He argues that the researcher must not be swayed by being inclusive of gender or other cultural groups, which are in a phenomenographic sense, artificial distinctions. However, Campbell and Wasco (2000) highlight the importance of considering emotion and how emotion can effect women’s experiences compared to men, an issue also raised by Hazel et al., (1997), who attests that emotional responses are important and differ between the genders:

> It would be useful for the phenomenographer in considering a purposive sample to include gender as a basis for ensuring adequate variation, to attend to sex differences in the analysis, and to choose to explore areas of learning central to women's as well as men's experiences (Hazel et al., 1997, p. 224).

The design of the survey or the general findings of the survey are not included in this thesis in order not to distract from the core of the research work: that being the phenomenographic study. It is also important to note that the study does not employ a mixed methods design, as the survey was only used as a way of creating a bank of interviewees. However, a summary of interviewees (with allocated codenames) and their key demographics are included in Table 3-2. More specific details on how interviewees were selected to ensure maximum variation (based on all survey questions) are included in Appendix C and some key findings from the survey data have been published in Beagon and Bowe (2018a; 2019b), copies of which are also included in Appendix C.

Table 3-2: Academics chosen for interview – key demographics

Assigned Name	Gender	Extent of Industrial Experience	Outlier in ATI survey response	PhD Academic Qualification	Education Qualification	Extent of Academic Experience	Main Role
Dermot	Male	>20 yrs	None	No PhD	No	5-10 yrs	Lecturing
Hannah	Female	None	ITTF Outlier	No PhD	Yes	11-20 yrs	Lecturing
Nathan	Male	>20 yrs	CCSF Outlier	PhD	No	5-10 yrs	Lecturing
Muireann	Female	11-20 yrs	None	No PhD	Yes	<5 yrs	Lecturing
Nichola	Female	11-20 yrs	ITTF&CCSF	No PhD	No	<5 yrs	Lecturing
Kathleen	Female	5-10 yrs	None	No PhD	Yes	>21 yrs	Lecturing
Sean	Male	11-20 yrs	None	PhD	No	<5 yrs	Lecturing
Charlie	Male	11-20 yrs	CCSF Outlier	No PhD	No	>21 yrs	Lecturing
Sebastian	Male	>20 yrs	None	PhD	No	<5 yrs	Research
Josephine	Female	5-10 yrs	None	No PhD	No	11-20 yrs	Lecturing
Greg	Male	None	None	PhD	No	5-10 yrs	Research
William	Male	>20 yrs	None	PhD	No	>21 yrs	Research
Rosaleen	Female	None	None	No PhD	Yes	>21 yrs	Lecturing
Christina	Female	11-20 yrs	None	PhD	No	11-20 yrs	Lecturing
Imelda	Female	11-20 yrs	None	No PhD	No	<5 yrs	Lecturing
Joe	Male	None	None	No PhD	No	>21 yrs	Lecturing
Monica	Female	< 5 yrs	None	PhD	No	<5 yrs	Lecturing
Mike	Male	None	None	PhD	Yes	11-20 yrs	Lecturing
Adrian	Male	Information not available for Adrian as he was one of the pilot interviews which was included and he did not complete the survey.					

Interview Methodology

Whilst some texts suggest 25-30 interviews are required (Green & Bowden, 2009) others suggest that saturation can be achieved with 10-20 interviews (Åkerlind, 2005b; Trigwell et al., 1999). The interviews should be undertaken by one researcher "in order to promote consistency in questioning and in the ways in which the responses are prompted and contrasted" (Green & Bowden, 2009, p. 58).

Reed (2006) posits that the interview should yield responses from a participant's **reflection** of a particular phenomenon. This suggests that each interview subject must have experienced the phenomenon and this will also affect the selection of interview participants. It is important for the interviewer to remain neutral and to avoid leading questions or comments which may influence the direction of the answers. In fact, the interviewer should minimise their input and only a few key questions should be planned. Follow-up questions should explore different aspects of the interviewee's experience as thoroughly as possible.

The purpose of the interview is to gain an understanding of the person's experience of a phenomenon and Marton and Booth (1997) liken the interview to a therapeutic discourse. The interviewer starts by bringing the phenomenon in question to the awareness of the interviewee in an "open and concrete form" (Marton & Booth, 1997, p. 130). Åkerlind (2005b) warns about the temptation to delve into the details of the particular phenomenal situation but argues that the details are not important. The reflection on the phenomenon is to be used as a medium to explore what the individual thinks and experiences whilst reviewing the phenomenon. Returning to the example of the banana gives an opportunity to explain this in more detail. In order to ascertain the interviewee's conception of a ripe banana, one would ask "Please talk me through how you selected a ripe banana from the fruit bowl?" Follow up questions may include "why did you choose that one?" and "how did you make that selection?". This would result in a description which could then be interpreted as the interviewee reflected on how they chose the banana and what they considered. This contrasts to an interview question which asks "What is a ripe banana?" which is likely to elicit an opinion or a dictionary definition as opposed to a reflection.

Pilot interviews

Four pilot interviews were carried in order to confirm that the interview questions were framed correctly and provided answers which exposed the interviewees' reflections on experiences in relation to the research questions. Transcripts from the pilot interviews were reviewed by the candidate and the supervisor. Several iterative amendments were made to questions as a result of the pilot interviews. More emphasis was placed on providing examples rather than generic opinions, some questions were omitted and follow up questions added as a prompt.

The pilot interviews gave me an opportunity to practice my technique and learn how to interview. Reflecting on the process revealed the following aspects. Having spent several hours transcribing sections of text which were not in the least relevant to my topic of interest, I became much better at redirecting the conversation when it began to stray off topic. I also learned the importance of staying quiet and not prompting responses, which was challenging. In one case, a particularly reflective answer came after a long pause for thought.

My biggest challenge however was to maintain good time management within the interview, knowing when to delve deeper into a particular statement or ask for clarification or to move on to another topic. I created a template to assist me during the interview which included the questions in a tabular form, to make it easy at a glance to see prompts for probing questions.

The final template used in the main interviews along with the introductory script is included in Appendix D. I found this immensely useful particularly in the early stages of the interview to calm my nerves.

Final interviews

Using the lessons learned from the pilot interviews, I then proceeded with the main interviews over the course of several months. Nineteen interviews were included within the study. Interviews were recorded digitally and transcribed in full.

3.4 Analysis of interviews - Introduction

The phenomenographic interviews were analysed in two phases. The first phase created Categories of Description (COD), describing the qualitatively different ways that academics experience each particular object of interest. The second phase created Outcome Spaces for each research question which describes the logical relations and Themes of Expanding Awareness in relation to the phenomenon.

There are several methods proposed to help phenomenographic researchers analyse the data itself, some of which were presented in this section (Bowden, 2000; Kinnunen & Simon, 2012; Marton, 1986, 1994; Svensson and Theman, 1983). Some researchers treat the transcript as a whole (Prosser, 2000) and Akerlind (2005b) specifically mentions working with transcripts and attempting to describe the similarities and differences between transcripts. Marton (1986) and Svensson and Theman (1983) prefer to use extracts from the whole transcripts, smaller chunks which are extracted for use in analysis and decontextualized in the Pool of Meanings, whilst of course always interpreted within the context of the overall interview. The Categories of Description which emerge, "while not the true story of any one of us, at some level help to define the story of all of us" (Cherry, 2005, p.62).

The detailed analysis of the interview scripts is included at the beginning of Chapter Four.

3.5 Ethical process and consent

It is important in any research work that involves human participants that researchers are mindful of the potential impact of the data collection on any participant. The Irish National Policy of maintaining integrity in research (IUA, 2014) and the European Code of Conduct for Research Integrity (ALLEA, 2017) provide guidance on undertaking research based on international best practice, ensuring integrity through good research practice. Whilst Cohen et al., (2018, p.111) argue that “Ethical issues are rarely as straightforward as rule-following would suggest” there is also a formal process of ethical approval within TU Dublin. The Research Information Sheets and consent forms for both the survey and interviews are included in Appendix B.

Approval was granted by the TU Dublin Research, Ethics and Integrity Committee (REIC) for both the survey and the interviews which form part of this study. Two individual submissions were made and required revisions in order to satisfy ethical concerns in relation to the anonymity of the survey and the ability to withdraw from the research work at specific periods of time. Once the interviews were transcribed, I committed to sending the transcripts to the interviewee for their review and approval. At that time, I had redacted any revealing characteristics which may cause embarrassment to an interviewee should the work be published. This included the name of their HEI, or the name of a particular module they described. Each interviewee was allocated a codename thus when quoting specific participants in the results chapters, their anonymity was assured.

Chapter Summary

This chapter began by describing the theoretical perspective I brought to this research study and the conceptual framework which informed the design of the study and research questions. Phenomenography was presented as the most appropriate method of inquiry to answer the research questions and its theoretical background, methods and comparisons to phenomenology were discussed. Variation theory was proposed as a way of justifying why a phenomenographic study is useful in a learning and teaching context. The importance of validity and reliability in the analysis phase and the consideration of gender during the research work was also highlighted. The overall research methodology for the study was described, which includes a Phase 1 Online survey and Phase 2 interviews. The use of pilot interviews and the framework used to guide the interview itself were discussed, along with lessons learned from the interview process. The final part of the chapter was dedicated to describing the ethical consent process used to ensure that the rights of the participants were respected.

CHAPTER FOUR – Variations in Conceptions of Professional Skills

This chapter presents the findings of the phenomenographic interviews which were carried out as part of this study in relation to the research question:

- What are the qualitatively different ways that academics **conceptualise what is meant by professional skills** in engineering?

Participants were interviewed as described in Chapter Three using the template of questions included in Appendix D. Rather than simply asking the direct question, "What is your conception of Professional Skills?", the questions were posed to allow the participant to describe their experiences. I then interpreted these experiences to draw out the different aspects of their conception. These included aspects such as:

- What do academics think professional skills actually are?
- What is included in their (definitions leading to) conceptions and what is not?
- Are they important/not important for engineers?
- Why are they important/not important?
- What has influenced their conceptions?
- Where do they think engineers learn those skills?
- How do they believe they developed their professional skills?

The interview transcripts were analysed to reveal, qualitatively different and logically interrelated Categories of Description. I will take this opportunity to describe the detailed analysis process used to create the Categories of Description, specifically focussing on variations in relation to conceptions of professional skills as the object of interest.

The findings are presented initially by discussing the Themes of Expanding Awareness uncovered in the analysis. The Categories of Descriptions are then described with a discussion on how each category varies in relation to the Themes of Expanding Awareness. This informs the outcome space which is revealed along with an account of how the logical relations between each category was determined. A proposed hierarchal structure is outlined taking into account the Themes of Expanding Awareness and the Categories of Descriptions described by each individual. Finally, the chapter concludes by discussing the specific findings in relation to relevant literature in this area.

4.1 Data collection and analysis process

Data analysis in a phenomenographic study is discussed in some of the literature presented earlier, mainly in relation to the theoretical concepts in the structure of awareness. However, there are more limited accounts of data analysis with specific instructions. The attempt here is to explain the detailed steps in how the data were analysed to provide what Cope (2004, p.8) describes as a “full and open account” of the analysis process. The data collection and analysis process is shown in diagrammatical form in Figure 4.1 and each step is now described in detail.

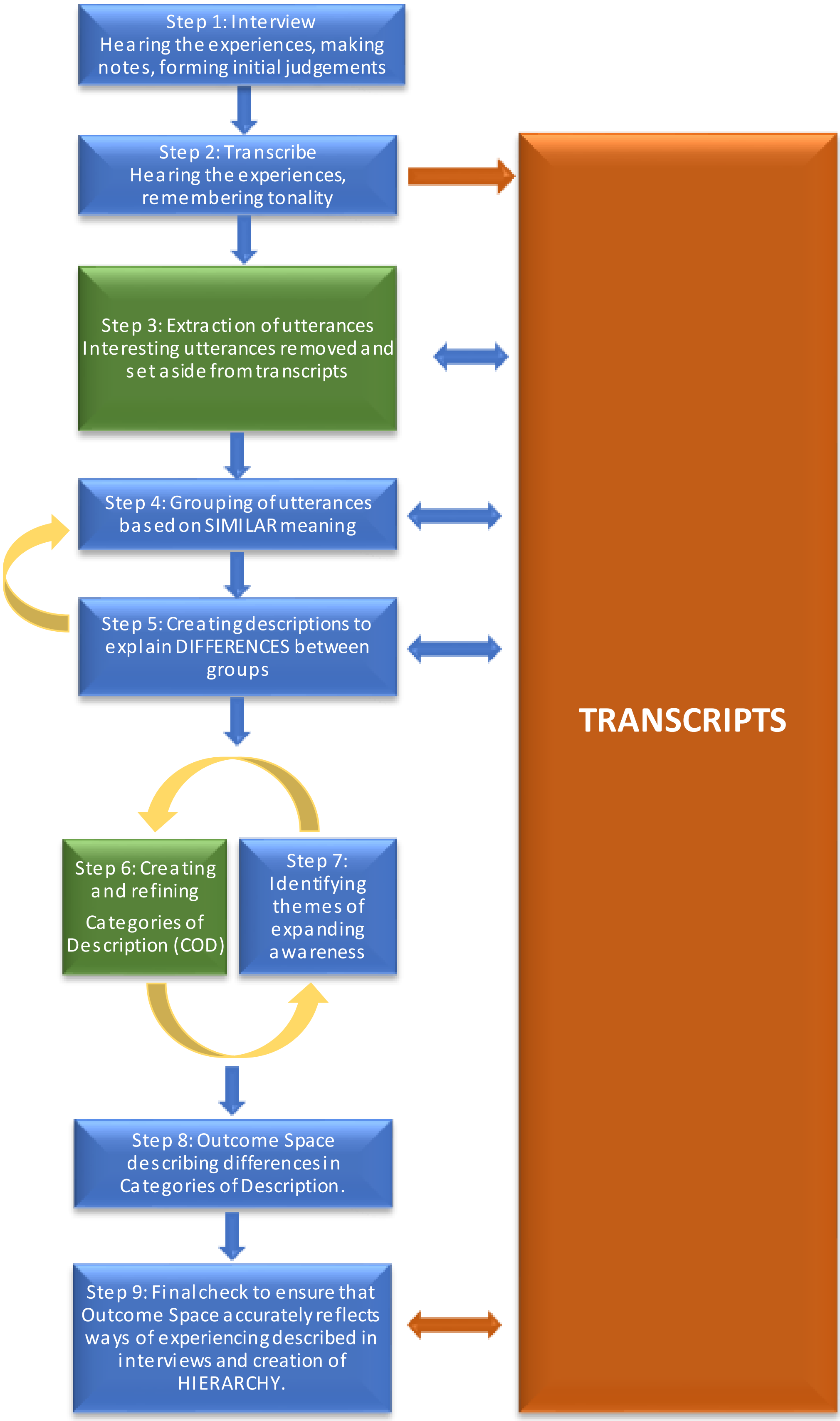

Figure 4-1: Flow diagram showing the process of analysis of interview data

Step 1: Interview

A set of interview questions and notes were prepared in advance and this was used to direct the format of the interview as well as make notes on specific follow up questions or insights gained during the interview. Whilst most of the main questions were similar in each interview, the opening questions were specifically created to put the interviewee at ease and to show them that the interviewer had done some preparatory research specific to them. During the interview, I took notes to help with follow up questions and notes relating to aspects of what they said. The template used for interview questions is included in Appendix D.

Step 2: Accurate Transcription.

Each interview lasted between 45-60 mins and was recorded digitally. A transcription software programme (happyscribe.co) was used to transcribe the voice recordings to Word documents, which although saved some time, also produced documents with many errors and inaccuracies. Therefore, this stage involved listening to the recording of the interview along with the Word document and confirming completeness and accuracy of the transcribed document. Mistakes were corrected and there were many instances where commas (indicating pauses) were auto transcribed in the wrong place, putting a different meaning to the text. This process typically took 3-4 hours per transcript but was very useful as it ensured that the voices and nuances of the interview were embedded within my memory so that when I later read utterances (Marton, 1986), I could remember the tonality of the interviewee's voice. This was important to contextualise the utterances which I may have read at a later date, as I could, for example, remember detecting sarcasm in some instances which altered the meaning of the words.

Step 3: Initial extraction of interesting utterances

Whilst some researchers suggest that the analysis should begin with a subset of 5-10 interviews to reduce the amount of data (Dahlgren, 1995; Prosser, 2000), others suggest looking at the interviews by considering different perspectives at a time (Bowden & Walsh, 2000). I took the latter approach and read the full set of interview transcripts considering only one research question at a time. During this stage I found it helpful to consider the concept of the structure of awareness described in Section 3.2. I considered what was in "focal awareness" when describing an aspect of the phenomenon, or what was within the "internal horizon" (Marton & Booth, 1997).

I read through each transcript and extracted paragraphs which I felt revealed an aspect of the interviewee's conception of professional skills (or the relevant research question). It was at this step where I separated the utterances from their transcript, i.e., whilst the interviewee name was attached to each utterance, the utterances were considered in isolation of the individual, as recommended by Marton (1986). In many cases I extracted full paragraphs which then needed to be distilled or utterances which were interesting, but of no relevance to the research question. Over time I became more confident at determining what was relevant.

Step 4: Grouping of utterances based on SIMILAR meanings.

At this stage, I had extracted utterances relating to the research question and the next step was to attempt to put them into groups based on similarities or rather, what I interpreted as similar aspects of focal awareness. I then attempted to give each group a description, or a common theme to explain why I had grouped them together. In recognition of the need to be parsimonious (Martin & Booth, 1997), I collated them in clusters reflecting the key aspects emerging from the data.

I went back through the utterances which I had initially selected. As I read each utterance, I found it helpful this time to consider the "what/how" (Pramling, 1983 cited in Harris, 2011) framework discussed in Section 3.2. For each utterance I asked myself a few questions:

- "What" is the theme or the focus of awareness in this utterance? (What are they talking about? What is at the forefront of their mind? What are they not talking about, what is on the margin?)
- "How" is it being described? (What is behind this utterance? Why are they talking about it in this way? What are they revealing to me by talking in this way?)

I wrote key notes on each utterance in this step as to the "what" and "how" noted above.

Step 5: Creating descriptions for groups based on their DIFFERENCES

In Step 5, I created descriptions for each group of utterances to accurately reflect the meaning I had drawn from the group. This iterative process moved back through Step 4 and 5 several times until when the new groups stabilised, I felt justified in calling them basic Categories of Description (COD). I went through this exercise several times and hand marked up changes within the description of CODs and added additional comments on the utterances as I reflected on them. I also added in new CODs, including one titled "No COD allocated yet" which included utterances that I couldn't envisage fitting in elsewhere. These were eventually subsumed into different CODs or discounted as irrelevant to the research question through subsequent iterations.

Stage 6: Creating and refining the Categories of Description

The outcome space of a phenomenographic investigation relates Themes of Expanding Awareness with the Categories of Description. In Stage 6, I again reviewed all the initial Categories of Descriptions, this time concentrating on aspects which set them apart, or the differences between them. I then updated the descriptions using a paragraph which described the similarities within the COD and the differences to other CODs.

This resulted in another iteration of all the utterances to ensure they were appropriately allocated within each COD. At this point, I had groups of utterances within CODs and descriptions of each COD.

Step 7: Identifying Themes of Expanding Awareness

At this point, I was also able to ascertain the Themes of Expanding Awareness. These were the aspects of the phenomenon that set each category apart from the next. As a reminder to the reader with regard to the banana example, the Theme of Expanding Awareness may be "colour" and the aspects that set it apart is the different colours you might find in a under-ripe banana, (green), a ripe banana (yellow) and an over-ripe banana (brown). Uncovering and validating the Themes of Expanding Awareness also led to further iterations of the Categories of Description.

Step 8: Creating an Outcome Space

The final stage of the analysis results in an Outcome Space which describes all of the Categories of Description in relation to the Themes of Expanding Awareness. I began this process by creating a table showing the differences in each Category of Description with regard to each Theme of Expanding Awareness. The table morphed into the outcome spaces presented in tabular form. In creating the table, I found it helpful to consider the structural and referential framework (Harris, 2011). In this way, I considered that the Themes of Expanding Awareness were those aspects which described the structure of the phenomenon, the "structural aspect" or the "what". When describing the categories, I used the concept of the referential framework, asking myself: "How does each Category reference that structural aspect, what way is it referenced?"

Step 9: Final check to confirm that the Outcome Space accurately reflected ways of experiencing the phenomenon revealed in interviews and creation of hierarchy.

At the beginning of the analysis process, the utterances which were of interest were isolated from individual transcripts (recommended by Marton, 1986) and although I constantly referred back to the transcripts to ensure that I had interpreted the correct context, at no stage had I attempted to define a "person" as describing Professional Skills in a particular way. The final stage of analysis consisted of re-reading all transcripts for two purposes. First, to satisfy myself that I had interpreted the categories accurately. Second, to help define the logical relations between the categories that had emerged. It was at this point that I went back to each individual transcript and whilst reading, highlighted which Categories of Description were evident in each transcript.

This thesis proposes that a person can reveal several ways of describing the phenomenon, in other words a person can use several Categories of Description to describe their conception of Professional Skills. Looking at which categories were revealed by each individual, gave perspective on the hierarchal nature of the outcome space. In this stage therefore, I used a template and re-read each individual transcript and highlighted the categories that had been revealed. This also allowed me another opportunity to further refine the categories.

This use of a structured method for analysis gave me confidence in the procedure I used and helped me feel comfortable that I had carried out a comprehensive and valid analysis. The exercise of isolating all utterances initially and then going back to the original transcripts to ensure I had accurately reflected the ways the phenomenon was experienced helped bring another layer of credibility and rigour to the work.

The last decision relates to the best way to present the findings of a phenomenographic study. I was conscious that one of the aims of this research is to help engineering academics reflect on their own conceptions of and approaches to teaching professional skills. In my own experience as an engineer, I am more likely to gravitate towards a diagram or a graph rather than read several pages of text and hence I wanted to present the findings in graphical form. In addition to the tabular outcome spaces, I therefore created diagrammatic representations of the outcome spaces to help explain the logical relations of the categories that emerged from the analysis.

Validity and Reliability

As discussed in Section 3.1, there are several ways to improve the validity of a phenomenographic study. Akerlind (2005a) and Bowden et al., (1992) suggest that a communicative validity check which comes from a researcher defending the particular interpretation of a set of data provides confidence in the findings, and this is the approach I took. Several times throughout the course of the analysis, I met with my supervisor to discuss the procedure that I was undertaking. However, once I had completed the Outcome Space for each research question, my supervisor and I held a defence meeting. The supervisor took a sample of transcripts and independently analysed them and created Categories of Description (COD), without looking at the COD that I had created. We then met and discussed and debated each other's findings, which resulted in a deeper understanding and defence of the categories. This was based on the concept of interjudge reliability (Sandberg, 1997). What emerged was a final set of categories which are presented in Chapters Four (Conceptions of Professional Skills) and Chapter Five (Approaches to Teaching Professional Skills). This Chapter moves now from describing the analysis process to presenting the results for the first research question.

4.2 Themes of expanding awareness

In this study, three Themes of Expanding Awareness were identified in relation to Conceptions of Professional Skills. They are:

1. **The purpose** of developing Professional Skills
2. To **whose benefit** the Professional Skills are
3. The **types** of skills or behaviours described

In other words, these three themes emerged as those which differentiated each Category of Description from each other and they are used to show the structural nature of the Outcome Space. They describe and distinguish the participants' conception of professional skills as revealed by interpreting the participants' experiences related in the interview. Each Theme of Expanding Awareness is now described in detail explaining the variation of the theme across the Categories of Description.

Purpose of developing the skills

This dimension captures the reason why engineers would develop these skills. In one category the focus is on communication, being able to communicate, usually in verbal or written form. Interviewees describe the skills of communicating and the importance of having their voice heard. The purpose of developing skills in this instance is so that the engineer can **communicate**, and the focus is inward, on the engineer themselves.

For others, the purpose of developing professional skills focusses on having discipline specific technical skills which an engineer needs to practice engineering. This theme expands further to include not only technical skills which an **engineer can use**, but to develop a mix of technical and other skills which allow an **engineer to function**.

Developing skills which not only allow an engineer to function, but **to be successful** is a further development of this theme. These are often referred to as the skills which translate technical knowledge into practical applications or enable engineers to solve problems. These are distinguished as something different from discipline specific technical skills and are recognised as those which make successful engineers. The purpose of developing skills in this instance is that the skills make an engineer successful and is at a higher level than developing skills just to be able to communicate or for the purpose of functioning as an engineer. Again, the focus is inward, on the engineer themselves.

Another tenet of this theme encompasses a much wider conception of the purpose of developing professional skills and is outward facing and includes a human and societal element. Utterances (Marton, 1986) describe the purpose of developing skills to enable engineers to **work with people** and build relationships with peers. Rather than describing skills, the utterances included in this aspect reflect behaviours: those behaviours that help build good relationships when interacting with people. Respect and courtesy to others are given as examples of behaviours in this instance. Working in teams with others and how communication is received by others is of most concern (outward facing) rather than focussing on the skills associated with learning how to communicate (inward facing). The final aspect of this theme also relates to behaviours, but in greater breadth to working locally with people, it looks externally to the outside world and the impact that an engineer **has on society**. Accounts consistent with this aspect of the theme reveal the importance of engineers taking responsibility for their own actions, reducing risks, being aware of health and safety considerations. The concepts of working with integrity, understanding ethics and considering sustainability are also revealed which shows a hierarchally superior purpose. The purpose in this final aspect is not only to be a good engineer, nor just to have the enabling skills to succeed on a personal basis, but to serve society in a respectful, responsible and ethical manner.

Benefit

This theme of awareness is used to differentiate how interviewees revealed the reason for developing skills. In some instances, the interviewees describe how engineers **serve industry**, they needed to develop skills because that is what industry required, but in other instances, development of the skills was for the **benefit of the person**, so the person could be successful in life, industry was not in their focal awareness. The **benefit to society** of an engineer behaving ethically and sustainably is also recognised as an aspect of this theme.

Type

Finally, the type is used to differentiate if categories describe different types of skills, whether that be **discipline specific technical engineering skills**, or more generic skills, described here as **non-discipline specific skills** or **behaviours** or a combination. Skills are assumed to be something that a person can learn and then apply to a situation, whereas behaviour is used to describe a more innate quality, such as ethical character. Some examples of the types of skills or behaviours revealed within each category are also provided for clarity in the outcome space.

4.3 Categories of Description

Six Categories of Description were revealed in the data. The categories are qualitatively different, based on the Themes of Expanding Awareness described earlier. Each Category of Description is now described in relation to the three Themes of Expanding Awareness along with associated utterances taken from the data. As a reminder, the interviewees have been given codenames for anonymity and are referenced as (Hannah), (Christina) etc.

Category A – Communication Skills

Category A represents a view of Professional Skills as those skills needed to communicate only. Included within this category is written communication in the form of reports, verbal communication in the form of giving presentations and communicating effectively in meetings. Interviewees see good communication being of benefit to the person themselves. The purpose of developing these skills is to be able to communicate and make your voice heard. Speaking and becoming confident in communicating one’s own voice are crucial foci of the interviewee’s awareness in this category.

Hannah provides a simple definition of professional skills as communication skills, comparable to Christina’s conception. Here we note that the skills are not discipline specific engineering skills, but more generic skills independent of the discipline (non-discipline specific skills):

> "Well I would say professional skills is your communication skills, your written skills, your presentation skills, you know those types of skills". (Hannah)

> "Professional skills are the skills that……. that all students regardless of discipline need to be comfortable with and be familiar with". (Hannah)

> "For me the professional skills are then………. It's very much about communication. So it's the written word, it's the presented word". (Christina)

Monica also describes professional skills as communication skills but explains the nuances of the different types of communication styles needed to speak to people on different levels.

> "The ability to communicate effectively, with not just your colleagues or your peers but to communicate to somebody senior and communicate to somebody junior because we're all the time talking to people at different levels". (Monica)

In addition, this category is also used to describe how engineers find their voice. Learning to stand up for themselves in meetings is mentioned several times by female interviewees, highlighted here by Muireann and Imelda. In this instance Muireann, although referring to an incident in the workplace, is focussing on her own voice, learning to be heard for her own benefit and not necessarily for the benefit of the workplace.

> "But to be able to articulate what you need. Now, I would say for me and if you were to say from a female perspective, I would've sat in endless meeting rooms where I'm the only female voice. So the simple thing …….and maybe that's why I'm going into spontaneous speaking and how you come across when you speak, because a few times I might have said something and either the room would just continue on with the chat, because they haven't heard what I said or I haven't said "Excuse me", you know politely, maybe too politely. But then when I say "Excuse me" again, and then because of the different tone, everything goes dead and they're all looking at you and what do you do?" (Muireann)

Imelda describes the importance of learning the skills of communication, to talk to people appropriately, to stand up for yourself.

> "You learn through working as well. You learn to be able to, especially whenever you're in a male dominated industry, you also learn, how to be professional and talk to people but still stand up for yourself. Because I've been in a room with maybe 20 men, all a lot older than I was. I'd have been what 24 or 25. And a lot of them would have had no respect for you. I sort of developed and learned myself, where's the boundary, what to say, what not to say, but still firm enough to stand up for me." (Imelda)

Category B - Discipline specific technical skills which engineers use

Accounts consistent with this category highlight the importance of discipline specific technical skills. The purpose of gaining these skills is that they are the discipline specific skills needed to be an engineer, the core technical skills that engineers use. The benefit in this case is for industry: these technical skills are being taught so that engineers can serve industry; industry is the object of focus.

Mike explains that the skills are those which are of benefit in professional life, suggesting skills which are of benefit whilst working as an engineer with no mention of the benefit to the individual.

> "It's really any skill … I suppose, I think of skills as things that are learnt. So say it's anything that a person learns, at any point in their life, which is useful in a professional context. So that's used or would be useful within their professional life." (Mike)

Dermot when describing Professional Skills, explains the importance of really understanding the baseline of what engineers do, the requirement to be technically proficient so that the buildings engineers design will stand up. He gives examples of working in an organisation as a consulting engineer and explains why clients could be convinced to hire particular engineers:

> "If you know what you're doing, I think that comes easy. That's technical, if you actually know what you're doing". (Dermot)

When describing how students learn these skills, he again reveals his conception of skills in reference to technical text books. Specifically:

> “You know there’s no substitute for actually reading the books and studying the materials”. (Dermot)

He goes on to explain that the role of an engineer is to solve problems. Note here the differentiation between “skills needed to solve problems” and “problem solving”. Dermot interprets the skills needed to solve problems as technical skills only.

> “Uh I think first and foremost it means actually really understanding and being good at what the thing is that you're doing, because if you don't do that, no amount of marketing, not in this business anyway … .marketing won't get you very far if the stuff doesn't stand up.” (Dermot)
>
> “Engineering is about just solving problems and that's what it is. That's the only skill actually- solving problems. Go back to the other question ….what was it again? (Dermot)
>
> Una: Professional skills are the skills that……………….
>
> Dermot: ………….. allow you to solve problems. All other skills are icing on the cake or distractions.” (Dermot)

Finally, Kathleen when asked to describe what the term professional skills means, immediately refers to discipline specific technical skills.

> ”So I suppose I would be looking at discipline specific skills as an engineer. You know, that you keep on top of your area, either through research, engagement with peers, that kind of thing and attending courses. Yeah. So discipline is always kind of my number one you know.” (Kathleen)

Category C - Skills which enable a person to be a successful engineer

In this category, professional skills are conceptualised as those skills which enable someone to become a successful engineer. Here the focus is on the person, the success is for personal benefit, not necessarily for the benefit of the engineering company. In several instances, the skills are described as "enabling skills", those which translate the foundational technical skills into something else, to allow someone to become a **successful** engineer. These skills are described as non-technical skills: communication, presenting an argument and problem-solving skills, and are separate from discipline specific technical skills.

Several interviewees specifically use the word "enable" in their definition of professional skills:

> "Professional skills are the skills that……………….. enable you to be a good engineer and to continuously develop throughout your career". (Sebastian)

> "Professional skills are the skills that……….enable a person to function and reach their potential in a workplace whether that be a private company or consultancy, whether that be a university and a teaching environment or even primary or secondary school and or whatever the work environment; that a person can achieve their potential". (Monica)

> "Professional skills are the skills that …………….enable our students to carry out their work as an engineer in a very professional and excellent way". (Christina)

William and Muireann reveal the importance of developing these skills for the person's benefit, for their personal success in life, not for the benefit of industry.

> "They're the skills that make or break a working engineer. They're massively important". (William)

> "Professional skills are the skills that…well I think…….that either makes or breaks you as an engineer. It's a key to success for me." (Muireann)

The distinction between discipline specific technical skills (Category B) and enabling skills (Category C) is revealed by Monica. When asked about the importance of developing these professional skills, Monica describes how they compare to the discipline specific technical skills, that there is too much emphasis on the technical skills suggesting the skills she is describing are something else, in essence non-technical skills.

> "Essential. I mean it's……..I think often, there's too much emphasis on the technical." (Monica)

Finally, Christina, Sean and Nichola discuss how there is little value in having technical skills if engineers do not have these enabling skills to translate technical ideas or to communicate their ideas to others. Again, the focus is on the benefit to the engineer, how the engineer will be more successful if they have these skills.

> "If you can't share your information, if you can't go to a public hearing, if you can't stand up in front of a committee and present, like it's going to be to the detriment of your own development in the profession." (Christina)

“To me, professional skills are those skills that allow an engineer to be able to communicate properly, to be able to write coherent, technical, reports. It's also presentation skills; to be able to present yourself. I tell my third years especially and sometimes the fourth years - you could be the greatest engineer I have ever come across. If I can't put you in front of the customer, you're gonna be sitting in a lab somewhere and I will get your friend who is not a great engineer, but can talk. He’ll go to all the trips with customers and I will tell him if you have any issues, ring John back in the lab and ask him to explain it to you”. (Sean)

“And you go out to industry, if you can’t communicate, you will be gone. You'll be out of there. If they don’t get you out of there, you’ll be shifted into some position where you're not being given any responsibility. You don't get any progression. Where you'll notice the guys who aren't as good as you, but can talk the talk – they’ll go up”. (Sean)

“Sometimes you can have the most intelligent brilliant engineer, but unless they’re able to communicate it or unless they can work on a team based approach, sometimes it doesn't work.” (Nichola)

Category D - A combination of Discipline Specific Technical and Non-Technical Skills

The prime focus in this category is that Professional Skills are a mix of both discipline specific technical skills and non-technical skills. Both sets of skills are seen as important aspects of an engineer's work. This category differs from Category C (Enabling skills) in two ways. Firstly, this category includes both discipline specific technical skills and non-technical skills, whereas Category C (Enabling skills) only refers to non-technical skills. Furthermore, in this category, having a combination of skills is to the benefit of both the company and the person, industry and the person are both in focus, compared to Category C, which only views the skills as a personal benefit.

Some accounts within this category refer to "soft skills" and describe these as communication, project management etc., yet there is an acknowledgement that discipline specific technical skills are also important.

> "I suppose it would be made up of both soft skills and hard skills. So I suppose the hard skills would be the technical side of things, the soft skills……………would be organization, self discipline". (Rosaleen)

Greg also acknowledges the importance of both types of skills and could be considered within Category C (Enabling Skills), except that the employer is the focus in Greg's utterance. He refers to the importance of being able to answer a question from your employer in the workplace.

> "The technical knowledge counts you know, it is important, it's very important. But you know, if you can't solve problems as

> well…….that could be your boss's question. There will be that kind of boss question, they come around and tell you this and you say "Oh, you didn't give me a table *[reference table for material properties]* - I don't know". The skill that you can do things without having the right information. That's the most important one. By making assumptions. That's what engineers do really you know in the workplace." (Greg)

Finally, Mike describes Professional Skills as being a mixture of both discipline specific technical skills and non-technical skills. He also references the importance of being able to perform in the workplace, referring to industry benefit and his reference to taking on certain responsibilities also shows the aspect of personal benefit.

> "In engineering I suppose, we would develop a sense that there's some technical skills which are definitely in that domain. So, like in electrical engineering, it could be everything from using like autocad to…you know….. integrating equations or whatever. There could be specific technical skills which are going to enable them to take on certain responsibilities within their professional lives. And so I think they're definitely professional skills. Then there's a whole other side of things which aren't maybe as specific to engineering but they are skills which are going to be useful in a professional workplace in the general sense. So it could be everything from writing a grammatically correct, well presented email. To chairing a meeting, to giving a presentation. I would see all of those things as skills which are potentially very useful in the workplace". (Mike)

Category E - Interpersonal behaviours to build successful relationships with people

Accounts associated with this category reveal the aspect of being able to work with other people and of the importance of building good working relationships with others in a team. The skills required in this category, include but are not limited to good communication skills. Attitude to others, empathy for others, negotiation, conflict resolution and good listening skills are also highlighted as skills within this category.

This differs from Category A as the emphasis is **not only on having** good communication skills, but being aware of and understanding **how** the skills are used. This is therefore described as a behaviour rather than skills. Being able to work in a team and understanding and responding to team dynamics is an aspect revealed in this category. As noted in the introduction, this category is limited to local encounters with team members in a workplace scenario and does not look outward to the world.

Monica talks about not only the skills, but being aware of how to use the skills effectively by asking a person a question "in the right way", whilst William specifically refers to working in a team and Muireann to working with difficult people. Greg although providing reference to Category D (Combination of skills) also refers to the importance of working in a team and how communication is part of that. How one reacts to a situation and their attitude towards other people is important here.

> "Negotiating, communicating, listening I suppose. Asking the right question of the right person in the right way. I suppose we could generically say people skills". (Monica)

> "I presume you're talking about what we often call the soft skills, so communication, teamwork - that sort of thing". (William)

> "Well the big ones for me that probably aren't usually taught would be that spontaneous speaking and negotiation skills, conflict resolution. Those are the big things, and working on a team. So like everything is teamwork. You know, there's always one person that you have to try and work with that you might not like to." (Muireann)

> "Well it's probably a set of skills. It could be this one, could be technical, technical knowledge, teamwork. And you know attitude. Attitude as well with other people and when under pressure, how do you perform. You know what's your reaction. Shouting? Could be you know there's nothing wrong with that". (Greg)

Finally, Joe puts it succinctly.

> "Professional skills are the skills that lead you to having a successful relationship with your peers". (Joe)

Category F – Acting in a professional manner towards people and society

The focus in this final category is acting as a professional, which involves both behaving in a professional manner to other people, and having the attitude, responsibility and ethical mindset to be a professional engineer. This category is much broader than Category E (Interpersonal) as it is not just about behaving appropriately around people, but includes aspects of a person's character and their worldview. It is not limited to local encounters in the workplace as was the case in Category E. In particular the reference to ethics, integrity and sustainability highlight the impact of the engineer in society and the responsibility engineers have beyond their everyday engineering work life.

Acting as a professional is described in different ways; behaving in a respectful manner to other people (Joe and Imelda), having responsibility for one's own actions (Monica and Imelda), behaving ethically (Muireann and Imelda), with honesty and trustability (Nichola), the effect of an engineer's actions on the environment (Sebastian), and finally, having a professional responsibility to society (Nathan).

The aspect of behaving professionally to other people was highlighted by Joe and Charlie. Joe gives an example of how he felt disrespected with a particular instance of student behaviour and how he considered that the behaviour was "unprofessional". He goes on to describe aspects of Enabling Skills, Communication Skills and Interpersonal skills within this description.

> "I mean professional skills can be very simple things as well. And I do say to….I said it this morning - behave in a professional way. So one student - he had a medical appointment, so he arrives an hour late. I don't think it's professional just to walk in and sit down. I

> think it's professional to address your line manager and say - sorry I had a medical appointment. And I encourage them to think like that, to think professionally. So, courtesy and good manners is a very important skill to have when you're dealing with other people. You get the best from people if you respect them and you respect their position. That's one thing. Other professional skills, I mean I suppose then you getting towards the technical areas, but being able to present an argument, being able to explain something to another person and that might involve technical language. Also I suppose having empathy for people's difficulties with things, and having patience with people". (Joe)

Imelda also refers to the concept of respect and gives an example of a workplace scenario where respect was not evident. This revelation was also presented as an example in Category A (Communication Skills) and includes aspects of Category E (People Skills). It is included here because it goes further than those Categories, the focal awareness is on respectful behaviour, not necessarily just about having the communication skills to deal with situation or the ability to work in a team.

> "You learn through working as well. You learn to be able to, especially whenever you're in a male dominated industry, you also learn, how to be professional and talk to people but still stand up for yourself. Because I've been in a room with maybe 20 men, all a lot older than I was. I'd have been what 24 or 25. And a lot of them would have had no respect for you. I sort of developed and learned myself, where's the boundary, what to say, what not to say, but still firm enough to stand up for me". (Imelda)

Imelda starts by explaining Professional Skills and then gives several examples of how she acts in a professional manner in the workplace. She also describes aspects of Category A (Communication Skills) and Category E (Interpersonal Skills).

> "I suppose for me it would be the ethics, conducting yourself I suppose in a professional manner………….. I think they should know how to conduct themselves whenever they're in an environment. And be responsible for what they do. One of the things I notice, even just in emails and how their skills are in that, I can find quite bad. There is no professionalism" (Imelda)

Examples of when she has used professional skills in the workplace:

> "I suppose conducting myself appropriately. Dressing appropriately. The manner in how I speak to the students……….In the lab situation, I will try and always bend down to their level in the lab. I'll never talk over someone in the middle of the lab, I'll always go down on my hunckers, look at the screen with them, because then they're on a one on one with me. So I would do all of that kind of stuff…………Then in industry, I suppose you had lots of it. It's the same thing, you're reporting to a manager. At the end of the day he's your boss. You have to speak to him appropriately. Turn up appropriately. Come into work appropriately. All of that really". (Imelda)

Nathan also reveals how in practice an engineer has to be mindful of their behaviour, they have to moderate their behaviour depending on the situation and this is an example of behaving professionally.

> "You then kind of from a professionalism point of view, have to understand that in practice you have to be a professional, irrespective of whether the client is treating you well or not. When you come up with a problem, on a site with a project, how do you professionally deal with that, not lose the rag. And what your responsibility is then." (Nathan)

The revelation that to behave professionally includes consideration of ethics and working with integrity reveals the broader conception that includes the character of the engineer. Muireann discusses behaving professionally, both in verbal and written communication but also adds the aspect of ethics and working with integrity, a view shared by Nichola.

> "Em so I think for me it is a form of communication and how they present themselves. So it's a way of - can they speak clearly and simply. In other words if you're walking down the corridor and your manager or somebody that's related to your project says "How are things going?" that they are able to spontaneously speak. So that would be one thing I'd kind of pull into it – "in a professional manner". I think whatever they write, their e-mails that they write, the documentation that they put together, you know, that it is professional. So then, I suppose I don't touch enough on it, but I really think on the ethics of ….. just working with integrity. You know, so many of them ask me like " Sure like how do you know, can I not just make up that data?". "Absolutely you can". You know. So, I do introduce that discussion. Now I do think there should be

> an awful lot more than that. It's very very hard to bring it in because it's so individual I suppose." (Muireann)

> "Professional skills to me means - honesty, trustability, good communication skills, integrity. Things like that, sometimes things that can't be learned from a book. To realise the importance of co-workers and colleagues, to listen to everyone's opinions." (Nichola).

Finally, Nathan and Sebastian describe professional skills including several key aspects; having the core technical skills so that engineers can do their job responsibly (Category B), how engineers interact with other people and with clients (Category E) and finally being aware of the impact of an engineer's work upon the environment and society in general (Category F).

> "So you need to be able to tackle problems you haven't seen before and poorly defined problems. Most of the time you don't have enough information and so I think to be a good professional engineer, you need to have a very solid founding in the principles of the profession, so that's maths, physics and those type of subjects. I think that's really important as your core. I think also a lot of the time as an engineer what you're doing is you're on the phone. Where you're meeting people and you need to get across to someone who might not have your background exactly what's important and why it's important. So communication is definitely really really big……..
> And then there's other things around ethics and maybe sustainability and things like that which would be good for an engineer to have in their mind as they go about their professional job. But definitely

> yeah, those core technical skills and communication I think would be the biggest things. If you're leaving college without either of those I think you're in trouble". (Sebastian)

Whilst it has been interpreted that utterances which mentioned the importance of acting ethically and with integrity show an awareness of how engineers interact with society, Nathan provides the quote which forms the pinnacle of this category, specifically recognising the impact on society.

> "So therefore professionalism is the technical knowledge that you bring into industry, but it's also the way you manage and run business, the way that you have a professional responsibility to your clients. And you have a professional responsibility to society and to contribute back." (Nathan)

In summary, six Categories of Description were revealed in the data:

A. Communication skills
B. Discipline specific technical skills which engineers use
C. Skills which enable a person to be a successful engineer
D. A combination of discipline specific technical and non-technical skills
E. Interpersonal behaviours to build successful relationships with people
F. Acting in a professional manner towards people and society

Table 4.1 shows a tabular form of the outcome space for Conceptions of Professional Skills which details the aspects of the Themes of Expanding Awareness in relation to each of the Categories of Description.

Table 4-1. Outcome space for Conceptions of Professions Skills (Tabular Form)

Variation	Category A Communication	Category B Technical	Category C Enabling	Category D Combination	Category E Interpersonal	Category F Acting Professionally
Purpose	To be able to **communicate** verbally and in written form and to make your voice heard	To have discipline specific technical skills which you can **use as an engineer**	To enable a person **to be successful** as an engineer	To have a mix of technical and other skills **to function** as an engineer	To be able to **work with other people**, to have good relationships with your peers	To **act in a professional manner**, towards people and society
Benefit	Personal Benefit	Industry Benefit	Personal Benefit	Personal and Industry Benefit	Personal and Industry Benefit	Personal, Industry and Societal Benefit
Type	Non-Discipline Specific SKILLS Verbal and written communication	Discipline Specific Technical SKILLS Technical Discipline Specific Skills	Non-Discipline Specific SKILLS Communication, present an argument, solve problems	Discipline Specific and Non-Discipline Specific SKILLS Combination of skills	Non-Discipline Specific BEHAVIOUR Attitude towards others. Respect and courtesy	Non-Discipline Specific SKILLS and BEHAVIOUR Attitude, Responsibility Ethics & Integrity

4.4 Hierarchal Structure – Conceptions of Professional skills

The first step in creating an outcome space is to reveal the Categories of Description. However a phenomenographic study considers that there are logical relations between the Categories of Description. Whilst the logical relations can be determined from considering the differences in the Themes of Expanding Awareness, there is also value in making the Outcome Space hierarchal, particularly if the intention is for the study to be used in an educational setting. Presenting an outcome space hierarchally allows readers to reflect on where they currently sit on the hierarchy and to consider more complete ways of understanding a phenomenon.

It is important to state some assumptions to differentiate between Conceptions of Professional Skills and Categories of Description at the beginning of this section to prepare the reader for the discussion on how the hierarchal structure was defined.

So far, this Chapter has described the six Categories of Description which were revealed in the data, that is Professional Skills can be described using six Categories of Description.

However, the term "**Conceptions of Professional Skills" is something different to the term "Categories of Description"** which describe Professional Skills. A Conception of Professional Skills may include **one or more** Categories of Description.

Hence, this thesis proposes that individuals will have a Conception of Professional Skills which may include one or several of the six Categories of Description revealed in this study. For example, a participant may have revealed that they believe Professional Skills to be Category A (Communication) **and** Category B (Technical) **and** Category C (Enabling) etc., evidenced in some of the utterances provided earlier.

The hierarchy was developed by reviewing the variation in the Themes of Expanding Awareness indicated in Table 4.1 and the different Categories of Description revealed by each participant. Each Category of Description will now be described in relation to the hierarchal structure by giving examples of those interviewees who revealed each Category. Diagrams will be used to highlight the Conceptions (i.e. the combination of Categories of Descriptions) revealed by some of the interviewees. It is important to note at this point, that **not every participant revealed the exact same combination of categories**, nor is there an attempt here to suggest that higher level categories (for example Category F) are **always** inclusive of lower level categories. The diagrams are merely provided to assist in visualising the logical relations revealed in the Outcome Space.

One of the key findings of this research study is that there is an acknowledgment amongst academics on the importance of behaviours, that Professional Skills are not limited to skills alone, but involve behaving in a particular way. Furthermore, the aspect of "benefit", to whose benefit the development of these skills are, is another important finding in this study. Therefore the diagrams are drawn in relation to two axes to show how each Category of Description differs with regard to the type of skills and to whose benefit revealed in each category, or rather the Themes of Expanding Awareness "Type" and "Benefit" have been used to show the relations between each category within this hierarchal diagram.

Category A – Communication Skills - Hierarchy

Only one interviewee (Hannah) revealed the conception of Professional Skills as Category A (Communication skills) only, with no reference to any other categories and therefore it has remained as an independent category in this study. Fourteen other participants also revealed Category A (Communication Skills) in addition to other categories. However, Hannah's Conception of Professional Skills is Category A (Communication Skills) **only** and is shown in Figure 4-2a.

Category B – Discipline specific technical skills which engineers use – Hierarchy

Three interviewees (Dermot, Josephine and Kathleen) described Professional Skills solely as discipline specific technical skills and are included within this category. Other participants also revealed this Category of Description in addition to other categories. However, since Dermot, Josephine and Kathleen did not reveal any other categories, it also remains as an independent category in this study. Figure 4-2b also shows their Conception of Professional Skills.

Category C – Skills which enable a person to be a successful engineer – Hierarchy

Thirteen interviewees revealed this Category of Description during their interview. Two interviewees (Sean and Christina) described only this category **and** Category A (Communication Skills). Since, Hannah (Category A) did not reveal Category C, but Sean and Christina revealed Categories A and C, it follows that Category A is a subset of Category C. Therefore, Sean and Christina's conceptions of professional skills is indicated in Figure 4.2c and is shown as Category C being hierarchally superior to Category A. The other eleven interviewees who revealed this Category C also revealed other categories.

Category D - A combination of discipline specific technical and non-technical skills – Hierarchy

Six interviewees in total revealed this category, although four of them went on to describe other categories not yet discussed in regard to hierarchy. Two of the interviewees also revealed aspects of categories A, B and C.

Referring to the tabular outcome space and the theme of "benefit", Category D (Personal and Industry Benefit) encompasses Categories A and C (Personal Benefit) and Category B (Industry Benefit). This category also clearly consumes Categories A, B and C when referring to the theme "type of skills", as this Category D (Combination) includes both the Discipline Specific Skills of Category B and the Non-Discipline Specific Skills of Categories A & C. Hence Category D has been shown at a higher hierarchal level than that of A, B and C. Mike has been used as example to show someone with this conception in Figure 4.2d.

Category E -Interpersonal behaviours to build successful relationships with people – Hierarchy

In total, ten participants revealed this Category of Description within their interviews, however there is no evidence to suggest that Category E is always inclusive of all the previous categories. This is also reflective in the Outcome Space which shows whilst there is both personal and industry benefit (hence hierarchally superior to Categories A, B and C) the type of skills revealed are not actually skills, but a shift to behaviours. However, there are two main groups of people who revealed this Category of Description within their interviews.

Greg and Rosaleen reveal all of the Categories A-E and their conception is shown in Figure 4.2e. William reveals Categories A, C and E only. His conception is shown in Figure 4.2f. Comparing both of these groups of people highlights that there is an acknowledgment that behaviours are important, however the key difference in conceptions is in regard to the inclusion or exclusion of technical skills as the case may be.

All other six participants who revealed Category E, also revealed Category F and hence will be discussed in the next section.

Category F - Acting in a professional manner towards people and society – Hierarchy

Finally, seven participants revealed aspects of Category F (Acting Professionally) as a category of description in their interview data. Again there were variations in the other categories of description that each of the six participants revealed as follows: Imelda (Categories A, E and F); Sebastien (Categories, A, B, C, D and F); Monica, Muireann, Joe and Nicola: (Categories A, C, E and F) and finally Nathan revealed all six categories (Categories A,B,C,D,E,F).

There is one key difference in the way participants who reveal Category F conceptualise professional skills and that relates to the to the inclusion or exclusion of technical skills in their conception of professional skills. Imelda, Monica, Muireann Joe and Nicola all refer to aspects of Category F (Acting Professionally) but do not specifically reveal that their conception (which includes Category F) also includes (Category B) Technical Skills. That is to say, Category F, whilst hierarchally superior to other Categories, does not always include those other categories. As a reminder to the reader, a Conception of Professional Skills can include one or more Categories of Description. On the other hand, Sebastien and Nathan's conceptions which include Category F (Acting Professionally) do also include the aspect of (Category B) Technical skills and hence could be considered a more complete conception. For reference, Monica, Muireann, Joe and Nicola's conceptions are shown in Figure 4.2g and for completeness, Nathan's conception is also shown in Figure 4.2h.

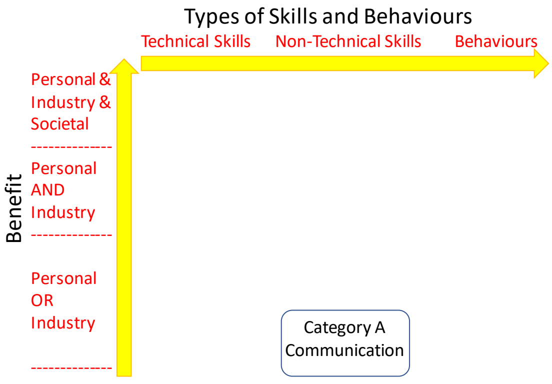

Figure 4-2a: Hannah's Conception of Professional Skills

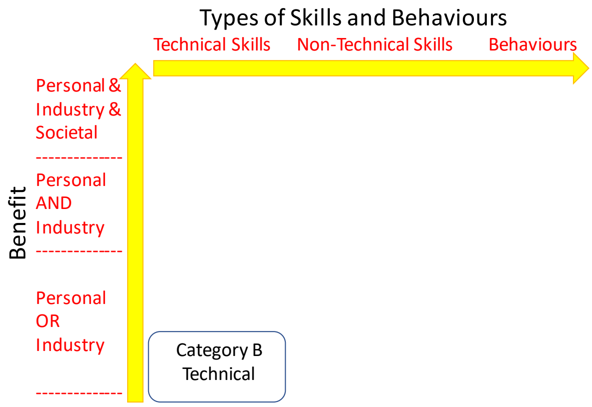

Figure 4-2b: Dermot, Josephine and Kathleen's Conception of Professional Skills

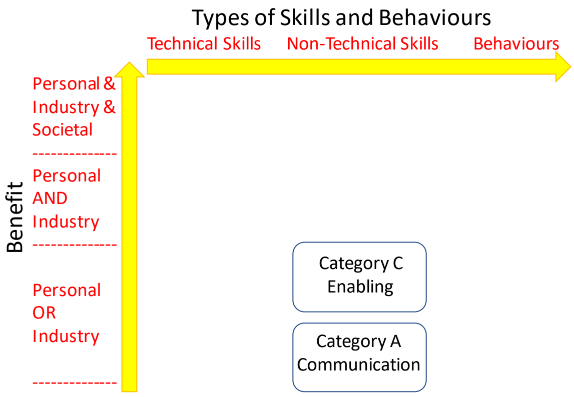

Figure 4-2c: Sean and Christina's Conception of Professional Skills

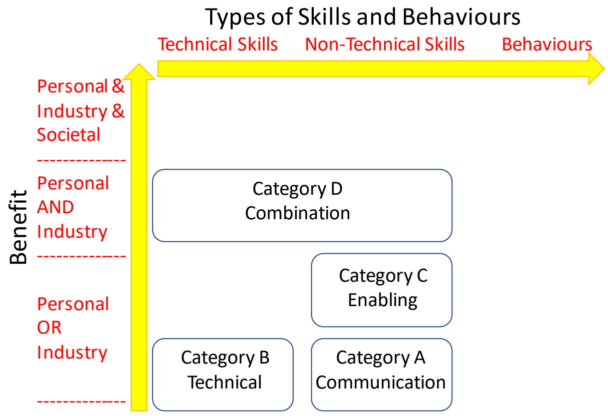

Figure 4-2d: Mike's Conception of Professional Skills

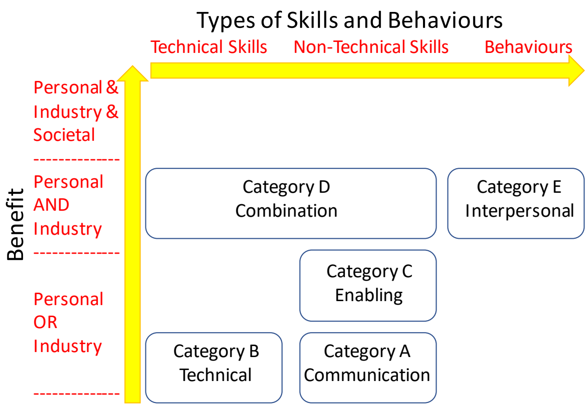

Figure 4-2e: Greg and Rosaleen's Conception of Professional Skills

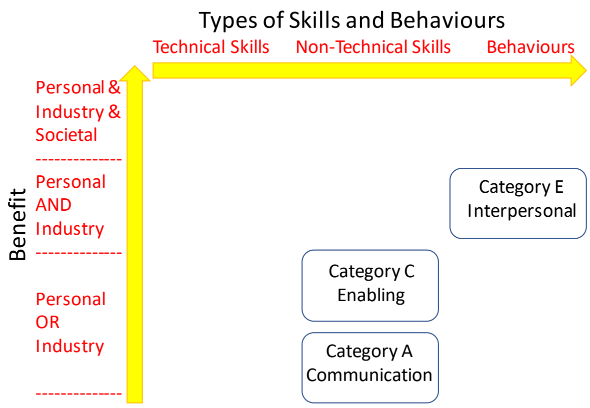

Figure 4-2f: William's Conception of Professional Skills

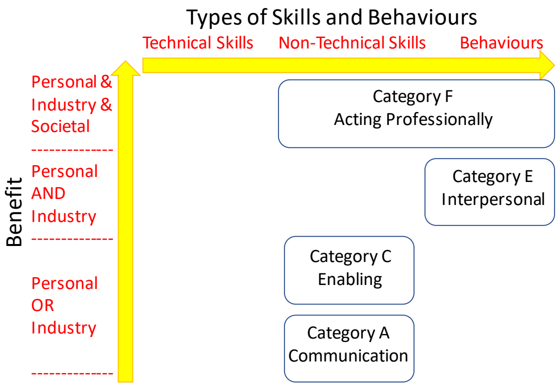

Figure 4-2g: Monica, Muireann, Joe and Nicola's Conception of Professional Skills

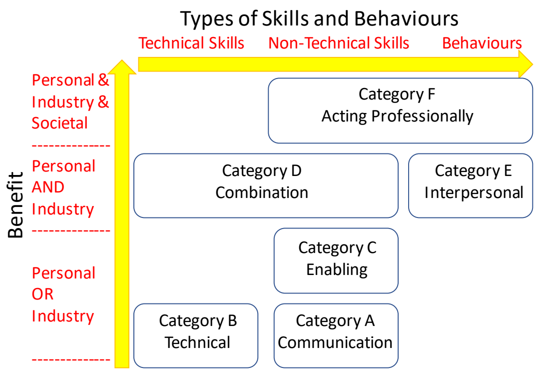

Figure 4-2h: Nathan's Conception of Professional Skills

Figure 4-2: Illustration of differing Conceptions of Professional Skills revealed in this study

The overall diagrammatic outcome space for Conceptions of Professional Skills is shown in Figure 4-3 using the Themes of Expanding Awareness of "Benefit" and "Type" as the axes to show relationships between categories.

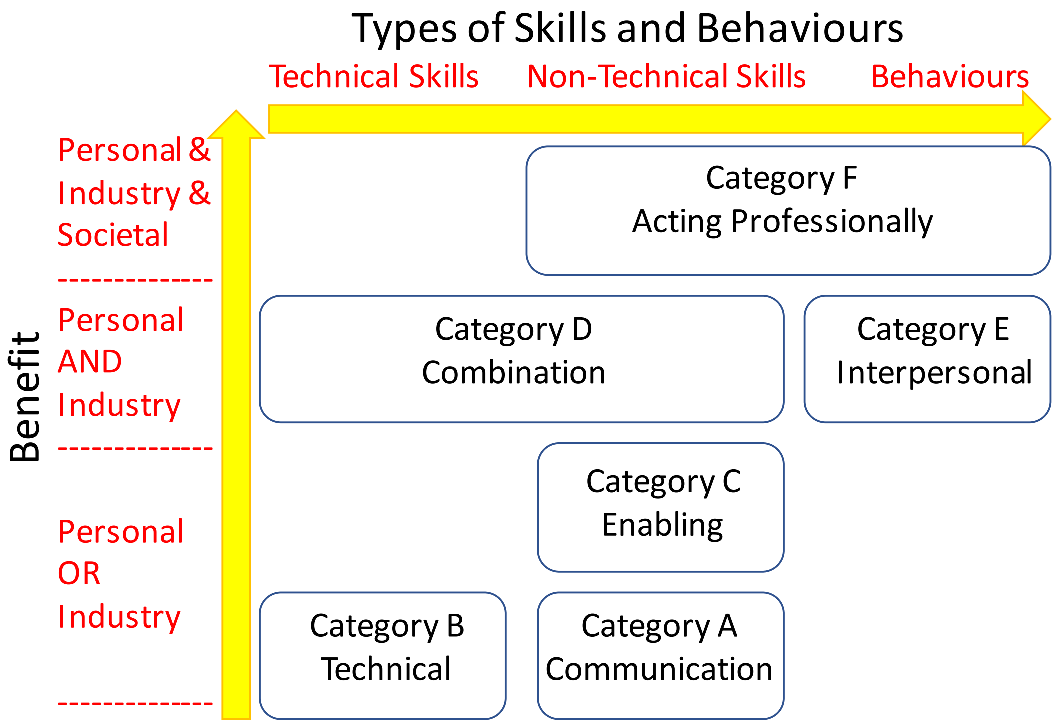

Figure 4-3: Outcome space "Conceptions of Professional Skills" in pictorial form

This pictorial outcome space is a key finding of this study and can be used as a learning and teaching resource to allow academics to reflect on their own conceptions.

4.5 Discussion on Conceptions of Professional Skills

One of the most important outcomes from this study is the creation of an outcome space to describe Conceptions of Professional Skills within the context of engineering academics in Ireland. Before we can start to advise on policies or teaching initiatives which can be used to enhance these skills, it is essential that we first understand how academics conceive of what is meant by Professional Skills. The findings in this chapter close a gap in the current literature and provide a fundamental prerequisite for achieving reform in academic practice. The outcome space presents six qualitatively different Categories of Description, differentiated by three Themes of Expanding Awareness: purpose, benefit and type. There are a few significant aspects of the outcome space which merit further discussion.

The first is the acknowledgement of Category F (Acting Professionally) as a way of conceptualising professional skills and in particular the emphasis on behaviours in addition to skills. Whilst there still seems to be a tension between professional skills being conceived as technical or non-technical skills, there is emphasis within two of the categories (E and F) on the aspect of behaviours. This finding adds new insight to the literature because it suggests that future research should concentrate on behaviours rather than skills.

Much of the previous research work investigates skills or competences (Male et al., 2011; Passow, 2012; Le & Tam, 2008; Husain et al., 2010; Kovesi & Csizmadia, 2016; Colman & Willmot 2016; Nair et al., 2009). Several of these studies do acknowledge the importance of some behaviours, but often limited to the concept of ethics. For example, Passow's (2012, p.99) study which considers the ABET competencies offers "appreciation for the ethical values of being a professional" and "understanding of professionals and ethical responsibility". Similarly, Le and Tam's (2008, p.360) study also uses the Engineers Australia competences which refer to sustainable development and "understanding of professional and ethical responsibility and committing to them". Other studies simply refer to technical and non-technical skills (Kovesi & Csizmadia, 2016) and others to hard and soft skills (Colman & Willmot 2016). Only one study identified in the literature review goes beyond the ethical considerations and recognises traits such as "being committed to doing your best", "acting with exemplary ethical standards", "actively promoting diversity within your organisation" (Male et al., 2011, p.154-155).

The omission of behavioural traits is also evident in the literature on engineering education reform and the engineer of the future. Spinks et al., (2006) discussed the need for an engineer to be able to solve problems, and even the T-shaped engineer which calls for a broad knowledge base and deep technical expertise falls short. Engineers can no longer suffice with only being technical experts. In fact, the picture attempts to show that whilst technical skills may form a good foundation, there are additional levels (add on skills) which are needed to reach the pinnacle of being a professional engineer. Richard Miller, President of Olin College does however acknowledge the need for emphasis on "a set of a attitudes, behaviours and motivations", what he calls a mindset, however he raises a concern about whether an educational programme can teach this mindset (Miller, 2015, p.11).

The value of this study finding is that it specifically calls out behaviours as a key requirement of what it means to be a professional engineer. However, reflecting back on Miller's (2015) views on whether academics are adequately trained to teach these skills does raise particular concerns about how to teach "Acting Professionally".

The second aspect of interest in the outcome space are the Themes of Expanding Awareness. Whilst the type of skills have been recognised in previous studies (Barrie, 2007) the themes of purpose and benefit add a new perspective. This brings new light on the discourse surrounding professional skills and can allow academics to reflect on their assumptions about the purpose of developing skills. The purpose of developing skills can be described as inward facing, where the focus is on the engineer themselves, or outward facing, where the focus is on interactions with others or with society. This finding may encourage academics to engage in dialogue with their peers and with engineering students bringing new understanding to the purpose of developing skills. There are academics who believe that professional skills are needed to satisfy industry requirements alone. There are others who see the value in developing professional skills in students to enable the student to be successful in life. However, the most developed conception, once which includes Category F (Acting Professionally), includes an acknowledgement that there will be a benefit to industry, the person and society from engineers developing such skills.

This is a surprising finding and it can be speculated that the influence of the Engineering Grand Challenges and in particular the SDGs appear to have awakened the academic community to the impact not only of engineering decisions but of individuals impact on the development of society (NAE, 2008; UN, 2015). For example, Muireann's comment regarding working with integrity and Nathan's justification that what we do as professionals is for the benefit of society, brings this concept to the fore.

> "So then, I suppose I don't touch enough on it, but I really think on the ethics of ….. just working with integrity. You know, so many of them ask me like " Sure like how do you know, can I not just make up that data?". "Absolutely you can". You know. So, I do introduce that discussion. Now I do think there should be an awful lot more than that. It's very very hard to bring it in because it's so individual I suppose." (Muireann)

> "So therefore professionalism is the technical knowledge that you bring into industry, but it's also the way you manage and run business, the way that you have a professional responsibility to your clients. And you have a professional responsibility to society and to contribute back." (Nathan)

With regard to the identification of the specific categories, it is important to compare with previous work. The identification of **Professional Skills as Technical Skills only (Category B),** was a surprising finding, because whilst most of the recent literature acknowledges that both technical and non-technical skills are required to be an engineer, Professional Skills are generally considered as the "non-technical skills" part of the equation. However, this does highlight that there are academics who still hold that technical skills are the most valued type of professional skills that engineers need. Those skills were in focal awareness when they were discussing professional skills. This gives credence to the use of a phenomenographic study and an outcome space as being a way to acknowledge the importance of technical skills and to expose academics to more complete understandings of professional skills.

Conversely it was also interesting to note that Technical Skills (Category B) were also revealed as a **component** of the Conception of Professional Skills. Again, Professional Skills when discussed in the literature appears to exclude the component of technical skills. There is usually a distinction between technical skills on one side and professional skills on the other. This has created a false dichotomy that has separated the two, as if they are two separate things, that must be taught separately. Furthermore, there is a struggle between which one is taught at the expense of the other. The outcome of this study is quite revealing: academics do not necessarily see them as two separate things. This is a key finding for the engineering education community and for policy makers. It suggests that we should stop talking about them as if they were completely different.

Whilst it is acknowledged that Barrie's (2007) study focused on generic graduate attributes and this study focusses on Professional Skills, it appears that the concept of professional skills is more aligned towards a situation where the graduate is in a workplace. In contrast, the generic graduate attributes are more aligned to what students are doing within the timeline of university life. Furthermore, higher levels of Professional Skills conceptions are outward facing; working with others, working to the benefit of society, whereas the conceptions of generic graduate attributes are more aligned to the person themselves. This suggests the use of the word "Professional" automatically encourages us to think about workplace scenarios and therefore it is important to carefully consider the terminology used in policy documents, with respect to the purpose of policy change, whether it is orientated towards the outside world or the individual.

However, there are similarities in Barrie's (2007) finding which provides a "Translation Conception" and "Enabling Conception" of graduate attributes. These are described as abilities that let students translate or apply disciplinary knowledge or that infuse learning and knowledge and has strong parallels to Category C (Enabling Skills) revealed within this study.

There are also parallels within Gilbuena's et al. (2015) ethnographic study which analysed the discourse between students and academics in a capstone project to ascertain what types of professional skills were mentioned. The analysis revealed five categories of professional skills: communication, experimental documentation, teamwork, economic impact of engineering solutions and project management. Comparing with the results of this study shows alignment with Category A (Communication), Category B (Technical), Category C (Enabling) and potentially Category E (Interpersonal). However, there is no evidence that the ethnographic study participants recognised that a combination of skills was required, nor is reference made to skills associated with Category F (Acting Professionally).

Category F (Acting Professionally) does however relate to Johansson and Ohlsson's (1993) concept of commitment culture; that an engineer commits to doing something they can be relied upon to do what was agreed. Here there are parallels with some of the utterances revealed in this study, particularly the concept of taking responsibility noted in Category F.

Returning to the taxonomy of engineering educational research (Finelli et al., 2016), it is proposed that Professional Skills as a hierarchal term should be upgraded a level and should have the following skills subsumed within it: communication, competence, critical thinking, engineering standards, ethics, information literacy, leadership, problem solving, teamwork, systems thinking. Furthermore, the outcome from this study suggests that the term "teamwork" does not adequately reflect the broad view of interpersonal skills, which is missing from the taxonomy. This study's definition within Category E (Interpersonal Skills) acknowledges both skills and behaviours and leans towards the concept of having respect for others, in the way in which you communicate, not confined to "working in a team".

The final observation relates to the gender influence in this study. Again, there are two things to consider. Four of the seven people who revealed Category F (Acting Professionally) were female. Furthermore, the analysis revealed that female participants in this study were more likely to conceptualise Professional Skills as Non-Technical Skills and Behaviours than to include Technical Skills as a component compared with males. Looking at the overall picture, six out of ten males (60%) revealed Category B (Technical Skills) compared with only three out of nine women (33%).

This finding also supports the original decision to attempt a fifty percent split of female and male interviewees as if they had not been recruited for this study, this finding may not have emerged as strongly. A key aspect of this category was the idea of respect between colleagues in the workplace and academics and students. In particular, two females related stories about their experiences in a male dominated world of engineering, which had impacted their views on professional skills and the idea of communicating to be heard and "standing up for yourself". It is a thesis that the females' experiences led them to reflect on the importance of acting professionally as a result of these instances. This apparent gender bias raises additional research questions which will be discussed later.

Chapter Summary

This Chapter began by describing the analysis of the interview data which was relevant for each research question. The chapter also presented the Outcome Space for Research Question 1: Conceptions of Professional Skills. Each of the Themes of Expanding Awareness which were identified in the process of analysis were described. Each Category of Description was then described in detail in relation to the Themes of Expanding Awareness along with a description of how the category compared or contrasted with others. Extracts from the transcripts were provided to justify the description of the categories. The Outcome Space was presented in a tabular format (Table 4-2) indicating the structural and referential components to each Category of Description revealed. The process used to create the hierarchal structure of the Outcome Space was described in detail and included a summary of the Categories revealed by some individuals, which provided a framework for the analysis process.

The key finding, that of the importance of focussing on behaviours in addition to skills was discussed and a commentary on some of the findings in relation to previous research studies was also presented. Finally, the chapter described the influence of gender in the findings and highlighted how gender impacted their conceptions of professional skills. The outcome space is provided as a resource to assist academics to consider the pathway to more complete conceptions of what Professional Skills are within an engineering education context. It is also hoped that the findings can initiate a dialogue on how and why academics teach the skills and behaviours needed for our students to become professional engineers. Finding out what academics conceptualise to be professional skills was the first step, the next is to consider how they teach them, which is the focus of Chapter Five.

CHAPTER FIVE - Variations in Approaches to Teaching Professional Skills

The second objective of this study was to describe the varying ways in which academics currently teach professional skills which would allow academics to reflect on ways to enhance their teaching practice. Specifically, this chapter presents the findings in relation to the research question:

- What are the qualitatively different **approaches to teaching Professional Skills** that academics use in engineering programmes in Ireland?

The interview transcripts were analysed to reveal, qualitatively different and logically interrelated Categories of Description. The analysis of the interview data followed the same process as that described in Chapter Four and will therefore not be included in this chapter. The findings are presented initially by discussing the Themes of Expanding Awareness uncovered in the analysis. The Categories of Description are then outlined with a discussion on how each category varies in relation to the Themes of Expanding Awareness. The final outcome space is presented along with an account of how the hierarchal relationship between each category was determined. Finally, the chapter concludes by discussing the findings in relation to relevant literature in this area.

It is important to declare some assumptions made in this part of the study. In Chapter Four, six Categories of Description of Professional Skills were revealed, one of which conceives Professional Skills as Discipline Specific Technical Skills only (Category B). This was a surprising finding and not typical of the literature relating to Professional Skills. The aim of this research question is to describe the ways in which academics approach teaching professional skills, which in the literature are typically considered non-technical, (or non-discipline specific), as this is where the gap in knowledge exists. Non-technical skills include communication skills, presentation skills and also those skills which translate technical knowledge into the ability to solve problems: think critically, work with people and behave professionally. These are described within Categories A,C,D,E and F in Chapter Four. For the purposes of this PhD study, and to put some boundaries on the limits of the research to ensure it was feasible within the time constraints of a PhD, the approaches to teaching technical skills were not included within this analysis. In this section of the analysis therefore, only utterances described in the context of teaching non-technical skills were included within the data pool. In essence, this meant that Dermot, Josephine and Kathleens' transcripts were excluded from this section of analysis as their conception of professional skills was technical skills only. It meant that when they were describing approaches to teaching, they were describing approaches to teaching technical skills only. Hence, sixteen interview transcripts were included for this part of the analysis. Furthermore, only utterances which related to instances where teaching of non-technical skills was being described are included in this section.

Five Approaches to Teaching Professional Skills were constituted and are described in this chapter differentiated by six Themes of Expanding Awareness.

5.1 Themes of expanding awareness

Six Themes of Expanding Awareness were identified through the iterative analysis process in relation to Approaches to Teaching Professional Skills. They are:

1. The **awareness** of the lecturer of teaching those skills
2. The **purpose of teaching** students in this way
3. The **role** of the lecturer

4. The **focus** of the lecturer
5. The teaching **environment**
6. **Assessment** technique

In other words, these themes emerged as those which differentiated each Category of Description from each other and they are used to show the structural nature of the Outcome Space. They describe and distinguish the participants' approaches to teaching professional skills (assumed to be non-technical skills) as revealed by interpreting the participants' experiences related in the interview. Each Theme of Expanding Awareness is now described in detail explaining the variation of the theme across the Categories of Description.

Awareness of lecturer

This theme relates to whether the lecturer is in fact aware that they are teaching non-technical skills in the approaches described. In some instances, such as a lecture on how to write an academic paper, the lecturer is **aware** that they are teaching the student, they refer to "showing them how to do it" and assume that the student will learn as a result of being in the lecture or being shown how to do things. However, in other categories, the lecturer is **not aware**. Whilst the lecturer is in fact creating a situation where the student will learn, gain feedback and improve on those skills, the lecturer is not necessarily aware that they are in fact "teaching" skills. Similarly, every lecturer, by virtue of interacting with students is role modelling, whether it be in a positive, neutral or negative way. Some lecturers are aware of this, but others make no reference to being aware that their actions and behaviour influences student learning. Hence this category has been described as either **aware or not aware**.

Purpose of teaching in this way

This dimension captures the intention of the lecturers in teaching in a particular way. This theme is described in four ways. First, the lecturer considers that the reason students need to develop skills is to be able to **function** as an engineer. Functioning as an engineer generally refers to the foundational knowledge or skills required in the engineering profession and it is orientated towards developing skills: mainly procedural skills: how to do something or how to carry out a task. Teaching in order to **improve** skills is the point of focal awareness for others. It is assumed that the basic skills are known, but lecturers aim to give feedback in order to help students improve their skills. The intention behind the approach to teaching can also be about success, that the person would be a **successful engineer**. This assumes they have been taught the foundation skills, and they have had opportunities to improve on them, hence they now have the skills to be a successful engineer. Finally, the last variation of this theme is revealed as more than just functioning as an engineer, or indeed succeeding as an engineer, but being **successful as a person** in any career. In this respect, the focal awareness refers to being a success in life and is not limited to being a success only in the engineering profession.

Role of lecturer

This dimension captures the changing role of the lecturer in each of these scenarios. In the first, the lecturer is understood to be the person with the knowledge and their role is to transmit information to the students: the lecturer is seen to be an **expert** in the field. Similarly, in another category, although the students are practicing the skills of being an engineer, they are still delivering an output to be checked by the lecturer: the expert.

The role of the lecturer can also be described as that of a **coach**. In this situation, the role of the academic is to sit beside the student on their journey, help them to enhance their skills and prepare them for life in industry. In this instance, the students are given more freedom, freedom to make mistakes and gain feedback. No longer is the academic considered as the all-knowing expert, the students themselves must develop their own expertise.

The role of the lecturer can also be that of a **facilitator**. They set up an environment which mirrors industry to facilitate the student to learn either through real life projects or real-life experiences. By engaging in these projects or experiences, the students can practice skills and practice scenarios relevant to industry. Whilst still student centered, the role of the lecturer in this scenario is somewhat removed compared to the coaching role: they stand back to guide or give advice, but the focus is on the student actions and student learning.

Finally, lecturers can also **lead by example** which is the final role discovered. This terminology has been used as it recognises that lecturers are role models whether they are aware of it or not. They lead by example in their actions and behaviours in all interactions with the student.

Focus

Focus has been used to describe the lecturer's focus within the classroom, whether it is concentrated on what the lecturer is doing or what the student is doing, or a combination of both. Three terms have been used to describe the variation in this theme: teacher centered, student centered and interaction. **Teacher centered** describes a situation where the focus is on what the teacher does in the classroom, whereas **student centered** is orientated towards focusing on what the student is learning and facilitating that learning process. However, one category described neither a teacher centred nor a student centered strategy and has been denoted as **Interaction**. The strategy which emerged in this category is that of a combination of both the teacher's actions (role modelling) and the student's actions (observing, absorbing, reflecting and making changes). The learning takes places through the interaction process itself.

Teaching Environment

This theme of variation interweaves all the Categories of Description and gives examples of which teaching environment is recognised in each category. It ranges from a typical lecture scenario, groupwork or project type classes, to any type of interaction with the student, regardless of the environment. Notably, work placement as an environment is denoted as an example of an environment. In this case, the student is not attending the HEI but as part of their programme is working directly for an employer. The "Any" teaching environment can include an environment where the lecturer, even by communicating by email with a student, can role model professional communication and hence this is designated as "Any environment".

Assessment technique

The assessment technique was also revealed as a theme of expanding awareness and offers several dimensions. In the first where the teaching is focused on transmitting information, summative assessment is used, assessing the **product** at the end of the module: "Did the student learn the material?" In others, assessment can be both formative and summative but, in this description, there is an awareness that both the activity of practicing and the final output can be assessed (**product and process**). Other approaches to teaching do not necessarily have an assessment aspect at all and this has been denoted as "**Not Assessed**". Students may receive coaching and guidance from lecturers and they will learn from reflecting on feedback. However, none of the interviewees revealed ways of assessing if that feedback, or indeed the role modelling was "learned" and then reproduced by the student.

Next follows a detailed description of each Category of Description revealed, along with associated utterances taken from the interview data.

5.2 Categories of Description

Five Categories of Description were revealed from the analysis of the data. The categories are qualitatively different, based on the Themes of Expanding Awareness described earlier. Each Category of Description is now described in relation to the Themes of Expanding Awareness along with associated utterances taken from the data. As a reminder to the reader, these categories emerged from interpreting lecturers' experiences of teaching non-technical skills only.

Approach A – Transmitting knowledge

Category A describes an approach where the lecturer transmits information, usually by telling the students what to do or how to do it in the form of a lecture scenario. Even though, this part of the study only considers non-technical skills, there are still instances where these are taught through a transmitting knowledge approach. Assessment techniques in this category generally have a formal examination or a submission where students are required to prove their knowledge usually in written form at the end of the course, so product and not process is assessed. The purpose of learning these skills is to be able to function as an engineer and lecturers are very aware that they are teaching these skills in this category. Lecturers are the expert in this category, they have the knowledge, and they set assessments so that students can prove they have gained the relevant knowledge.

Hannah describes a module she teaches which involved an assignment to write an academic paper (one example of a non-technical skill considered within this section). She describes how she showed them the structure of a paper, gave them examples of her own papers. In describing how she assessed the students, she explained that they were marked on whether they could put an academic paper together and in particular if they could reference properly. The language used here is that she showed them how to reference, transmitted the knowledge on how to reference properly. In this approach, the focus is on what the lecturer is doing, a teacher centered approach.

> "Well I was assessing them on their research skills - how they could go off and maybe research a topic and put an academic paper together. You know how they could reference, and that's something that students are very bad on. I showed them how to reference, APA and I showed them how to reference with the name, comma and the date. And as I say it was only one student that actually did that right". (Hannah)

Approach B – Practicing

Accounts consistent with this category prioritise practicing and learning by doing and go a step further than Category A. Whilst this approach can also be included within a lecture setting, where the academic will break up the lecture by using practice questions or examples, it is mainly associated with tutorials, or practical lab work and projects. It is a student centered approach, the focus is on what the students are doing. The role of the lecturer is engaged, usually interacting with the students, asking questions, challenging their conceptions, but the lecturer is still the expert. The purpose of "practicing" is to enable students to apply knowledge in order to function as an engineer. Assessment techniques include both written or formal examinations, but also assessment of students whilst they are practicing the competency itself, such as assessment of presentation technique. The assessment in this case is both of the process and of the product.

Nathan gives an example of a design project module where students are given a real world problem and are required to create a design and give a presentation to visiting clients. This is a way of practicing the work of a professional in the field. Students are graded not only on the technical response to the brief (which is judged by the expert Nathan) but on their skills associated with how well they made the presentation (process and product).

> "So it can be for example an A0 board with a design development folder and they'll have to present the design to a set of clients, real world clients. Those real world clients often ask oddball questions that like maybe I wouldn't. It's probably the first time that students have stood in front of a real world client. They'll have plans,

> elevations, visuals and they'll have an oral presentation which explains how they've addressed the design challenges and I will grade them based on how well then they've addressed the design challenges, how well they made the verbal presentation, how well the scheme actually follows the strategies for resolving either workplace or hospitality issues". (Nathan)

Nichola describes one aspect of a module she teaches which involves a presentation. Here she describes the marking scheme within the presentation. Students are assessed on both what is contained within the presentation and how they present. She also reflects on the importance of being able to practice these skills to be able to work in industry and function as an engineer.

> "So in the presentation, it is the delivery of the presentation. It is the content of the presentation. It's the format that the presentation takes. It's their presentation skills. There is a rubric that we use in order to assess them. You know we find some students will stand with their backs to us, with their back to the class when they are presenting. Some students will read everything word for word. Presentations are a big part of industry work, so it's just to give them the opportunity to develop and practice that". (Nichola)

Finally, Sebastien describes how important it is to practice skills rather than just observing or hearing about them in a lecture. Here he talks about communication skills and project management skills.

“A lot of these skills are learned through doing. So you could sit in lectures and you could observe people being very good communicators or I could tell you exactly how to manage projects and stuff. But until you've done that, I don't think you can learn it that way essentially. So. I think what we're doing is reasonable in that, we have modules where those skills are fostered and where students have the opportunity to start to learn those skills, so presenting their work, managing their own research projects, going into industry and then seeing what the expectations are in industry and how things are done and then coming back”. (Sebastien)

Approach C – Coaching

The focus in this category is on coaching students, working closely with them and giving them feedback on their work. This can be in the form of presentations, posters, essays or practical work as students are undertaking it. Some lecturers are not aware that by giving feedback, they are providing opportunities for students to learn. Whether the feedback is taken on board or results in changes to the students' outputs is not assessed. However, the focus of awareness in this category is not on **what** is done, but on **how well** things are done. The focus is on how work is presented, how a student communicates or presents themselves, not necessarily the technical or academic content of the work. The purpose of the lecturer is to help students improve their skills and the lecturer acts as a coach, guiding the students.

Mike speaks about a PBL project that he teaches, and the following example highlights his coaching style. His focal awareness is on helping the students during the process of the project. Here he describes how he approaches giving feedback on difficulties within a team. In fact, he asks the student to reflect on their own actions, setting up a scenario where the student learns by reflection rather than being taught by an expert.

> "I would say it actually throughout most of the module, it's less about planning what grade the person is getting and more of trying to address any shortcomings they have". (Mike)

> "OK. So it could be that there is a problem in the group where somebody is failing to attend class or somebody is……………...this kind of thing. So we would invite that person to reflect on what strategies they could use to overcome the problems within the team. And if we see that they are trying the right things whether or not

> their initiatives are successful we would certainly regard that as very positive. So that's somebody who is trying to resolve problems within the team by tackling things head on". (Mike)

Adrian recognises that feedback is an appropriate way to help students enhance or refine their skills but assumes that this will enable them to become better the next time. However, there is no evidence or reference to assessment.

> "In terms of getting students to communicate, I suppose in many ways they're learning it as they go through. They are making presentations and getting feedback on their presentations…….So it's helping them to refine their ideas. So I suppose at every stage along the process they're writing reports, they're getting feedback on the reports, so therefore they can refine their ability to write better reports in the future". (Adrian)

The coaching approach is student centred, what the student does is most important. In this case the lecturer is not the expert with all the knowledge, but their role is to sit beside the student and work with the student on a one to one basis to help the student achieve their own goals.

Approach D – Mirror Industry Environment

In this category, the approach to teaching professional skills is to set up an industry environment so that students can experience and practice the skills needed to work as an engineer. In this instance, the lecturer assumes a facilitator role. They create an environment where they allocate work to the student such as a boss might in a typical workplace and then act as a guide on the side. The environment in this category can be inclusive of lectures, tutorials, workshop, practicals and so on and is not limited to one context.

The intention of the lecturer in this approach is to develop the student skills to enable them to be a success as an engineer, they are of course improving their skills, but the lecturers are mirroring an industry approach so that students can imagine and practice what it is like to be in an industrial scenario. The focus of assessment is on both process and product. Students are guided by the lecturers, but the lecturers are considering both the process of being involved and the end product, the outcome of the learning activity.

Charlie teaches a practical module which involves practical work in a laboratory. Here he describes how he sets up the scenario to mirror an industrial environment and he is explicit about why the class is set up this way. He goes on to describe his role in this scenario, as someone who "highlights the way for them", but somewhat removed from the student, more similar to a facilitation role than a coaching role.

> "When we come in here, it's a normal standard workshop like you would see if they were mechanical or anything like that. They come in with their PPE and if they don't have it, I send them out. It's as simple as that. They're not allowed to sign in, so there's very specific

safety elements to it. And then each class they come in here and they know, because I tell them, out in the real world, you could come into work and you could be doing absolutely anything - it depends on the requirements of the day and it's the same here". (Charlie)

"You know as I see these young people - I say - gosh they could be my kids. And you know it's great - not to hold their hand on the journey, but certainly to highlight the way for them". (Charlie)

One other aspect included within this category is that of work placement. Whilst work placement is outside the scope of how lecturers approach teaching professional skills, it is important to include it in this section. Sebastien, when asked where students develop professional skills within the programme recognises that technical skills are taught in college, but also refers to work placement. In this utterance he reveals that he feels unqualified to teach them aspects of the work environment and that "mirroring industry", by having students on placement is the best way to achieve this.

"I think obviously the technical ones are developed in college. I think….I have students at the moment on placement and they're learning very little in terms of technical skills but they're learning a lot of things that I couldn't teach them. So things around responsibility for example and around ownership of work and around communication". (Sebastien)

"Yes, the internship which again really develops …………..it's kind of like throwing our responsibilities onto industry, but it really works. And I was a bit sceptical when I came back here from [UNIVERSITY NAME] about how does that work and you know, is

> that the best thing that we should be doing, but actually the personal development that they come back with is really unbelievable". (Sebastien)

Mirroring an industry environment through the use of practical project or real life scenarios or using problem based pedagogies is one approach to teaching professional skills revealed in this study. The role of the lecturer is broader than that of a subject expert (Approaches A and B), but yet not quite the one to one intensity of a coach (Approach C). However, it is still a student-centred approach and one which aims to help students become successful engineers in the workplace.

Approach E – Role modelling

This final category emerged from a set of utterances which describe the actions of the lecturer in the hope that they will act as a role model to the students. Whilst they describe their actions, they are not always aware of their intention to set standards for the students. Imelda for example, hopes by role modelling that students will mirror this behaviour; however, Charlie is more explicit and sets expectations. He is aware that this way of teaching is a way to teach students about professional skills. The lecturer takes a leading role, by leading by example. Typically, this category includes the aspect of behaviour, behaving professionally in particular.

The emphasis and thus the value placed in this category is that of being a successful person in life, the focus is not necessarily limited to how students perform in their engineering life, the aim of role modelling behaviour is to show the importance of being respectful, polite and empathetic to other people. The focus is not on what the student is doing, nor the lecturer in isolation but the interaction between the two; how the student assimilates and reflects on the lecturer's behaviour.

Several interviewees describe how they set expectations within the classroom or role modelled professional behaviour to students. Charlie was asked where within the programme professional skills are taught. He is explicit about setting expectations in order that students will behave a certain way.

> "I suppose in the classroom environment, something as simple as coming in on time, having respect for classmates. You know, I would have no problem telling the students - this is not acceptable. You know we've had students come in and they're eating food in a destructive way not quietly. They'd be playing music, they'd be just

> messing. And I'd say. Okay well – I have a choice. I'm here for the students who want to be here. If you're here just to come in and disrupt. Well, that's fine. I'm not going to pull the class down, so I let them make choices. But I tell them what's acceptable what's not". (Charlie)

Joe describes how he sets expectations for students to behave in a professional manner and how he uses his professional skills every day, revealing the aspect of behaviour:

> Well I mean professional skills can be very simple things as well. And I do say to….I said it this morning - behave in a professional way. So one student - he had a medical appointment, so he arrives an hour late. I don't think it's professional just to walk in and sit down. I think it's professional to address your line manager and say - sorry I had a medical appointment. And I encourage them to think like that, to think professionally……..I encourage them, that you know you shouldn't be referring to Alpha as a squiggly thing. You know you should be professional and if you're putting equations on a presentation, they should look like proper maths equations. Simple things like that. (Joe)

> Well I hope I'm using them every day by turning up on time for my lectures and being at my lectures and also being empathetic with the student when they have difficulties. (Joe)

Finally, Imelda gives two examples of how she explicitly sets standards for students in order to teach them about respect and how to speak to each other. In the first she sets standards and in the second quote she explains a specific situation.

> I set a boundary with my first years. I have a lecture with them and then I have a two hour lab in the afternoon. The lecture is sort of to see what they're going to do in the lab. Basically I always talk for about 10 minutes and as I said to them, when I'm doing that 10 minutes talking to respect me, because the next 20 minutes they're going to be talking and discussing. (Imelda)

> In the lab situation, I will try and always bend down to their level in the lab. I'll never talk over someone in the middle of the lab, I'll always go down on my hunckers, look at the screen with them, because then they're on a one on one with me. So I would do all of that kind of stuff. (Imelda)

The role modelling approach can take place in any environment, in fact it is not limited to physical interaction with students either. A lecturer writing an email to students in a professional manner can be an example of good role modelling. However, one of the key aspects of this research finding is that no interviewee revealed that the behavioural aspect of this approach was assessed in any fashion.

Thereby, in relation to the second research question, the Approaches to Teaching Professional Skills can be described using the following Categories of Description:

A. Transmitting knowledge
B. Practicing (Learning by doing)
C. Coaching
D. Mirroring the Industrial Environment
E. Role modelling

Table 5.1 shows a tabular form of the outcome space for Approaches to Teaching Professional Skills which details aspects of the Themes of Expanding Awareness in relation to each of the Categories of Description.

Table 5-1. Outcome Space for Approaches to Teaching Professional Skills (Tabular Format)*

Theme of expanding awareness	**Approach A** **Transmitting knowledge**	**Approach B** **Practicing**	**Approach C** **Coaching**	**Approach D** **Mirror Industry Environment**	**Approach E** **Role modelling**
Awareness of lecturer in teaching non-technical skills	Aware	Aware	Not aware	Aware	Aware or not aware
Purpose of teaching in this way	To **function** as an engineer	To **function** as an engineer	To **improve skills** as an engineer	To be a **successful engineer**	To be a **successful person**
Role of the lecturer	Expert	Expert	Coach	Facilitator	Lead by example
Focus	Teacher Centred	Student Centred	Student Centred	Student Centred	Interaction
Teaching Environment	Lecture	Tutorial, practical, groupwork, projects, presentations	Tutorial, practical, groupwork, projects, presentations	Groupwork, projects or work placement	Any environment
Assessment technique	Product	Product and Process	Not assessed	Product and Process	Not assessed

* these approaches were constituted from utterances which described approaches to teaching Professional Skills but excluded utterances which described teaching technical skills only.

5.3 Hierarchal Structure – Approaches to Teaching Professional Skills

The hierarchal structure between categories is described by the differing Themes of Expanding Awareness presented in a tabular form (as Table 5-1). Similarly to the Conceptions of Professional Skills (Chapter Four), where one person's conception can include one or more Category of Description, a lecturer may use several approaches to teaching depending on the context. It may depend on what type of class they teach, how many students are in the class or the surrounding environment. Hence, with regard to approaches to teaching professional skills, one person is not always described fully by one approach to teaching professional skills.

Hence, this thesis proposes that individuals will have Approaches to Teaching Professional Skills which may include one or several of the Categories of Description revealed in this study. For example, a participant may have revealed that in one scenario they may use a Practicing Approach (Category B) and in another, a Coaching Approach (Category C).

In this instance, the hierarchy is not developed in relation to a specific person, yet the categories that a specific person reveals do provide an insight into their hierarchal place. For example, someone with only a lower level approach, would be unlikely to use a higher-level approach, yet someone with a higher level approach may well use one of the lower level approaches too.

Hence, by reviewing the variation in the Themes of Expanding Awareness indicated in Table 5.1 and the different Categories of Description revealed by each participant a hierarchal structure can be determined. Each Category of Description will now be described in relation to the hierarchal structure by giving examples of those interviewees who revealed each Category. Diagrams will be used to highlight the different approaches revealed by some of the interviewees. It is important to note at this point, that **not every participant revealed the exact same combination of categories**, nor is there an attempt here to suggest that higher level categories (for example Category E) are **always** inclusive of lower level categories. The diagrams are provided to merely assist in visualising the hierarchal structure revealed in the Outcome Space.

The hierarchal structure was informed by the following relationships:

Approach A – Transmitting knowledge – Hierarchy.

Three interviewees revealed one of their approaches to teaching professional skills as Approach A (Transmitting knowledge) yet not one person **only** revealed this Category.

Approach B – Practicing - Hierarchy

All participants revealed an approach to teaching professional skills as Approach B (Practicing). Three of them (Hannah, Sean and Imelda) also revealed Approach A (Transmitting Knowledge). Both of these approaches are very similar with the only differentiation being that of the focus of the learning, whether it is teacher-centred (Approach A -Transmitting knowledge) or student-centred (Approach B - Practicing). A student-centred approach is deemed to be hierarchally superior to a teacher-centred approach and hence Approach B trumps Approach A. Imelda and Sean went on to reveal other approaches to Teaching, but Hannah only revealed Approach A and B and hence her approaches to teaching are included in Figure 5.2a.

Approach C – Coaching - Hierarchy

Approach C (Coaching) appears as the next step in the hierarchy as everyone who had a coaching approach, also revealed a practicing approach (Approach B), but not everyone with a practicing approach, revealed a coaching approach (Reference Hannah above). Furthermore, from the interpretation of the utterances, coaching takes place within the practicing sessions. So, for example, Mike describes coaching in a PBL project where he asks the students to communicate, to give presentations and he gives feedback on this in order that they can improve their skills. The coaching is taking place as an add-on to the practice session, by virtue of the feedback the students are receiving. Hence this category is hierarchally superior to Approach A (Transmitting Knowledge) or Approach B (Practicing). Christina, William and Mike all reveal approaches to teaching professional skills as Approach B (Practicing) and Approach C (Coaching) and their approaches to teaching are highlighted in Figure 5.2b.

Approach D – Mirror Industry Environment – Hierarchy

There are less obvious differences between Approach C (Coaching) and Approach D (Mirror Industry Environment) and in fact these can be independent of each other. For example, lecturers describe how they facilitate an industry environment, by providing students with an opportunity to practice real life projects, however the coaching does not necessarily form part of the mirror industry environment. Conversely, lecturers who revealed a coaching approach (Approach C) did not necessarily do this in combination with a Mirror Industry Environment approach (Approach D).

In this study, of the nine interviewees who are associated with Approach D (Mirror Industry Environment), four also used a coaching approach, yet five did not. Hence, the key differences between these two different approaches is with respect to the purpose of teaching and the role of the lecturer. With regard to the hierarchy, there are two key groups of people who revealed Category D (Mirror Industry Environment) as a teaching approach. Greg, and Nathan use Approach D (Mirror Industry Environment) and Approach B (Practicing) only, whereas Monica, Muireann, Sebastien, Adrian and Nichola use Approach D (Mirror Industry Environment) and Approach B (Practicing) **and** Approach C (Coaching). The figures are used to show the difference between the approaches to teaching of Greg and Nathan (Figure 5.2c) and Monica, Muireann, Sebastien, Adrian and Nichola (Figure 5.2d).

Coaching as described above also differs from the role of facilitation which is the lecturer's role in Approach D (Mirror Industry Environment). Facilitating is used to describe a situation where a lecturer stands somewhat removed from the student, allowing the student to form their own conceptions, and construct their own understanding, dipping in with advice when required. As Adrian gives an example of facilitating:

> "The students are in various tables and they've got flip charts or whiteboards that they can actually work on and we're going around commenting and basically answering questions. So we're not going to interfere unless they actually ask a question. I mean at the end of the day we're putting the onus on the students to actually learn, but the students will typically have quite a lot of questions. Sometimes we'll tell them go and find the answer themselves and sometimes we will actually nudge them into where they can actually find those answers". (Adrian)

Coaching suggests a closer relationship with the student, with more one to one interaction through feedback and getting to know the student on a deeper level.

The purpose of teaching also differs between Approach C (Coaching) and Approach D (Mirror Industry Environment). As a coach, it is the lecturer's intention to give feedback so the student can improve on their skills, the focus is on skills and improvement. However, in Approach D (Mirror Industry Environment), the lecturer's focus is on how the student performs in industry. The mock industry environment is used so that when students go out into the workplace, they will have practiced being an engineer, allowing them to become successful. The focus in this instance is on the workplace and being a success, not necessarily the journey through learning skills. Diagrammatically therefore, these two categories have been shown as separate and independent.

Approach E – Role Modelling – Hierarchy

The final hierarchal relationship deems that Approach E (Role Modelling) is more complete than other approaches. The approaches that Imelda and Joe use, (Figure 5.2 e-f), provide the justification for this assertation as they include other approaches. Furthermore, the purpose of teaching in this way, is not just about being able to function as an engineer (A and B) nor to improve skills needed for engineering (C) nor to be a successful engineer (D). It subsumes each of those aspects into being a successful person; an ethical, honest respectful person. Finally, this category is not limited by the teaching environment nor whether the approach is student centred or teacher centred, in fact it requires a combination of the two. The graphical representation of the hierarchy is shown in Figure 5-3.

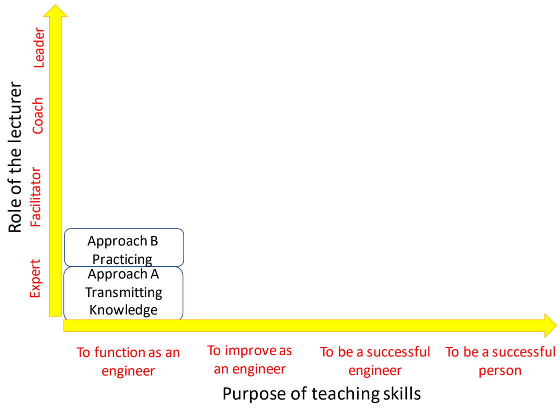

Figure 5-2a: Hannah's Approaches to Teaching Professional Skills

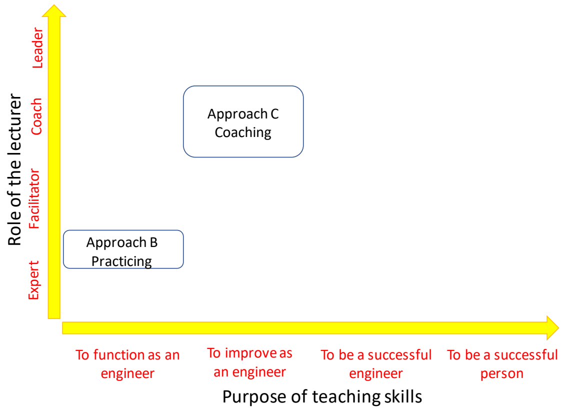

Figure 5-2b: Christina, William and Mike's Approaches to teaching professional skills.

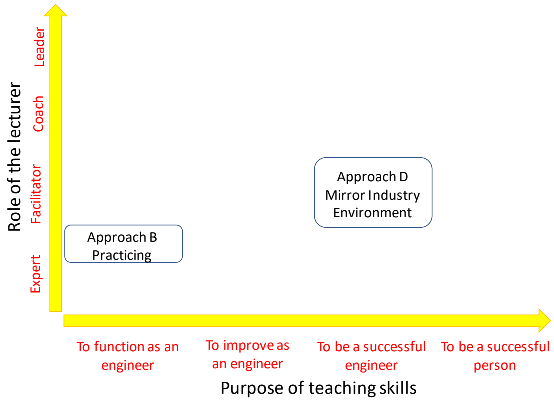

Figure 5-2c: Greg and Nathan's Approaches to Teaching Professional Skills

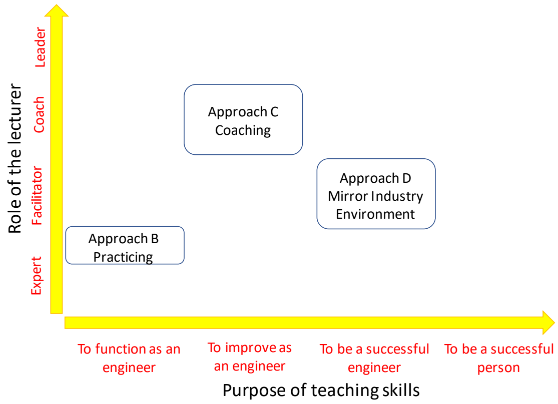

Figure 5-2d: Monica, Muireann, Sebastien, Adrian and Nichola's Approaches to Teaching Professional Skills

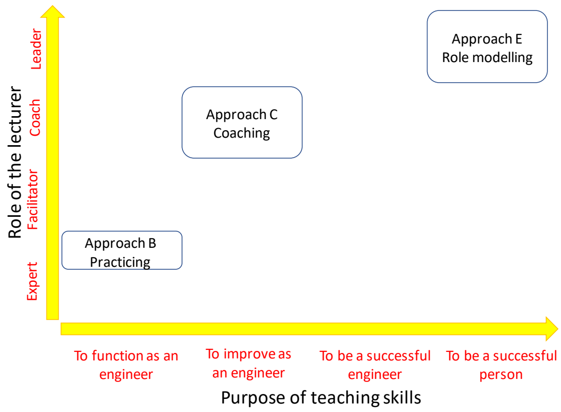

Figure 5-2e: Joe's Approaches to Teaching Professional Skills

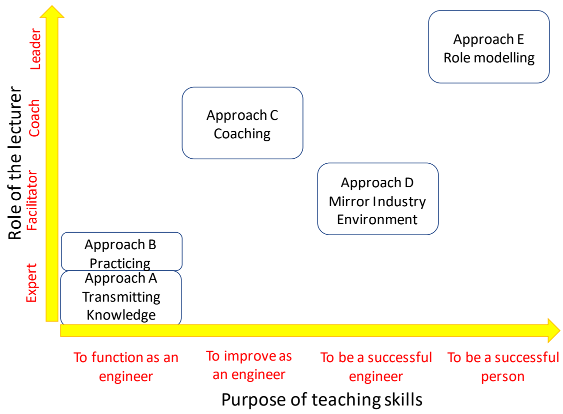

Figure 5-2f: Imelda's Approaches to Teaching Professional Skills

Figure 5-2: Illustration of differing Approaches to Teaching Professional Skills revealed in this study

Using the data presented in Table 5.1, the interpretation of the interviews and with reference to the Themes of Expanding Awareness the hierarchal structure for the Approaches to Teaching Professional Skills is presented in pictorial form in Figure 5.3 using the axes of the Role of the Lecturer and the Purpose of Teaching skills as the key differentiating factors.

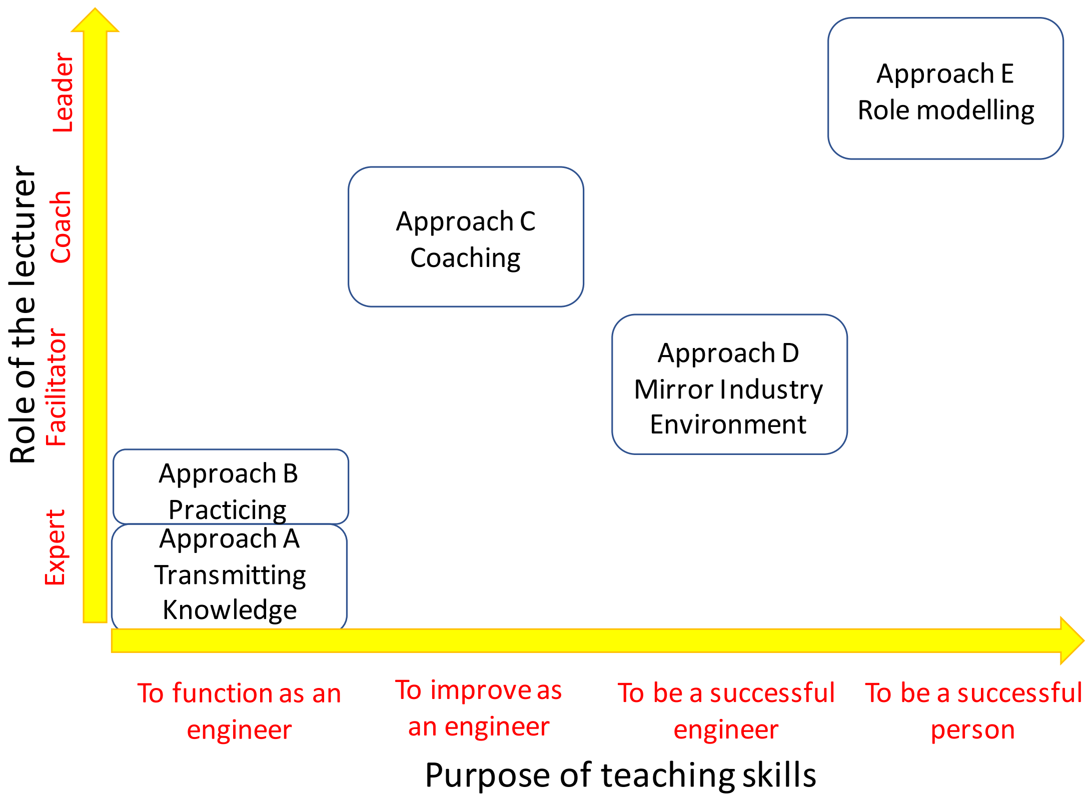

*Figure 5-3: Outcome space "Approaches to Teaching Professional Skills" in pictorial form**

*these approaches were constituted from utterances which described approaches to teaching Professional Skills but excluded utterances which described teaching technical skills only

5.4 Discussion on Approaches to Teaching Professional Skills

One of the most important outcomes from this study is the creation of an outcome space to describe Approaches to Teaching Professional Skills within the context of engineering academics in Ireland. It is essential that we gain an insight into the ways in which academics approach teaching professional skills, not only in a generic form, such as a survey might produce, but to better understand the factors which influence their approaches. This deeper understanding which has been revealed in this phenomenographic study offers an opportunity for academics to relate the findings to their own experiences. The results presented in this chapter not only close a gap in the current literature on approaches to teaching professional skills, but also provide a vital tool to assist academics to reflect upon and improve their teaching practice. The outcome space presents five qualitatively different ways which describe an increasing hierarchy of categories along six Themes of Expanding Awareness: awareness, purpose, role, focus, environment and assessment technique.

There are a few significant aspects of the outcome space which merit further discussion. The key finding is the identification of an approach to teaching as role modelling which has not been identified by other approaches to teaching studies. It is asserted that this category emerged specifically because of the context of teaching professional skills where professional skills are deemed to be non-technical skills for the purposes of this study. This insight allows us to acknowledge that a different teaching approach is required to teach professional skills (as non-technical skills and behaviours) compared to teaching technical skills. Bandura's (1999) social cognitive theory argues that behaviour can be learned through observing the environment and is a clear example of the influence of role modelling behaviour. Furthermore, the importance of teaching students appropriate attitudes and behaviours is also raised by

Hammer (2000) who advises that there are three influences which effect student behaviours and attitudes. They are “the values and behaviours that students bring into professional programs, role models in the professional and academic environments and the environments themselves” (Hammer, 2000, p.457). The importance of this approach to teaching cannot be overstated and is in direct alignment with the concept of the hidden curriculum, what can be described as the “implicit attitudes, knowledge, and behaviours, which are conveyed or communicated without aware intent” (Alsubaie, 2015, p. 125). In fact, this finding has revealed aspects of the hidden curriculum and in particular the influence of the academic on how students learn, more particularly, how his/her conceptions and approaches are impacting the development of professional skills in engineering education. As discussed in the introduction, if a lecturer makes light of a particular topic, the student may perceive that it is therefore unimportant and may not prioritise learning of that topic. The lecturer’s actions whether performed consciously or not can affect the student learning experience and learning outcomes.

The value in this finding is that it provides credence to additional research work into specific strategies or interventions to provide lecturers with opportunities to learn how to engage in role modelling activities. Making them aware of their conceptions, their implicit attitudes, knowledge, and behaviours may be the first step.

The Role Modelling approach also has parallels to Bloom’s affective domain taxonomy (Krathwohl et al., 1964) which recognises the different ways in which people deal with emotions, values and motivations. Five levels are proposed: receiving, responding, valuing, organising and conceptualising, characterising by values. Comparing the approaches revealed within this study with the affective domain, highlights several similarities.

It is important to consider what is happening with the student, when a lecturer approaches teaching professional skills in different ways. In Approach A, the lecturer is transmitting, knowledge, therefore the student is receiving knowledge, typically in a lecture scenario with little interaction. This compares with the “receiving” terminology from the affective domain, which describes how a student is taking in the environment. In Approach B (Practicing), the student is translating what they have heard into application, by practicing being an engineer. This could be through tutorials, groupwork, practical and assignments and relates well to the “responding” level of the affective domain. The student is responding to a situation, using the information received. The links between the approaches in this study and the affective domains of valuing and organising and conceptualising are not so clear. However, the top hierarchal level of the affective taxonomy (Characterising by Values) does relate well to Approach E (Role Modelling). Characterising by values assumes that students’ behaviours are reflected by their value system. Hence if a student views a particular behaviour of a lecturer and this agrees with their value system, they are more likely to re-enact that behaviour. For example, Imelda gave the example of bending down to speak to a student while they were working in a computer lab, rather than towering over them when giving them instructions. By role modelling this behaviour, she is showing respect to the student. Her value system suggests that she does not want the student to feel inferior in this teaching scenario, she is attempting to set up an equal environment, where both student and teacher work together. If the student is aware of this specific behaviour and it agrees with their value system, they are more likely to do the same when talking to other students or helping explain things to others. She is in effect, leading by example.

Bloom’s affective domain taxonomy therefore provides a framework for us to better understand how a role modelling approach can work, by appreciating how people deal with emotions, values and motivations.

The second aspect of interest in the outcome space are the Themes of Expanding Awareness, in particular the awareness and role of the lecturer. It is important to acknowledge the surprising finding that lecturers are not always aware that they are teaching professional skills. If the aim is to enhance academic practice in professional skills, then in the first instance lecturers should be made aware of opportunities where they can influence student learning. The best example of this is in the Role Modelling approach by making it explicit that any interaction with a student has an influence on what they consider to be professional behaviour.

The role of the lecturer in this study (Expert, Coach, Facilitator and Lead by Example) has similarities to the Kolb (2018) Educator Role Profile which included: Facilitator, Subject Expert, Standard Setter and Coaching Role. At least three of these roles are also identified in this study. In Kolb’s (2018) model, the coach is described as someone who helps learners apply knowledge to achieve the learner goals and gives feedback on performance. This same terminology is used in this study in Approach C (Coaching) to reflect a lecturer whose intention is to improve the student’s skills, usually in a teaching environment which includes interaction with the lecturer, but where the focus is on the student’s learning. Vygotsky’s concepts of the Zone of Proximal Development and of scaffolding is also witnessed in approaches in which the lecturer acts as a coach. Their role is to support the student when needed, so that the student then becomes confident in completing the task on their own.

In Approach D (Mirror Industrial Environment), the lecturer's role is described as a facilitator, someone who sets up a scenario where the student can practice real life work as an engineer. This compares with the Kolb model description of facilitator, as someone who sets up a scenario to help students reflect on their personal experience. The Kolb (2018) description of a subject expert also aligns with the role of the lecturer as an expert in this study. Both studies describe how in this role, the lecturer typically delivers knowledge to students through lectures or texts and has an authoritative style. Finally, Kolb's (2018, p.13) description of a standard setter and evaluator is a role where "educators help learners master the application of knowledge and skill in order to meet performance requirements. They create performance activities for learners to evaluate their learning". Whilst this definition describes to some extent what happens in Approach B (Practicing), and Approach D (Mirror Industry Environment), this is not identified as a separate role for lecturers in this study. Approach B (Practicing), through tutorial, practical work, projects and presentations is student centred, but the lecturer is still the expert, the one who sets the standard to be reached. In Approach D (Mirror Industry Environment), the lecturer is creating performance activities for learners, but their role is that of a facilitator. Aspects of all four of Kolb's educator roles were revealed in this study, however conversely Approach E (Role Modelling) does not appear in the Educator Role Profile.

The role of a lecturer as a facilitator in this study also relates back to the constructivist paradigm, in which Apple and Teitelbaum (2001) argue that students learn by active experimentation and social interaction. Dewey and Piaget proposed that the role of the teacher (as a facilitator) was critical to create activities and resources that allow students to make connections between experiences, construct their own learning. In fact, all approaches which take a student centred or interactive perspective also show alignment with constructivist paradigms. Similar to Dewey's ideas on self-directed learning and the role of the teacher as a facilitator, Knowles recognised this as a key element for adult education specifically, for helping adults to learn, not by transmitting fact and figures, but by guiding the learner. This view is shared by Carl Rogers, who attests that "we cannot teach another person directly; we can only facilitate his learning" (Rogers, 1951, p.389). In fact, Rogers also proposed that learners learn by experience, through building relationships and in Knowles' opinion the best educational experiences are enclosed within a co-operative learning climate with guided interactions between the teacher and learners (Knowles, 1980; Blondy, 2007). Aspects of Approach D (Mirror Industry Environment) are clearly linked to these educational theories.

The role modelling approach is presented in this study as the overarching hierarchal approach. It represents a more holistic view of teaching; the purpose of which is to help students become a successful person in life and is not limited to the engineering profession, nor any content that a lecturer could impart to a student. This approach emerged from utterances which tended to describe behavioural skills: dealing with people, showing respect for others, behaving professionally and hence at its heart is the importance of social and interpersonal relationships.

Approaches to Teaching

One of the key discussions of the findings relates to comparison between the original Trigwell et al. (1994) study on Approaches to Teaching (generally). It is important to compare if the focus on professional skills specifically revealed additional or alternative approaches as it provides new scholarship in this area. Although the Trigwell et al. (1994) study was bracketed during the analysis for this study, there are some similarities and differences between both studies which are worthy of discussion. Trigwell et al. (1994) presented five approaches to teaching differentiated through two Themes of Expanding Awareness: intention and strategy. Four aspects were identified with regard to the intention of the teacher: information transmission; concept acquisition; conceptual development and conceptual change. Three aspects were highlighted within the strategy dimension: teacher focused, student teacher interaction and student focussed. The approaches were later simplified to two main approaches: Information Transfer/Teacher Focussed (ITTF) and Conceptual Change/Student Focussed (CCSF).

In this study, there were also five Approaches to Teaching Professional Skills revealed but through the lenses of six Themes of Expanding Awareness: the awareness of the lecturer; purpose of teaching; role of the lecturer; focus; teaching environment; assessment technique.

The theme of variation entitled "Focus" within this study, very clearly aligns with the strategy dimension of the Trigwell et al. (1994) study. By bracketing, I not only purposely did not consider the previous study (I had a long break between reading the study and completing this analysis), but I allowed the new findings to emerge organically. It was somewhat surprising therefore when I realised that I had used similar terminology, that of teacher centred and student centred. However, these are common terms in current educational literature and discourse and therefore not necessarily only associated with the previous study. Again, surprisingly the term "interaction" was coined to describe the focus of the lecturer in the role modelling approach, and student-teacher interaction is one of the strategies used in the Trigwell et al. (1994) study. This term also emerged organically without reference to the previous study.

It could be argued that the "intention" theme in the Trigwell et al. (1994) study is similar to the "purpose of teaching", however, I see this as being different in two ways. Firstly, in the intention concept, the focus is on what the teacher intends to do in that particular instance or context of teaching. For example, whether their intention is to transmit information or to develop conceptions within that class. The purpose of teaching dimension revealed in this study is much broader. Whilst it does consider the intention of the teacher, it is not restricted to the particular instance of what the teacher is doing in class on that particular day: it focuses on what the teacher is doing to help the general development of the student. Secondly, the purpose of teaching dimension is forward looking and more holistic. It considers the future career and life of the engineer and the importance and value the teacher places on each of these approaches to teaching professional skills, to prepare the engineering student for the future. This differentiation comes from what lecturers consider important in an engineering career, or in life in general.

Comparing to Kember and Kwan (2002) who found that six dimensions were necessary to capture the range of variation in approaches to teaching, there are also some comparisons to be drawn. Firstly, they recognise the main division of teacher-centred or student-centred approaches, which they term Content-Centred and Learning-Centred teaching. With the strategy dimension, they also recognise assessment as a differentiating factor but related to the type of assessment (frequent tests or more flexible assessment types) rather than whether the product or process or neither were assessed. One strategy dimension is listed as focus, where the focus of the teacher is on an individual student or the whole class. Whilst there are parallels to the role of the lecturer identified in this study (particularly as an expert, coach or facilitator) there is no reference to aspect of leading by example which was a key finding in this study.

This study adds to the approaches to teaching literature through four additional dimensions of variation: the awareness of the lecturer in teaching non-technical skills; the role of the lecturer, the teaching environment and assessment. All of these additional aspects assist a lecturer in considering ways in which their teaching can be more effective.

The final comment in this discussion relates back to the introduction chapter and the historical experience of Brunel in designing the Clifton Suspension bridge. At that time, engineers in Britain were trained under an apprenticeship system where the student learned by emulating their patron: by observing their role model in an industrial environment. I can imagine that the patron gave them information on how to design structures, let them practice some calculations and coached them through feedback, on what was incorrect or could be improved. There was no need to mirror the industrial environment as that is where the learning took place and there is no doubt that they were influenced by the role modelling behaviour of their patron, similar to my own experience in my formative years. Perhaps Miller's (2015) commentary on "rebalancing engineering education" and Seely's (2005) "reinventing the wheel" accurately relate to the outcomes of this research question: that academics should reflect back and mirror the good practices of the early engineering profession.

Chapter Summary

This chapter presented the results of the analysis to describe the qualitatively different ways that lecturers approach teaching professional skills in engineering programmes in Ireland. The analysis was based on descriptions of teaching non-technical skills only, and therefore 16 interviewee transcripts were used.

Five approaches were revealed which were qualitatively differentiated by six Themes of Expanding Awareness. The chapter began by summarising each theme of expanding awareness to highlight the differences in each category. The five approaches to teaching professional skills were then described in detail, along with relevant utterances to show examples. The five approaches are: Transmitting Knowledge; Practicing; Coaching; Mirror Industry Environment and Role Modelling. The methodology used to form the hierarchal relationship was also discussed. The findings of the analysis of interview data compares well to the results of the Approaches to Teaching study and Kolb's Educator Role with one exception. The highest-level category (Role Modelling) was not recognisable in these previous studies, perhaps related to the fact that the type of skills selected for this analysis are professional (non-technical) skills specifically. This forms the key message and finding from this study to add to the literature.

Lecturers and curriculum developers must be more aware of the affective domain and the importance of developing behavioural skills in engineering students in order that they be successful in life: role modelling is a teaching approach which may be appropriate to achieve this goal. Furthermore, lecturers must become aware that any interaction with the student provides an opportunity for leading by example and by setting standards. According to Bandura (1999), people learn and repeat behaviours they have observed, so if students see ethical and respectful behaviour, they are more likely to mirror good behavioural skills in any environment.

CHAPTER SIX – Discussion and Conclusions

The findings from the study are closely aligned to engineering educational requirements, specifically how the study outcomes close a gap in the engineering education literature with regard to professional skills. There is a strong connection between findings and recommendations, and implications for future practice in this field, and the resulting impact on students choosing this career path.

This thesis sought to investigate academics' conceptions of, and approaches to, teaching Professional Skills. Recommendations for change to approaches to teaching will only come about if they are consistent with the associated conception of teaching. This makes the case that it is important therefore not only to educate academics about the different approaches to teaching professional skills but also to educate them in the more complete conceptions of what professional skills are. Fundamental changes to how academics approach teaching professional skills many only result from changes to their conceptions of professional skills.

Academics teaching on engineering programmes in Ireland formed the data pool and were asked to complete an online survey to facilitate a purposive sample of interviewees for the main phenomenographic study. In total, nineteen academics were interviewed as part of this study and the interviews were analysed using a phenomenographic methodology to answer the following research questions:

- What are the qualitatively different ways that academics **conceptualise what is meant by professional skills** in engineering?
- What are the qualitatively different **approaches to teaching Professional Skills** that engineering academics use in engineering programmes in Ireland?

- How do academics manifest their conceptions of professional skills through their approaches to teaching professional skills?

The results of this study aim to support reform in engineering education in two ways: as a top down approach through informing policy development and as a bottom up approach by providing a resource for academic training.

This final chapter summarises the findings related to the first two research questions and discusses the relationships between them in order to answer the final research question. It concludes by discussing the implications for the findings in engineering education and identifies opportunities for further research work which will add to the body of knowledge in this area.

6.1 Relationships between Conceptions of Professional Skills and Approaches to Teaching Professional skills

Chapters Four and Five presented the main findings of this study and proposed two new outcome spaces: Conceptions of Professional Skills and Approaches to Teaching Professional Skills. This section investigates if any relationships exist between academics' Conceptions of Professional Skills and their Approaches to Teaching Professional Skills. In particular, this section presents the findings in relation to the final research question:

- How do academics manifest their conceptions of professional skills through their approaches to teaching professional skills?

As a reminder, data from three interviewees (Dermot, Kathleen and Josephine) are not included in this section on the analysis of relationships. These interviewees revealed their conception of Professional Skills as Category B (Technical) only. As discussed in Chapter Five, the gap in the literature relates to how academics teach non-technical skills. Hence when Dermot, Kathleen and Josephine described their approaches to teaching, they were focussing on how they approach teaching technical skills. For the purposes of this PhD study, and to put some boundaries on the limits of the research to ensure it was feasible within the time constraints of a PhD, the approaches to teaching technical skills were not included within this analysis. Hence, for the purposes of this study, the analysis considers Professional Skills as non-technical skills, and hence their interviews are not relevant to this particular research question.

This study identified six Categories of Descriptions which can be used to describe Professional Skills and five Approaches to Teaching Professional Skills, which are summarised in Table 6-1. In order to ascertain if there were any relationships between individual lecturers' conceptions of and approaches to teaching professional skills, I reviewed each individual transcript and identified the highest Category of Description of Professional Skills revealed by each individual. I then looked for evidence on the ways in which each individual approached the teaching of professional skills. Table 6-1 summarises the relationships between Conceptions of Professional Skills and Approaches to Teaching Professional Skills by locating each person by virtue of their highest category and the various approaches they used in teaching Professional Skills. Whilst it is not suggested that this be viewed in a statistical manner, its purpose was to highlight patterns which would allow a focus on potential relationships between Conceptions of and Approaches to Teaching Professional Skills. For example, Hannah whose highest Conception of Professional Skills, was that of Communication, revealed ways of teaching professional skills as both Approach A (Transmitting knowledge) and Approach B (Practicing) and was thus included in both columns.

Table 6-1: Summary of interviewees showing highest Categories of Description of Conceptions of Professional Skills and Approaches to Professional Skills

	Approaches to Teaching Professional Skills				
Conceptions of Professional Skills (highest COD revealed)	**Approach A** Transmitting knowledge	**Approach B** Practicing	**Approach C** Coaching	**Approach D** Mirror Industry Environment	**Approach E** Role modelling
Category A – Communication	Hannah	Hannah			
Category B – Technical(1)					
Category C - Enabling	Sean	Sean Christina	Sean Christina		
Category D - Combination		Adrian Mike	Adrian Mike	Adrian	
Category E – Interpersonal		Charlie William Greg Rosaleen	William	Charlie Greg	Charlie
Category F–Acting Professionally	Imelda	Imelda Muireann Monica Nichola Sebastien Nathan Joe	Imelda Muireann Monica Nichola Sebastien Joe	Imelda Muireann Monica Nichola Sebastien Nathan	Imelda Joe

(1) No-one who revealed their conception of Professional Skills as Conception B (Technical) only were included in this section of analysis. This is because this part of the study focuses on non-technical skills and behaviours, and hence their interviews did not discuss how they taught non-technical skills and behaviours.

Discussion

Some interesting relationships are indicated in this analysis which are presented in this section, beginning with possible associations and then highlighting unlikely associations.

Role modelling as an approach to teaching is typically employed by those interviewees who conceive of professional skills as being Interpersonal skills or Acting Professionally. Charlie provides an example of a situation where he role models by encouraging the students to complete a task. Although the class is already completed, he shows the students that he is willing to stay longer in order to finish the task. Here he is role modelling grit and persistence.

> "The last time we had a class here, I admitted to the students - what I'm doing to you now is actually teaching you persistence because one of the things that students were doing…. all the students have different skills, but some are better at using hand-eye coordination. The class finished at five, but they were still working away on the aircraft at twenty past five. Now I don't mind. And I says "You can't stop the job, once you start the job you have to finish it" The two of them in particular were getting agitated with me, and I said "But lads, if you were out in the real world……you know, I can't stop you, you can walk out the door, but in the real world, you would be required to stay. So I don't want you to let that beat you. That's only a bit of metal. Don't let that bit of metal beat you. You persist". And then they continued on after about half an hour of delay, then they were delighted. It's great to see their enthusiasm". (Charlie)

Imelda on the other hand gives an example in industry of where she learned Interpersonal Skills through watching someone role model, albeit badly. This may have impacted how Imelda teaches as she has also been identified as using role modelling in her own teaching. When asked where she learned her professional skills:

> "I suppose probably from observing other people. Whenever you start going to big meetings like that and you see what's going on and you know when you see someone that says something that's like really just inappropriate and you think God I never want to say

> something like that, you know it just looks so unprofessional and just rude”. (Imelda)

Example of role modelling approach used.

> “In the lab situation, I will try and always bend down to their level in the lab. I’ll never talk over someone in the middle of the lab, I’ll always go down on my hunckers, look at the screen with them, because then they're on a one on one with me”. (Imelda)

Interviewees who conceive of Professional Skills as including Enabling Skills (Category C) reveal approaches to teaching as Transmitting Knowledge, Practicing or Coaching. Sean’s account of a particular module highlights all three approaches. He initially explains how he presents the theory in a lecture type scenario and then in the physical lab the student practises the work by building a circuit board. Finally, when there are issues, Sean literally sits beside the student to coach them through the project by asking questions to encourage the student to think for themselves. During this process the student is thinking critically, analysing options and solving problems, all examples of enabling skills associated with this relationship.

> “Basically, teaching them how to solder is quite hard because you can't, I can't teach anyone how to solder - I have to show them. What I do is I show them and I give them scrap pieces of board. I don't care what they do – they’ve just got to practice practice practice. ……………… So then what we do is we go through a circuit design up on the board and we split down into sections……So it is more lecture type. …….

> So in the latter weeks it becomes about them calling me over when they have a problem they can't solve. So at this stage, they know what the circuit is doing. They pretty much know if it's not working, what to go look for, the basics to go look for. After they check for the basics then they'll call me over. "Look we've checked for x, y, z. I still can't figure out what's gone wrong". So then I step in. ……..
>
> I'm sitting down with them and saying " Come on then, let's figure this out". Let's go through this. I want you to probe here and here. What are the results? What results do you expect to get? If you get those results, why do you think you might be getting it? And then go back and figure out why". (Sean)

Second, according to the interviewees in this study the following associations are also unlikely:

Teaching as Transmitting Knowledge (Approach A) is not typically employed by those who conceive of professional skills as Interpersonal Skills (Category E) or Acting Professionally (Category F). This suggests that the academics in this study do not consider that Acting Professionally or Interpersonal Skills can be taught in a lecture type scenario where a lecturer tells the students what to do. Practicing, Coaching or Mirror Industry Environment are more likely to be used as approaches to teach these type of skills.

On the contrary, for those interviewees who conceive of professional skills as communication skills only, Transmitting knowledge or Practicing approaches are more likely to be used. Since Hannah is the only interviewee in this category, the following extract highlights her approaches to teaching, in particular allowing them to practice by submitting interim reports and giving feedback to students about their written communication skills.

> "We would often give the students an opportunity to submit an interim report. And we would take the interim report say in October around the bank holiday, and we would take them home and we would read them and then we would go back to the students and then show them where they've gone wrong really". (Hannah)

Two other overall observations can be made. Interviewees within this study who conceptualise Professional Skills as Category F (Acting Professionally) are most likely to use a varied range of Approaches to Teaching Professional Skills (all five approaches identified by this group). Approach B (Practicing) is the most widely used approach to teaching professional skills, revealed by all 16 interviewees.

Previous work by Trigwell et al. (1999) shows a relation between teaching approaches and student learning. Work by Kember and Kwan (2002) showed a strong relationship between approaches to teaching and conceptions of good teaching. Therefore, if student learning depends on lecturers' approaches to teaching, and lecturers' approaches to teaching are linked to their conceptions of teaching, this study also proposes that there is also a relationship between a lecturer's Conception of Professional Skills and their Approaches to Teaching Professional Skills. Kember and Kwan (2002) propose that recommendations for change to approaches to teaching will only come about if they are consistent with the associated conception of teaching. This makes the case that it is important therefore not only to educate academics about the different approaches to teaching professional skills but also to educate them in the more complete conceptions of what professional skills are. Fundamental changes to how academics approach teaching professional skills many only result from changes to their conceptions of professional skills.

Summary of findings

This study revealed several key findings which expand on the body of knowledge surrounding professional skills in an engineering education context. First, the study created two new outcome spaces: Conceptions of Professional Skills and Approaches to Teaching Professional Skills. Both studies are contextual to academics teaching on engineering programmes in Ireland.

Second, six Categories of Description which can be used to describe conceptions of Professional Skills were identified, the most surprising of which was entitled "Acting Professionally" and includes not only skills, but behaviours.

Third, there was a gendered influence in the identification of conceptions of Professional Skills, with female academics more likely to reveal conceptions which included Category F (Acting Professionally) and less likely to include Category B (Technical Skills).

Fourth, five Approaches to Teaching were revealed using Themes of Expanding Awareness which include the role and awareness of the lecturer, the purpose of teaching, the focus, teaching environment and assessment technique.

Fifth, Role Modelling as an Approach to Teaching Professional Skills was revealed by participants and was described as leading by example, the purpose of which was to enable the engineer to become a successful person in life outside the confines of engineering.

Sixth, there is a relationship between lecturers' Conceptions of Professional Skills and their Approaches to Teaching Professional Skills.

Implication for Engineering Educational Research

The outcome space for Conceptions of Professional Skills can be used in two ways: to influence policy development and to enhance academics' understanding of the more complete ways to conceptualise what the term Professional Skills means.

The findings of the analysis of interview data compare well to the outcomes of the Approaches to Teaching study and Kolb's Educator Role with one exception. The highest level category (Role Modelling) was not recognisable in these previous studies, perhaps related to the fact that the type of skills selected for this analysis are non-technical skills specifically. This forms the key message and finding from this study to add to the literature: lecturers and curriculum developers must be more aware of the affective domain and the importance of developing behavioural skills in engineering students in order that they be successful in life: role modelling is an approach which can achieve this goal.

The results suggest that there appears to be a relationship between Conceptions of Professional Skills and Approaches to Teaching Professional Skills. Through making academics aware of the more complete conceptions of professional skills, they are more likely to wish to utilise more of the approaches to teaching professional skills.

6.2 Further work

The outcomes of this study did answer the research questions; however the findings also highlight some other important aspects which warrant further research. As an aid to my future work plan, I am listing the additional research which is needed in relation to this topic, but also some interesting ideas which have been presented and which I would like to work on in the future.

Other studies

- This study included a data pool of academics teaching on engineering programmes in Ireland. I would be interested in comparing non-engineering academics and academics from around the world.
- In particular the Conception of Professional Skills outcome space was specific to engineering and it would be interesting to undertake a similar study from another profession (Business or Accounting perhaps).
- A study to ascertain the percentage of learning outcomes in engineering programmes which reflect the different conceptions of professional skills.
- Future work could include the creation of an instrument on Approaches to Teaching Professional Skills (similar to the ATI or Kolb Educator Role Profile). The aim would to be to create a tool that academics could use to see where along the hierarchy they currently sit, and what they can do to improve.
- The outcome space for Conceptions of Professional Skills could be developed into a model with sub-categories of skills lists within each conception. This could then develop into a framework for current engineering students to assess and record their progress in developing these skills, much like an e-portfolio.
- It would be interesting to undertake a similar study on Conceptions of Professional Skills with engineering students and with engineering employers to ascertain if there are differences in conceptions.
- Finally, this study highlighted some gendered differences in both the outcomes for Conceptions of Professional Skills and Approaches to teaching

Professional Skills. A study which focuses on gendered differences between engineering educators and how this impacts student experiences could form a new area of research in this field.

6.3 Concluding remarks

At the beginning of this thesis, I outlined my motivation for this study; to better prepare engineering students for the world of industry so that we could have a better impact on society. I began by outlining the call from employers about the skills gap in engineering students, and I presented a case for working with academics as change agents in order to make this happen.

Therefore, there were two aspects to the study: to produce something which could be used in a top down approach (through policy development) and a bottom up approach (through academic training). The outcomes from this study do this in two ways.

Before we begin to set standards and guide policies in HEIs about professional skills or create accreditation criteria which aims to influence curriculum design, we must first have a multi-level policy which appeals to all academics' different ways of understanding. It is proposed therefore that any policy changes in relation to developing Professional Skills in engineering students, must recognise, that there are those who would like to concentrate on the lowest level conception; that of communication skills. There are also those academics who have a more complete conception of professional skills. All policies should recognise this multifaceted way of understanding to encourage all academics to engage in the process.

This study has described the qualitatively different ways academics understand the concept of professional skills. In doing so it has highlighted the fact that lecturers do not share a common understanding. The nature of the variation in understandings would suggest that some lecturers are unlikely to be receptive to calls for a reform of engineering education by implementing more professional skills in engineering curricula. It also provides an insight into some of the reasons that may underlie the lack of educational reform in this area. The findings of this study may prove helpful in the context of the accreditation bodies and policy development at University level. This is timely given the increasing demands for universities to produce well rounded graduates.

The conceptions identified provide a tool to support the academic community in engaging in a dialogue as to the nature of the professional skills they espouse for their graduates, in particular by reflecting on the various Themes of Expanding Awareness identified within.

Despite the assumption of a shared understanding, there are lists of skills circulating which highlight the dissonance amongst the academic community. Bringing the variation in understandings of professional skills into the discourse in engineering education literature, where they can be debated and discussed, would seem to be an essential element of the process of agreeing on the specific skills needed. It is thus a vital precursor to successful curriculum reform to facilitate the achievement of such outcomes. For example, the outcome space on conceptions of professional skills provided could be morphed into a framework with a list of skills provided under each category mirroring the skills needed within that aspect of professional skills. Furthermore, once the skills have been identified, the relevant approaches to teaching can be considered in tandem with each conception. For example, when attempting to teach professional skills under the conception of Technical skills (Category B), an Approach A (Transmitting knowledge) or B (Practicing) may well be appropriate.

However, understanding Professional skills as Conception F (Acting Professionally) requires a teaching approach such as Practicing, Coaching, Mirror Industry Environment, Role Modelling or perhaps a combination of all.

By articulating the key differences and similarities in understandings, the Categories of Description identified in this study can bring to the surface and make explicit the limited nature of some conceptions of professional skills. Therefore, one of the key uses of this study is in creating an opportunity for dialogue by highlighting the critical aspects of variation between different understandings (i.e. the Themes of Expanding Awareness). By becoming aware of the differences, academics can better appreciate how others understand the concept which will enable them to reflect upon and develop more complex conceptions themselves (Bowden & Marton, 1998).

Secondly, academics who are interested in developing their learning and teaching capability also need resources. Resources which are specifically aimed at helping academics appreciate how their conceptions or approaches are limited and how they can develop further are welcomed. The outcome spaces (in pictorial form) can be used as such a resource. As a further resource, examples of learning outcomes written in relation to professional skills and specific case studies on how behavioural skills can be taught would be welcomed.

A phenomenographic research design with a robust validity and reliability process was employed in this study which allowed the outcome spaces to emerge organically. However, it is also important to note the limitations of the study. The outcomes are contextual to academics teaching on engineering programmes in Ireland and thus are not claimed to be representative of all engineering academics as local social and political factors can have an influence.

In conclusion, this thesis has made several achievements in relation to Professional Skills in engineering that have allowed the discussion in the literature to be progressed to some extent.

- By creating an outcome space for the qualitatively different ways that academics conceptualise professional skills.
- By creating an outcome space for the qualitatively different approaches used by academics to teach professional skills.
- By showing there is a relationship between conceptions of professional skills and approaches to teaching professional skills

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Appendix A - Printed copy of Phase 1 Survey

As an academic teaching on an engineering programme in Ireland, I invite you to complete this survey for my PhD research study. I am interested in better understanding how academics conceptualise and experience the teaching and the development of professional skills in Engineering Programmes in Ireland.

The survey is being undertaken in conjunction with **Engineers Ireland** and should take a **maximum of 10 minutes.**

Aim: The study has two parts; the first being this online survey to gather background information, thoughts on professional skills and information relating to your teaching practice. I then intend to follow up with in depth interviews in line with my phenomenographic approach.

Confidentiality: You may complete the survey without providing contact details and in that case, the survey will be anonymous. However, as I would like to follow up with interviews, I have invited you to provide an email address. By providing contact details, the survey will no longer be anonymous in the initial stages. All contact details will be encrypted and stored separately to survey responses. Once the interviews are complete, all data will be anonymised, encrypted and stored on a DIT password-protected computer.

Withdrawal: Your participation is voluntary and if you have provided contact details on the survey you may withdraw at any time. Withdrawal is only possible if you have provided contact details.

Timescale: We are obliged to retain data for the period of the study (to December 2021) after which it will be destroyed.

Many thanks, Una Beagon

- ◯ Yes - I agree to partake in this study
- ◯ No - I do not wish to proceed

Please select your academic qualifications. (Please tick all that apply)

- ☐ Higher Cert or equivalent (Level 6)
- ☐ Ordinary Degree or equivalent (Level 7)
- ☐ Bachelors (Hons) Degree (Level 8)
- ☐ Masters Degree (Level 9)
- ☐ Postgraduate Certificate (Level 9)
- ☐ Postgraduate Diploma (Level 9)
- ☐ PhD (Level 10)
- ☐ EdD (Level 10)

Are these qualifications in ....?

- ☐ Education and Engineering
- ☐ Engineering only
- ☐ Other (please specify)

Please indicate which **Educational Qualification** you have achieved;

- ☐ CPD Course
- ☐ Postgraduate Certificate in Third Level Learning and Teaching
- ☐ Postgraduate Diploma in Third Level Learning and Teaching
- ☐ Other (please specify)

Are you currently a Member of **Engineers Ireland**?

- ◯ Fellow
- ◯ Chartered Member
- ◯ Ordinary Member
- ◯ Associate Member
- ◯ Technician Member
- ◯ Other (Graduate Member, Student Member, Affilate)
- ◯ Not a member

If you are a Member of another professional Institution, please indicate the **Institution** and **Grade of Membership**.

Have you contributed to an Engineers Ireland Accreditation in the last 5 years?

- ◯ Yes
- ◯ No

How long have you worked in academia?

- ◯ < 5 yrs
- ◯ 5-10 yrs
- ◯ 11-20 yrs
- ◯ > 21 yrs

Is your role?

- ◯ Mainly Lecturing
- ◯ Mainly Research
- ◯ Mainly Admin / Management

How many hours do you **teach** (contact hours) in a typical week?

- ◯ <5 hours
- ◯ 6-10 hours
- ◯ 11-15 hours
- ◯ > 15 hours

Were you employed in industry since achieving your undergraduate degree?

- [ ] Still working / consulting in industry
- [ ] Did not work in industry
- [ ] 0-5 yrs industry experience
- [ ] 6-10 yrs industry experience
- [ ] 11-20 yrs industry experience
- [ ] > 20 yrs industry experience

Did your role in industry include?   (tick all that apply);

☐ Project Management

☐ People Management

☐ Senior Management (Director Level)

☐ Little or no management

Were you involved in recruiting, mentoring or training new graduates?

◯ Yes

◯ No

The next set of questions relate to your **teaching practice.**

For the following questions, select the class/module you teach **most often.**

Academic level of programme:

- ◯ Level 6
- ◯ Level 7
- ◯ Level 8
- ◯ Level 9
- ◯ Level 10

Typical numbers in your class:

- ◯ <15
- ◯ 15-25
- ◯ 26-40
- ◯ 41-80
- ◯ >80

Name of module:

[ ]

Main method of teaching this class/module:

- ◯ Lectures
- ◯ Laboratories
- ◯ Tutorials
- ◯ Studio classes
- ◯ Other (please specify)

[ ]

The following is a **standard validated set of questions** relating to teaching practice in a specific context. (Approaches to Teaching Inventory, Trigwell and Prosser, 1996)
For each item, please select one answer;

only rarely true for me in this subject
sometimes true for me in this subject
true for me **about half the time** in this subject.
frequently true for me in this subject.
almost always true for me in this subject.

REMEMBER: Answers should be based on how you teach the **module you have just chosen**

	Only rarely	Sometimes	Half the time	Frequently	Almost always
I design my teaching in this subject with the assumption that most of the students have very little useful knowledge of the topics to be covered.					
I feel it is important that this subject should be completely described in terms of specific objectives relating to what students have to know for formal assessment items.					
In my interactions with students in this subject I try to develop a conversation with them about the topics we are studying.					
I feel it is important to present a lot of facts to students so that they know what they have to learn for this subject.					
I feel that the assessment in this subject should be an opportunity for students to reveal their changed conceptual understanding of the subject.					
I set aside some teaching time so that the students can discuss, among themselves, the difficulties that they encounter studying this subject.					
In this subject I concentrate on covering the information that might be available from a good textbook.					
I encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop.					
In teaching sessions for this subject, I use difficult or undefined examples to provoke debate.					
I structure this subject to help students to pass the formal assessment items					
I think an important reason for running teaching sessions in this subject is to give students a good set of notes.					
In this subject, I only provide the students with the information they will need to pass the formal assessments.					
I feel that I should know the answers to any questions that students may put to me during this subject.					
I make available opportunities for students in this subject to discuss their changing understanding of the subject.					
I feel that it is better for students in this subject to generate their own notes rather than always copy mine.					
I feel a lot of teaching time in this subject should be used to question students' ideas.					

Assuming all engineering graduates have **baseline technical skills**, please indicate on a scale of 1-5, how important you think the following skills are for new engineering graduates of today?

	1 - Not important	2	3	4	5 - Essential
Character and Interpersonal Skills (integrity, social skills, work ethic)	◯	◯	◯	◯	◯
Teamwork & Collaboration Skills (working with diverse people)	◯	◯	◯	◯	◯
Communication (written, oral, listening skills)	◯	◯	◯	◯	◯
Excellence in Technical Skills (excellent technical capability in engineering)	◯	◯	◯	◯	◯
Problem Solving (visualise and present practical solutions)	◯	◯	◯	◯	◯
Self Direction (initiative, independent work, continuous learning)	◯	◯	◯	◯	◯
Project Management (time management, planning skills)	◯	◯	◯	◯	◯
Leadership (responsibility, leading and directing teams)	◯	◯	◯	◯	◯
Critical Thinking (evaluate all aspects of problems and solutions)	◯	◯	◯	◯	◯
Research Skills (conduct research on a project or product)	◯	◯	◯	◯	◯
Practical Focus (apply theory to real life problems)	◯	◯	◯	◯	◯
Foreign Language Skills (communicate in a second language)	◯	◯	◯	◯	◯
Global Outlook (international and intercultural skills)	◯	◯	◯	◯	◯
Business Acumen (financial and budgeting /cost control awareness)	◯	◯	◯	◯	◯
Risk Management (identify and reduce risk)	◯	◯	◯	◯	◯
General Knowledge (current affairs, politics)	◯	◯	◯	◯	◯
Health & Safety (within a specific industry)	◯	◯	◯	◯	◯

Please indicate how much you agree with the following statements;

Candidates with First Class Honours are always the best prepared for industry.

Strongly disagree ◯———————————— Strongly agree

Excellent technical skills are more important than excellent professional skills.

Strongly disagree Strongly agree

The engineering curriculum has capacity for more emphasis to be placed on teaching professional skills.

Strongly disagree Strongly agree

It is the employer's responsibility to teach professional skills.

Strongly disagree Strongly agree

It is the academic's responsibility to teach professional skills.

Strongly disagree Strongly agree

Engineering graduates in Ireland should have a global outlook.

Strongly disagree Strongly agree

Finally, some background information

What gender do you most identify with?

- ◯ Female
- ◯ Male
- ◯ Other / Prefer not to say

What is your age?

- ◯ Less than 25
- ◯ 25 to 34
- ◯ 35 to 44
- ◯ 45 to 54
- ◯ 55 or older

In which Institution do you currently work?

[ ]

Thank you for your inputs to the survey. The next step in this research is to undertake individual interviews.

Please provide **your email address** if you would be willing to participate in an interview. By providing contact details, the survey will no longer be anonymous, as I may need to contact you regarding interview. Once the interviews are complete, all data will be anonymised.

Email:

[ ]

If you have any other comments, I would love to hear them here;

[ ]

If you have any questions about this research or the management of the research data, please email me at una.beagon@dit.ie or 01 402 3638.

Researchers Involved: Ms Una Beagon (PhD candidate), Prof. Brian Bowe (Supervisor) College of Engineering and Built Environment, DIT, Bolton Street, Dublin 1

Ethical Approval: This project has been approved by the DIT Ethics committee on 23rd October 2017. You are free to contact the ethics committee researchethics@dit.ie should you wish to make a complaint on ethical grounds.

Regards
Una Beagon, (PhD Candidate)
MEng PGDip CEng MICE MIStructE MIEI
Assistant Head of School, School of Civil & Structural Engineering,
Dublin Institute of Technology, Bolton Street, Dublin 1

☐ **EXIT SURVEY**

Appendix B - Research Information Sheets for survey and interviews

TITLE OF PROJECT:

The Teaching Professional skills in Engineering Programmes: The Academic Perspective

Dear Respondent,

Many thanks for taking the time to complete this online survey, which should take 15 minutes.

Aim: I am undertaking a PhD research study to better understand how academics conceptualise and experience the teaching and the development of professional skills in Engineering Programmes in Ireland.

The study has two parts; the first being this online survey to gather background information, thoughts on professional skills and information relating to your teaching practice. I then intend to follow up with in depth interviews in line with my phenomenographic approach.

Confidentiality: You have the option to complete the survey without providing contact details and in that case, the survey will be anonymous. However, as I would like to follow up with interviews, I have invited you to provide contact details at the end of the survey. By providing contact details, the survey will no longer be anonymous, as I may need to contact you regarding interview.

All contact details will be encrypted and stored separately to survey responses. Once the interviews are complete, both the survey and interview data will be anonymised. All responses will be treated confidentially and all data will be encrypted and stored on a DIT password protected computer.

Withdrawal: Your participation is completely voluntary and if you have provided contact details on the survey you may withdraw at any time. Withdrawal is not possible if you have not provided personal contact details. If you have any questions about this research or the management of the research data, please email me at una.beagon@dit.ie or 01 402 3638.

Timescale: We are obliged to retain data for the period of the study (to December 2020), during which time it will be held securely and confidentially, and after which it will be destroyed.

Researchers Involved: Ms Una Beagon (PhD candidate), Prof. Brian Bowe (Supervisor) College of Engineering and Built Environment, DIT, Bolton Street, Dublin 1

Ethical Approval: This project has been approved by the DIT Ethics committee on XXXXX. You are free to contact the ethics committee researchethics@dit.ie should you wish to make a complaint on ethical grounds.

Regards

Una Beagon, (PhD Candidate)

MEng PGDip CEng MICE MIStructE MIEI

Assistant Head of School, School of Civil & Structural Engineering,

Dublin Institute of Technology, Bolton Street, Dublin 1

OLLSCOIL TEICNEOLAÍOCHTA BHAILE ÁTHA CLIATH
DUBLIN
TECHNOLOGICAL UNIVERSITY DUBLIN

A phenomenographic study of academic experiences of learning and teaching on engineering programmes in Ireland.

Participant information Sheet

Aim: This research work relates to a PhD study which seeks to explore academic conceptions of their role in developing professional skills in engineering students. The aim of the research is to produce a developmental framework to assist academics in reflecting upon their own approach to teaching professional skills in an engineering programme.

The study will be undertaken in two phases. Phase One consisted of an online survey to engineering academics in Ireland to gather background information, provide data for triangulation and to provide a purposeful sample for Phase Two interviews.

Phase Two will comprise 15-20 phenomenographic interviews with selected participants.

Interviews: The interviews will take place during the 2019 calendar year with a maximum of 20 interviews, lasting 45mins – 1 hour each.

Confidentiality: The interview will be recorded and will be transcribed using an online HappyScribe Automated Transcription Software (https://www.happyscribe.co/) and will be immediately deleted once the transcribed file has been downloaded. Security details for the Happy Scribe system are included here; https://www.happyscribe.co/security. The transcriptions will be treated confidentially, any identifying names or markers removed before publication and will be stored on a TU Dublin password protected computer. The transcript of the interview will be sent to each participant to review before any material is published.

Withdrawal: Your participation is completely voluntary you may withdraw at any time up until December 2019, when analysis of the interviews will be complete.

Timescale: We are obliged to retain data for the period of the study (to December 2021), during which time it will be held securely and confidentially, and after which it will be destroyed.

CONSENT FORM FOR INTERVIEW	
Researcher's Name	**UNA BEAGON**
Academic Unit	**School of Civil & Structural Engineering, TU Dublin**
Title of Study	**A phenomenographic study of academic experiences of learning and teaching on engineering programmes in Ireland.**

Dear Participant,
Many thanks for agreeing to undertake this interview which should last 45-60 minutes. Please refer to the participant Information sheet which provides details on the aim of the project, issues surrounding confidentiality, options for withdrawal and the timescale in which we will keep the interview data.

Researchers Involved: Ms Una Beagon (PhD candidate), Prof. Brian Bowe (Supervisor) College of Engineering and Built Environment, TU Dublin, Bolton Street, Dublin 1: contact: una.beagon@dit.ie

Ethical Approval: This project has been approved by the TU Dublin Research Ethics and Integrity Committee on 7th March 2019. You are free to contact the ethics committee researchethics@dit.ie should you wish to make a complaint on ethical grounds.

The following section should be completed by the research participant	Yes	No
Have you been fully informed of the nature of this study by the researcher? (Note that this would typically include use of a participant information sheet.)	☐	☐
Have you had an opportunity to ask questions about this research?	☐	☐
Have you received satisfactory answers to all of your questions?	☐	☐
Have your received sufficient information about the potential health and/or safety implications of this research?	☐	☐
Have you been full informed of your ability to withdraw participation and/or data from the research?	☐	☐
Have you been fully informed of what will happen to data generated by your participation in the study and how it will be kept safe?	☐	☐
Do you agree to take part in this study, the results of which may be disseminated in scientific publications, books or conference proceedings?	☐	☐
Have your been informed that this consent form shall be kept securely and in confidence by the researcher?	☐	☐

Do you agree to your interview being recorded and transcribed as described on the participant information sheet?			☐	☐
Name of Participant	Please use block capitals			
Signature of Participant		**Date**		
Signature of Researcher		**Date**		

Appendix C - Selection of interviewees from survey responses.

It was originally intended to undertake 20 interviews as part of this phenomenographic study, hence approximately 30 respondents were initially selected as either First Choice or Backup candidates. The procedure for selection of interviewees is described in this Appendix. The selection criteria were prioritised based on the research questions and the type of relationships which I wished to investigate. The priority in which these were determined were;

1. Gender
2. Industrial Experience
3. ATI Results
4. Academic and Educational Qualifications
5. Academic Experience
6. Engineers Ireland Activity
7. Outlier opinions on provocative statements
8. Outlier opinions on the importance of relevant skills
9. Age
10. Institution

Survey respondents were invited to provide contact email addresses should they wish to be considered for interview as part of the study. In total, 162 respondents provided contact details and thus this provided the original pool for selection.

Through each selection step, every respondent who was identified of interest in relation to that priority was tagged (Px). This was created within an excel spreadsheet as shown in Figure C-1. Upon completion of all 19 tagging steps described below, the number of tags allocated to each respondent was recorded and this allowed a ranking system of potential interviewees to be drawn up. For example, ten separate priority tags were allocated to one respondent, so they became top of the interview list, with a respondent with nine tags in second place. The potential interviewee list was then back checked to ensure there were minimum respondents within each category of interest.

Respondent ID	P1 (Female)	P2 (No Industrial Experien	P3 (>20 yrs industr	P4 (Worked with gradua	P5 (Outlier ATI results)	P6 (PhD)
6546217763			P3 (>20 yrs industry)	P4 (Worked with graduates)	P5 (Outlier CCSF)	
6487080580	P1 (Female)				P5 (Outlier ITTF and CCSF)	
6551935959	P1 (Female)			P4 (Worked with graduates)	P5 (Outlier CCSF)	
6545611312			P3 (>20 yrs industry)	P4 (Worked with graduates)		
6536058873			P3 (>20 yrs industry)	P4 (Worked with graduates)		
6532813430				P4 (Worked with graduates)	P5 (Outlier CCSF)	
6530132268	P1 (Female)	P2 (No Industrial Experience)			P5 (Outlier ITTF)	
6528333966	P1 (Female)			P4 (Worked with graduates)		
6508432726	P1 (Female)	P2 (No Industrial Experience)				P6 (PhD or DEd)
6508305707			P3 (>20 yrs industry)	P4 (Worked with graduates)	P5 (Outlier CCSF)	P6 (PhD or DEd)
6501015956			P3 (>20 yrs industry)	P4 (Worked with graduates)	P5 (Outlier CCSF)	P6 (PhD or DEd)
6500542113	P1 (Female)			P4 (Worked with graduates)		P6 (PhD or DEd)

Figure C-1. Extract from excel sheet showing how each respondent was tagged in relation to the priorities above.

Each step in the tagging process is now described.

Gender

The first priority relates to gender. Although only 22% of respondents were female, it was thought worthy to attempt a 50% split of interviewees by gender. Reed (2006) argues that the researcher must not be swayed by being inclusive of gender or other cultural groups, which are in a phenomenographic sense, artificial distinctions. However, Hazel et al., (1997) argue the opposite: that emotional responses are important and differ between the genders. It is advocated therefore that a purposive sample including gender as a basis for variation provides a clearer picture. This aspect became even more important based on the results of the survey which showed a gender bias in some of the responses.

Ten of the remaining 162 respondents selected 'Other / Prefer not to say' and this was not used as a basis for selection at this point, but the final list was reviewed to ensure at least one interviewee is included with this gender choice. Thirty-six of the 162 respondents indicated a female gender and these were tagged as Priority 1 (P1).

Industrial Experience

I considered that industrial experience and the length of time and interactions with graduates were important in this study. Three priority items were included in this category: no industrial experience (P2); greater than 20 year's experience (P3) and recruited, trained or worked with graduates (P4). Each person who fell into one of these categories received a priority tag.

Approaches to Teaching Inventory Results

The Approaches to Teaching Inventory is designed to identify, within a particular context, whether a lecturer uses a teacher centred or student-centred approach. I am interested in how this approach relates to teaching professional skills and therefore the respondents who indicated extreme alliances with each of these approaches were identified in this priority list.

In order to select respondents for interview, the extreme or outlier CCSF and ITTF scores were considered with thresholds of 20, 26, 28 and 30, where the maximum score is 32. The number of respondents identified in each threshold is shown below in Table C-1.

Table C-2. Threshold Analysis of ITTF and CCSF Scores.

Threshold Value	No of respondents who exceeded threshold in ITTF scale	No of respondents who exceeded threshold in CCSF
Greater than 20	60	93
Greater than 26	6	22
Greater than 28	2	10
Greater than 30	1	2

A threshold value of 26 was used out of a maximum score of 32. All those with CCSF or ITTF values greater than 26 were tagged as a Priority (P5).

Academic and Educational Qualifications

I am interested in the effect that a research career can have on academic's conceptions and so priorities (P6) and (P7) were used to identify those with a PhD or EdD and those without. Although in effect this means that each respondent will score either P6 or P7 in this step, it allows for checking at the end to make sure there is an even spread of those with and without PhDs. This is also the case for the following categories.

Many respondents have undertaken educational qualifications and so for maximum variation it is important to have a mix of both. Hence, Priority (P8) was allocated to those with Educational Qualifications and Priority (P9) to those without.

Academic Experience

There is a range of Academic Experience from under 5 years to over 21 years and therefore these extremities were used within this priority as P10 and P11. Other lengths of academic experience should also be included and this was checked within the final list.

I was also interested in obtaining contrasting views of those who are mainly lecturing (P12) and those respondents who consider themselves researchers (P13). Both of these were allocated priorities.

Engineers Ireland Activity

Chartered or Fellowship Membership of Engineers Ireland suggests a time spent in industry and a commitment to keeping abreast of new challenges within engineering. For this reason, Priority (P14) was allocated to Chartered and Fellow Members of Engineers Ireland and (P15) to those respondents who are not members of Engineers Ireland at all.

Contribution to an Engineers Ireland Accreditation would also assume that respondents are aware of the programme outcome requirements of the accreditation process which specifically required academics to include professional skills such as communication and teamwork skills within modules. Hence, those involved in an accreditation received Priority (P16) and those who were not, (P17).

Outlier opinions on provocative statements

The provocative statements were used to gauge the range of opinion of all respondents. In this section, only the outliers were identified, i.e., those who did not agree with the majority opinion. The outliers were determined by considering the average score and then selecting those whose opinion differed the most from this view. Table C-2 shows the average score for each provocative statement. As most statements resulted in an overall score between 0 and 1, only those respondents who selected 'Strongly Disagree' (-5) or 'Strongly Agree (+5)' were tagged, (P18).

In relation to the statement on Global Outlook, the average score was 2.21 and hence in this case, and outlier was considered as someone who scored -3 or less in this category (i.e. those who disagreed with the majority opinion). The summarised outlier scores are also shown in Table C-2.

Table C-2. Outlier Scores considered for each statement.

Statement	Mean Score	Outlier score considered
Candidates with First Class Honours are always the best prepared for industry.	-0.16	-5 or +5
Excellent technical skills are more important than excellent professional skills.	-0.22	-5 or +5
The engineering curriculum has capacity for more emphasis to be placed on teaching professional skills.	0.41	-5 or +5
It is the employer's responsibility to teach professional skills.	-0.43	-5 or +5
It is the academic's responsibility to teach professional skills.	0.57	-5 or +5
Engineering graduates in Ireland should have a global outlook.	2.21	-5, -4 or -3

Outlier opinions on the importance of relevant skills

A similar tagging system was undertaken for those respondents who were outliers in the list of important skills, (P19). Each extremity was identified bearing in mind the average score for the overall sample, which is shown in Table C-3 overleaf.

Table C-3. Extremities used to identify outliers with opinions on skills requirements.

Skill	Mean score out of 4	Extremity identified
Foreign Language Skills (communicate in a second language)	1.5	Score of 0 (Not Important) or 4 (Essential)
General Knowledge (current affairs, politics)	2.0	Score of 0 (Not Important) or 4 (Essential)
Business Acumen (financial and budgeting /cost control awareness)	2.3	Score of 0
Global Outlook (international and intercultural skills)	2.5	Score of 0
Leadership (responsibility, leading and directing teams)	2.6	Score of 0
Risk Management (identify and reduce risk)	2.7	Score of 0
Research Skills (conduct research on a project or product)	2.9	Score of 0
Health & Safety (within a specific industry)	3.0	Score of 0
Project Management (time management, planning skills)	3.1	Score of 0
Excellence in Technical Skills (excellent technical capability)	3.2	Score of 0
Character and Interpersonal Skills (integrity, social skills, work ethic)	3.3	Score of 0
Teamwork & Collaboration Skills (working with diverse people)	3.5	Score of 0
Self Direction (initiative, independent work, continuous learning)	3.5	Score of 0
Practical Focus (apply theory to real life problems)	3.5	Score of 0
Critical Thinking (evaluate all aspects of problems and solutions)	3.6	Score of 0
Communication (written, oral, listening skills)	3.6	Score of 0
Problem Solving (visualise and present practical solutions)	3.7	Score of 0

Sample selection

The respondent's tags were added and ranked. One respondent was allocated 10 tags, six were tagged 9 times and a further 26 respondents tagged 8 times. The sample was therefore condensed to a pool of 33 potential interviewees.

The next step was to check if all variables had been included in the sample and of the list of 33 interviewees, the numbers allocated to each attribute is indicated in Table C-4 overleaf.

Table C-4: Mapping of attributes in chosen respondents.

Attribute	**Range**	**Actual number included within sample of 33 respondents**
Gender	Male Female Other /Prefer not to say	16 16 1
Age	Less than 25 25 to 34 35 to 44 45 to 54 55 or older	0 (Note:No respondents were <25) 5 7 13 8
Institution	20 options	26 from Institutes of Technology 6 from Universities
Academic Qualifications	Higher Cert (Level 6) Ord Degree (Level 7) Bachelors (Hons) Degree (Level 8) Masters Degree (Level 9) Postgraduate Certificate (Level 9) Postgraduate Diploma (Level 9) PhD (Level 10) EdD (Level 10)	Higher Cert (Level 6) 1 Ord Degree (Level 7) 1 Bachelors (Hons) Degree (Level 8) 15 Masters Degree (Level 9) 20 Postgraduate Certificate (Level 9) 4 Postgraduate Diploma (Level 9) 6 PhD (Level 10) 12 EdD (Level 10) 0
Discipline of academic qualifications	Engineering Only Engineering and Education Other	15 6 12 (Ranges from Sociology to Architecture to MA in Teaching Maths)
Professional Qualifications	CEng Engineers Ireland CEng of other Institution No professional qualifications	10 9 14
Length of time working in academia	< 5 yrs 5-10 yrs 11-20 yrs > 20 yrs	8 4 8 13
Your main role	Mainly Lecturing Mainly Research Admin / Management	29 4 0 (focus is on teaching so not as important)
Teaching Load	<5 hours 5-10 hours 10-15 hours 15+ hours	0 (very few respondents in survey) 8 5 23
Involved in EI Accreditation?	Yes No	24 8
Industry experience	Did not work in industry 0-5 yrs industry experience 6-10 yrs industry experience 10-20 yrs industry experience > 20 yrs industry experience Still working in industry	7 5 6 7 2 6

Table C-4 continued: Extremities used to identify outliers with opinions on skills requirements

Attribute	**Range**	**Actual number included within sample of 33 respondents**
Industry role	Little or no management Project Management People Management Senior Management	4 17 14 6
ATI Responses	Exceed threshold in ITTF Scale Exceed Threshold in CCSF scale	2 ITTF 9 CCSF
Most important skills	Choose outliers in skills list	11 outliers in Skills list
Provocative Statements	Choose outliers in statements list	15 Outliers in provocative statements list

It was determined that the 33 academics selected within the pool provided a good and varied range of academic and industry backgrounds along with outlier scores on the ATI, the provocative statement and the skills list. The top selected interviewees were then determined by considering location and ease of access for interview and these were contacted first. The key demographics for each interviewee are summarised in Table C-5.

Table C-5: Key demographics for interviewees included in study

	P1 (Female)	P2 & P3 (Industrial Experience)	P4 (Work with graduates)	P5 (Outlier ATI results)	P6 (PhD) or P7 (no PhD)	P8 & P9 (Educational Qual)	P10 & P11 (Academic Experience)	P12 (Lecturing) P13 (Research)	P14 (Chartered Member IEI)	P16 & P17 (EI Accreditation)	P18 (Outlier in provocative statement)	P19 (Outlier in skills ranking)	Total Tags
Dermot		P3 (>20 yrs)	P4 (Yes)		P7	P9 (No)		P12 (Lecturing)	P14 (Yes)	P16 (Yes)	P18 (Outlier)	P19 (Outlier)	9
Hannah	P1 (Yes)	P2 (None)		P5 (ITTF)	P7	P8 (Yes)		P12 (Lecturing)	P15 (No)	P16 (Yes)		P19 (Outlier)	9
Nathan		P3 (>20 yrs)	P4 (Yes)	P5 (CCSF)	P6 (PhD)	P9 (No)		P12 (Lecturing)	P15 (No)	P17 (No)	P18 (Outlier)		9
Muireann	P1 (Yes)		P4 (Yes)		P7	P8 (Yes)	P10 (<5 yrs)	P12 (Lecturing)	P14 (Yes)	P16 (Yes)	P18 (Outlier)		9
Nichola	P1 (Yes)			P5 (ITTF&CCSF)	P7	P9 (No)	P10 (<5 yrs))	P12 (Lecturing)	P15 (No)		P18 (Outlier)	P19 (Outlier)	9
Kathleen	P1 (Yes)		P4 (Yes)		P7	P8 (Yes)	P11 (>21 yrs)	P12 (Lecturing)	P14 (Yes)	P16 (Yes)			8
Sean			P4 (Yes)		P6 (PhD)	P9 (No)	P10 (<5 yrs)	P12 (Lecturing)	P15 (No)	P16 (Yes)		P19 (Outlier)	8
Charlie			P4 (Yes)	P5 (CCSF)	P7	P9 (No)	P11 (>21 yrs)	P12 (Lecturing)	P15 (No)	P16 (Yes)			8
Sebastian		P3 (>20 yrs)	P4 (Yes)		P6 (PhD)	P9 (No)	P10 (<5 yrs)	P13 (Research)	P14 (Yes)	P16 (Yes)			8
Josephine	P1 (Yes)		P4 (Yes)		P7	P9 (No)		P12 (Lecturing)	P15 (No)	P16 (Yes)	P18 (Outlier)		8
Greg		P2 (None)			P6 (PhD)	P9 (No)		P13 (Research)	P15 (No)	P16 (Yes)	P18 (Outlier)	P19 (Outlier)	8
William					P6 (PhD)	P9 (No)	P11 (>21 yrs)	P13 (Research)	P14 (Yes)	P16 (Yes)	P18 (Outlier)	P19 (Outlier)	8
Rosaleen	P1 (Yes)	P2 (None)			P7	P8 (Yes)	P11 (>21 yrs)	P12 (Lecturing)	P15 (No)	P16 (Yes)			8
Christina	P1 (Yes)		P4 (Yes)		P6 (PhD)	P9 (No)		P12 (Lecturing)	P14 (Yes))	P16 (Yes)	P18 (Outlier)		8
Imelda	P1 (Yes)		P4 (Yes)		P7	P9 (No)	P10 (<5 yrs)	P12 (Lecturing)	P15 (No)	P17 (No)			8
Joe		P2 (None)			P7	P9 (No)	P11 (>21 yrs)	P12 (Lecturing)	P15 (No)	P16 (Yes)	P18 (Outlier)		8
Monica	P1 (Yes)		P4 (Yes)		P6 (PhD)	P9 (No)	P10 (<5 yrs)	P12 (Lecturing)	P14 (Yes)	P17 (No)			8
Mike		P2 (None)			P6 (PhD)	P8 (Yes)		P12 (Lecturing)	P15 (No)	P17 (No)			6
Adrian		Information not available for Adrian as he was one of the pilot interviews which were included and he did not complete the survey.											

The following papers are included as reference material with regard to the design and findings of the survey undertaken in Phase 1 of this study. Please note the versions presented here are the submitted version, however formal proceedings of the SEFI conference are available at www.sefi.be.

Beagon, U., & Bowe, B. (2018a). The Academic Perspective: A study of academic conceptions of the importance of professional skills in engineering programmes in Ireland. Presented at SEFI Conference, 2018, Copenhagen, Denmark.

Beagon, U. & Bowe, B. (2019b) A Demographic Picture of Academics Teaching on Engineering Programmes in Ireland and their Approaches to Teaching (ATI).47th SEFI Annual Conference in Budapest. 16-19 September 2019.

The Academic Perspective:

A study of academic's perceptions of the importance of professional skills in engineering programmes in Ireland

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Keywords: Professional Skills, Phenomenography, Gender influences in Academia

INTRODUCTION

It has been argued that Industry 4.0 will revolutionalise the way we live, work and communicate with each other and engineers must develop appropriate professional skills to meet the challenges associated with an ever-increasing, energy-consuming population [1,2]. Much has been written in the last ten years about the need for reform in engineering education and in particular the need to prepare graduates to work on a global scale in diverse teams [3,4,5,6]. Engineering education research has responded by informing innovative teaching pedagogies but there is limited research investigating the human influence on engineering education; the academic's perspective. This paper presents the results of an online survey of engineering academics in Ireland (n=273). The survey represents Phase 1 of a phenomenographic study to explore academic conceptions of the importance of professional skills in engineering programmes. Whilst the principal aim of the survey was to identify participants for Phase 2 interviews, we also sought to answer the following research question;

- What factors influence an academic's consideration of the relative importance of specific professional skills?

The outcomes highlight aspects of an academic's life experience which may have an influence on their views on the importance of professional skills. In order to reform engineering education, we must not only look at new policies and procedures, nor only consider innovative teaching pedagogies, we must also consider how we can encourage academics of all backgrounds to engage in educational reform. To do that we must better understand the beliefs, perceptions and conceptions of academics working with students every day. The results of this survey provide an initial insight into the perceptions held by academic staff, which will be explored further in the main phenomenographic study.

1. BACKGROUND

Engineering has always been central to society's progress. In the past, the work of engineers significantly improved the quality of life of large populations through advances in technology and new innovations by improving healthcare, housing, nutrition, education, transport and communication. Today, engineers need skills and competencies to work in multi-disciplinary teams, transcending international boundaries and dealing with globally complex issues in unfamiliar surroundings. Policymakers, economists, politicians and social scientists will also be key members of any team which aims to provoke societal change. Engineering graduates need to be prepared to engage with a diverse range of people and disciplines outside of the technical domain of engineering itself.

6.4 Skills Requirements

There have been several calls for reform in engineering education, in order that graduates are equipped with the relevant skills to meet future societal challenges [3,4,5,6]. Engineering education researchers have informed innovative pedagogical practices which will help develop those skills in students.

The outcomes provide a rich catalogue for engineering educators, of initiatives which can be implemented in engineering programmes to meet this aim. There is no doubt that the use of project driven, group-based pedagogies, community-based projects, work placement and other student-centred approaches have a place in developing relevant professional skills. There is also an increasing recognition of the importance of emulating engineering practice in the classroom [5,7,8] which may suggest there is value in employing engineering academics who have engineering practice experience, sometimes called 'Pracademics'.

1.2 Career Academics versus Practical Experience

The academics involved in such innovative pedagogies do not need to be convinced about the benefits to the students of these teaching and learning methods, nor the importance of developing professional skills in students. However, not all engineering academics have the same interest in engineering education. Some may be less inclined to implement innovative pedagogies in the classroom or even move away from traditional didactic teaching where learning is predominantly seen as the accumulation of knowledge and technical skills. Other academics may consider that the development of professional skills is at the expense of technical knowledge, when in fact they can be developed in synergy.

Many engineering academics value research over teaching, which is encouraged by the research orientated promotional policies of many Institutions [5,9,10]. Pilcher et al., [11] argues that academics who have significant practice experience can be better placed to advise on the professional skills that engineers need in the workplace, and are in a position to teach using real-life examples. However, recruitment policies which require a PhD as a minimum qualification can create a barrier to those industry practitioners considering a mid-career change [11]. Pilcher et al., [11] also attest that it is questionable whether someone with industry experience would attain employment ahead of what is termed the 'career academic' in UK universities, as a result of the emphasis on research output metrics associated with the Research Excellence Framework. The Royal Academy of Engineering (RAE) foresee perhaps the inevitable decline in industry experienced academic staff "HE appointments are often driven by a need to improve the research profile of an institution and many academics are recruited on their research track record. The result is that fewer lecturers in UK universities will have significant industrial experience." [9,10, p.21]. Glenn Miller, Dean of Olin College, attests that many engineering academics are not trained to teach professional skills since they were hired for technical expertise and not their professional skills [6]. He proposes that teaching professional skills is more complex and nuanced than teaching technical skills which can easily be defined and measured. Whilst there are calls for the employment of more academic staff with industry experience [11], there is little published research on the variation of conceptions of 'career academics' and 'industry experienced academics'.

The reform of engineering education can only be successful when academic staff come to understand the value of integrating professional skills within the curriculum. This survey comprises the first step to ascertain conceptions of what professional skills are and the value placed upon them by engineering academics.

2. SURVEY DESIGN

An online survey was circulated to all academics teaching on engineering programmes in Ireland. A response rate of 34% was achieved and n=273 (29%) respondents answered all questions. Whilst the main purpose of the survey was to identify interview participants and therefore a representative sample was not required, we were unable to determine if there was a biased response as overall population data of engineering academics in Ireland was unavailable. The survey collected information on the following topics; gender, age, HEI employer, engineering, other and teaching qualifications, membership of professional bodies, extent of academic experience, role and number of teaching hours, extent of industry experience, role, involvement with graduate recruitment or initial training of graduates.

Respondents were asked to score the importance of a list of professional skills for today's engineering graduates. The list of skills was created from a systematic literature review of recent engineering educational publications and research papers and comprised 17 'non technical' skills with just one 'technical' skill option. The purpose of the survey was to attempt to show some correlations and relationships between different aspects of the response data

3. RESULTS AND DISCUSSION

3.1 Demographics

The majority of respondents were male 72% (n= 197) and only 8% of respondents indicated an age below 35 years old. Approximately half (49%) of all respondents had achieved a PhD/EdD qualification. There was a wide range of primary qualification types selected by respondents with 87% (n=268) having an engineering qualification of some type. Respondents who answered 'Other' (n=39) indicated primary qualifications in the following broad categories; Science and Mathematics, Architecture and Construction, Business / MBA or Economics and Arts and Sociology. Sixty-nine respondents (23%) highlighted that they had undertaken an educational qualification, such as a CPD course, Post Graduate Certificate, Diploma or Masters in Education.

Eighty-two percent of respondents held roles in industry, with 34 academic staff still working or consulting in industry as shown in *Fig. 1*. The authors acknowledge however that there may currently be academics working in joint research projects with industry in a consultancy role and whilst this may have prompted a 'yes' to this question, it is not the equivalent to spending several years in full-time practice. Thus, the responses from this category of academic must be considered carefully.

Those who had industry experience were asked to select the most senior role undertaken as indicated in *Fig. 2*. Intuitively, the number of respondents who undertook project management, people management and senior management roles increased with length of time spent in industry. However, even 46% of those with less than 5 years' industry experience had opportunities for people and project management roles suggesting that they would have had direct exposure to new graduates and hence an understanding of their attributes and potential weaknesses.

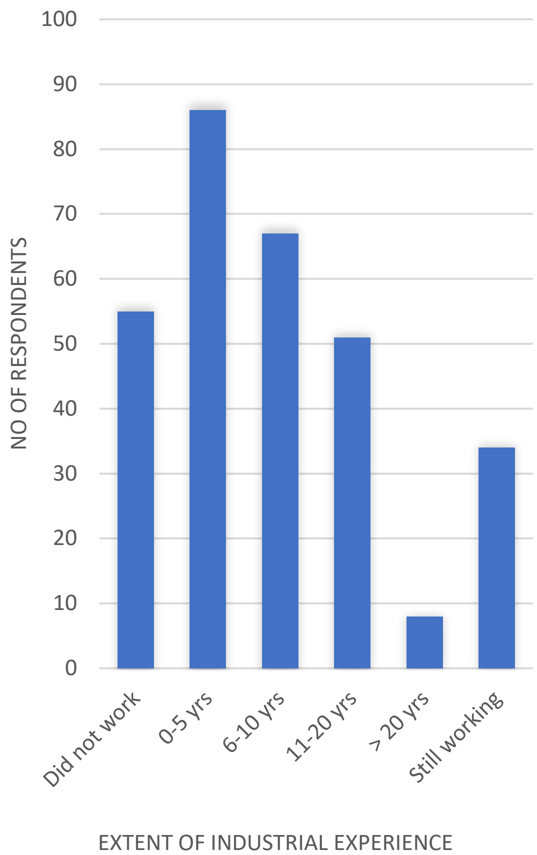

Fig. 1. No of respondents indicating length of industrial experience

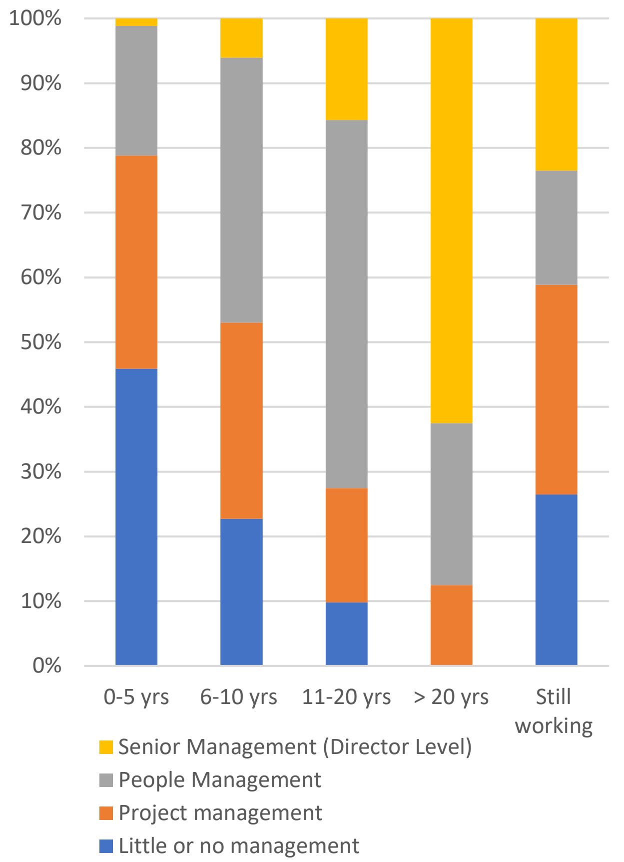

Fig. 2. Percentage of respondents in each category indicating most senior role in industry

3.2 Importance of specific skills

Participants were asked to comment on the importance of a list of skills for the engineering graduates of today. A sliding scale question was used with 'Not important' (scored as 0) to 'Essential' (scored as 4). The authors acknowledge that a ranked question may have yielded a more robust response and the question was originally trialled in that fashion. Feedback from the pilot surveys indicated that a ranked question with 17 options did not flow well within the overall survey and respondents were more likely to drop out of the survey at that point. Hence respondents were asked to score each skill individually.

It is accepted that technical skills are a critical aspect of an engineer's formation, however, this question sought to investigate if respondents would choose 'excellent technical skills' as more important than the other professional skills. Hence, the question was phrased "*Assuming all engineering graduates have baseline technical skills, please indicate on a scale of 0-4, how important you think the following skills are for new engineering graduates of today?*". A summary of the skills in rank order of importance calculated by mean score and the number of respondents which scored '0 -Not important' for specific skills are shown in *Table 1*.

Table 1. Average scoring of skills and number of respondents who indicated 'Not Important'

Professional Skill	**Mean score (*M*) out of 4**	**No of resps who scored '0' - not important**
Problem Solving (visualise and present practical solutions)	3.7 (*SD* = .48)	0
Communication (written, oral, listening skills)	3.6 (*SD* = .64)	0
Critical Thinking (evaluate all aspects of problems and solutions)	3.6 (*SD* = .65)	0
Practical Focus (apply theory to real life problems)	3.5 (*SD* = .60)	0
Self Direction (initiative, independent work, continuous learning)	3.5 (*SD* = .66)	0
Teamwork & Collaboration Skills (working with diverse people)	3.5 (*SD* = .71)	0
Character and Interpersonal Skills (integrity, social skills, ethic)	3.3 (*SD* = .78)	2
Excellence in Technical Skills (excellent technical capability)	3.2 (*SD* = .74)	0
Project Management (time management, planning skills)	3.1 (*SD* = .73)	0
Health & Safety (within a specific industry)	3.0 (*SD* = .95)	0
Research Skills (conduct research on a project or product)	2.9 (*SD* = .89)	3
Risk Management (identify and reduce risk)	2.7 (*SD* = .89)	2
Leadership (responsibility, leading and directing teams)	2.6 (*SD* = .86)	4
Global Outlook (international and intercultural skills)	2.5 (*SD* = .92)	4
Business Acumen (financial and budgeting /cost awareness)	2.3 (*SD* = .90)	8
General Knowledge (current affairs, politics)	2.0 (*SD* = .91)	12
Foreign Language Skills (communicate in a second language)	1.5 (*SD* = .96)	46

There is minimal difference in the scoring of the first six skills; Problem Solving, Communication, Critical Thinking, Practical Focus, Self Direction and Teamwork and Collaboration Skills, which are typical of those highlighted most often in the literature review exercise.

There is clearly a low score attributed to the importance of foreign language skills, which reflects the fact that English is the main form of communication in Ireland. The survey did not collect information relating to the language skills of the respondents, which would have provided further insight into the level of internationality in academic staff on engineering programmes in Ireland.

3.3 Gender differences

Initially, the results were sorted by gender and although this was not an initial research theme, it highlighted a surprising result. *Table 2* shows the average scores for females, males and those who chose ‘Other or Prefer not to say’.

Table 2. Average scores of respondents on the importance of specific skills

	Female Mean Score (n=60)	Male Mean Score (n=197)	Other/Prefer not to say Mean Score (n=16)	Difference between Female - Male mean score
Problem Solving	3.78	3.71	3.81	0.08
Communication	3.71	3.59	3.44	0.12
Critical Thinking	3.78	3.53	3.56	0.26
Practical Focus	3.69	3.50	3.44	0.19
Self-Direction	3.62	3.44	3.50	0.17
Teamwork & Collaboration Skills	3.71	3.41	3.25	0.30*
Character and Interpersonal Skills	3.60	3.27	2.93	0.33*
Excellence in Technical Skills	3.17	3.23	3.00	-0.07*
Project Management	3.22	3.07	3.06	0.14
Health & Safety	3.20	2.94	3.31	0.26
Research Skills	3.12	2.82	2.94	0.31
Risk Management	2.97	2.66	2.75	0.31
Leadership	2.82	2.56	2.38	0.26
Global Outlook	2.80	2.46	2.50	0.34
Business Acumen	2.42	2.31	2.06	0.10
General Knowledge	2.15	2.01	1.88	0.15
Foreign Language Skills	1.58	1.43	1.38	0.16

*Indicates cases in which a statistically significant correlation was observed with regard to gender.

Within this survey, in all but one professional skill, women were more likely to score the importance of professional skills more highly than men, i.e., they appeared to place more importance on each skill than men did. Only ‘Excellence in technical skills’ was scored as less important by women than men. Since excellence in technical skills could be considered the only technical skill presented within the survey, and all others are non-technical, this suggests that within this population, female academics place more importance on non-technical skills in engineering graduates than male academics.

Although this initial result suggested a gendered difference, a statistical test carried out on SPSS sought to clarify which factor was the highest determinant of scoring of each professional skill; Age, Gender and Length of Industrial Experience. There were no correlations observed with regard to length of industry experience. A significant correlation was observed between Age and the importance of Teamwork and Collaboration Skills, Pearson’s $r(238) = .127$, $p = .05$. The results also indicated that whilst there was no significant correlation observed between the overall average score and gender, significant correlations were identified between; Gender and the importance of Character and Interpersonal Skills, Pearson’s $r(235) = .144$, $p = .03$, Teamwork and Collaboration, $r(238) = .128$, $p = .05$ and Excellence in Technical Skills, r (237) = .145, $p = .03$. As this finding was based on only one question within the survey, it is difficult to draw a solid conclusion however, it suggests that there is value in a further study to investigate differences in gender profiles of academic staff and their attitudes or approaches to teaching non-technical skills.

3.4 Influence of Industry Experience in relation to the importance of skills

Table 3 shows the percentage of respondents who selected 'Essential' for specific skills in relation to their industry experience. *Fig. 3* also shows the average score for specific skills in relation to industry experience. Industry experience has been refined to show comparisons between those with none or up to 5 years experience, and those with more than 6 years experience, but excluding those still working in industry, which has been discounted due to potential ambiguity in the question.

Table 3. Percentage of respondents selecting 'Essential' for specific skills

Industry Experience	Practical Focus	Leadership	Problem Solving
Greater than 6 years experience (n=110)	68.2%	19.1%	57.3%
Less than 6 years experience (n=135)	52.6%	13.3%	42.2%

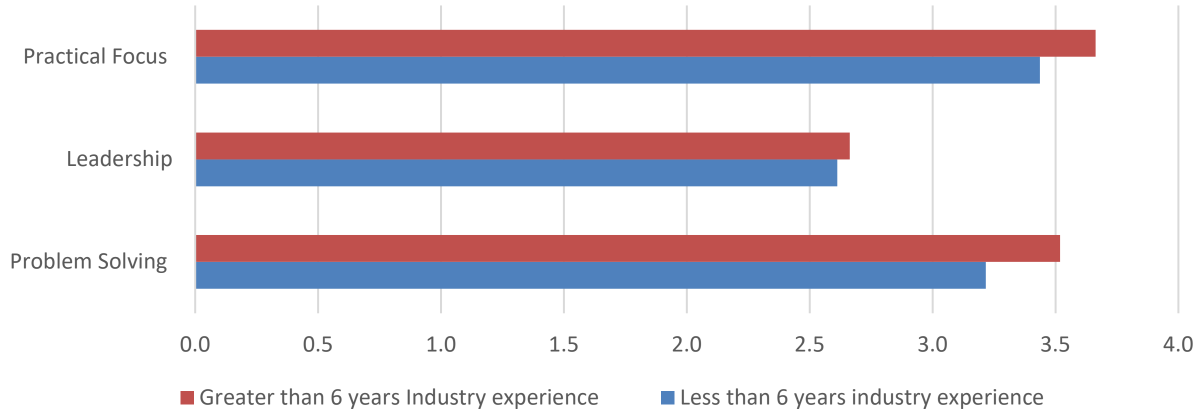

Fig. 3. Mean score of respondents with differing industry experience on specific skills where 0 = 'Not important' and 4= 'Essential'

3.5 Skills and Industry Experience

The results suggest that that the importance placed on practical focus, leadership skills and problem solving may be linked to time spent in industry and this is an issue we intend to address further within the main phenomenographic interview sessions. Problem Solving is clearly an essential requirement for engineers and achieved the highest score in the overall survey. It is also highlighted here as showing the largest difference in score between those with little or no industry experience and those with more than 5 years experience.

4. CONCLUSIONS AND FURTHER WORK

The aim of this survey was to consider influences on an academic's opinion on the importance of specific professional skills in engineering graduates of today. The study showed that gender appears to have an influence not only on the importance of all professional skills, but particularly in relation to the importance of pure technical skills over non-technical skills. There is evidence to suggest that an academic's experience in industry also influences their judgements on the importance of professional skills and highlights the value of employing a diverse range of academic staff, including both career academics and those with industry experience, a proposal also put forward by Pilcher et al., [11].

The survey was administered to gather a range of views from academic staff in Ireland and to identify varied participants for a phenomenographic study. This work is ongoing. However, the results of the survey highlighted some interesting findings which will be investigated further in interviews. The authors would also welcome a comparative analysis of the same study of academics in another country.

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A demographic picture of academics teaching on engineering programmes in Ireland and their Approaches to Teaching (ATI).

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Conference Key Areas: Impacts of demographics in tertiary education, Diversity in Engineering Education

Keywords: Engineering academics, Approaches to Teaching, ATI

ABSTRACT

This paper presents the results of an online survey (n=293) carried out on academics teaching on engineering programmes in Ireland in 2017/18. The primary purpose of the survey was to provide a selection pool for interviewees in a separate phenomenographic study, however the survey also provided some interesting findings. Previously, there has been little published data on the diversity of personnel teaching on engineering programmes in Ireland and this paper aims to provide an insight.

In addition to collating the demographics of the survey respondents, and their background experiences in academic and industry, the Approaches to Teaching Inventory (ATI) [1] was also used as part of the survey. The results show that the respondents were more likely to use a Conceptual Change/Student Focussed Approach (CCSF) to teaching than an Information Transfer/Teacher Focused (ITTF) approach in the context of the modules they considered. Finally, diagrams are presented which show relationships between the Approaches to Teaching (ATI) responses and the level of programme being taught, the length of academic experience and any academic qualifications in teaching. A study of demographics and attitudes of engineering staff was undertaken in Australia in 2010/11 [2] and we hope that both these results may encourage other countries to undertake a similar survey so that we may compare and contrast between different countries in order to better understand the diversity of our engineering academic community.

1 INTRODUCTION

The paper reports on an aspect of a larger phenomenographic study which aims to describe the qualitatively different ways that academics approach teaching professional skills in engineering programmes in Ireland. As part of the selection process for interviewees for the phenomenographic study, an online survey was circulated to all academics teaching on engineering programmes in Ireland. The main aim of this survey was to undertake purposive sampling of interviewees, but some of the data collected also provided some interesting findings in relation to general demographics of academic educators and their approaches to teaching, both of which are presented here.

1.1 Demographics

A phenomenographic study aims to identify the qualitatively distinct ways in which people conceptualise or experience a particular phenomenon. A phenomenographer looks for variation and hence seeks to interview a varied range of people. In this case, the researchers aimed to interview academics teaching on engineering programmes in Ireland, but realised very quickly that there was no central database of academic profiles nor published material which could be used to select appropriately differing interviewees and hence an online survey was used for this purpose. Ireland is not alone in the dearth of information about engineering academic staff and work undertaken by Cameron, Reidsema and Hadgraft [2] sought to collate similar information in an Australian context. The purpose of their study was to identify challenges, opportunities and barriers for change management within engineering education, but they collected demographic information, previous industry experience and they also used extracts from the ATI to highlight attitudes to teaching.

Although it was not the main aim of the Irish survey, the demographic results are nevertheless considered worthy of publication, to showcase the diversity of those teaching on engineering programmes in Ireland.

1.2 Analysis

It is important to bear in mind that no statistical analyses have been carried out within this study, all results presented are based on a comparison of frequency counts.

2 ACADEMICS' APPROACHES TO TEACHING PROFESSIONAL SKILLS

One aspect of diversity that was interesting from the aspect of the phenomenographic study, was how academics differ in their teaching practice. The theory of academic approaches to teaching provides a lens through which to consider this aspect. Prosser, Trigwell and Waterhouse [3] purport that the academic's conception of teaching has a direct influence on how the students learn and have created an Approaches to Teaching Inventory (ATI) survey instrument [1,3,4]. This instrument was used within the survey and highlights how an academic approaches teaching in a particular context. The research work that led to the creation of the Approaches to Teaching Inventory resulted from a phenomenographic study of first year university science teachers [3,4]. The analysis yielded five qualitatively different approaches to teaching (A-E), which are summarised in *Table 1.*

Table 1. Approaches to teaching (from Trigwell, Prosser and Taylor, 1994 [4])

	Strategy		
Intention	Teacher-focused	Student/Teacher Interaction	Student focused
Information transmission	A		
Concept acquisition	B	C	
Conceptual development			D
Conceptual change			E

Approach A: A teacher-focused strategy with the intention of transmitting information to students.
Approach B: A teacher-focused strategy with the intention that students acquire the concepts of the discipline.
Approach C: A teacher/student interaction strategy with the intention that students acquire the concepts of the discipline.
Approach D: A student-focused strategy aimed at students developing their conception.
Approach E: A student-focused strategy aimed at students changing their conceptions.

The ATI was revised in 1999 and the wording of some of the inventory items was updated to accommodate more flexible learning situations than those of first year university science teachers [1]. The original five sub scales were reviewed and a two factor subscale was now proposed, representing two fundamentally different approaches to teaching; Information Transmission / Teacher Focused Approach (ITTF) and Conceptual Change/Student Focussed Approach (CSSF).

2.1 Recent research – Approaches to Teaching Inventory

The original ATI was developed with first year physics and chemistry science teachers and the limitations of the research were highlighted as being relational and not necessarily the same for all disciples and contexts. It has since been used in a range of situations to relate approaches to teaching to other aspects of the teaching environment such as class size and teaching workload [5], impact of a teaching development programme [6], and disciplinary content [7,8,9]. Mean values of the CCSF and ITTF approach scales were analysed per discipline in these studies and showed statistical differences between discipline groups. Higher CCSF scores were found in the 'soft' disciplines (arts, humanities social science etc,) compared to the 'hard' disciplines which have a greater use of the ITTF approach (engineering, science, medicine) [9].

2.2 ATI – Criticism of conceptual foundation and procedures used

There has been criticism about the use of the ATI in scenarios where it was not originally intended and in the conceptual foundation and procedures which were used in its development [10]. For example, it is postulated that in two of the five categories, only one teacher's voice may have been used to support the construct and since the gender of the 24 teachers was not identified, it is likely that 80-90% of interviewees were male and the scope of variation one could extract with such a gender bias is questioned [10].

2.3 Survey circulation

The survey was distributed to academic staff teaching on engineering programmes in all Higher Educational Institutions (HEIs) in Ireland. Staff listings were obtained from published staff contact details on each of the HEIs websites and this gave an estimate of approximately 1,000 relevant academic staff. Responses totalled n=273 giving an approximate response rate of 27%.

Whilst it is difficult to say whether the respondents are a representative sample, responses were received from each of the HEIs contacted and there was a varied range of discipline profile, academic qualifications, industry experience and age. Perhaps the only anomaly is that only 12.6% of those contacted to complete the survey appeared to be female based on their name, but as the results show in the next section, 22% of respondents were female. This is perhaps explained by the fact that the researcher is also a female engineering academic and female respondents may have been more likely to respond to a survey circulated by a fellow female engineer.

Fig. 1 and *Table 2* show the breakdown of gender and age of respondent profiles. The majority of respondents were male (n= 197) and 16 respondents selected "Other /

Prefer not to say". No respondent indicated an age of less than 25, and less than 8% of respondents indicated an age of below 35 years old.

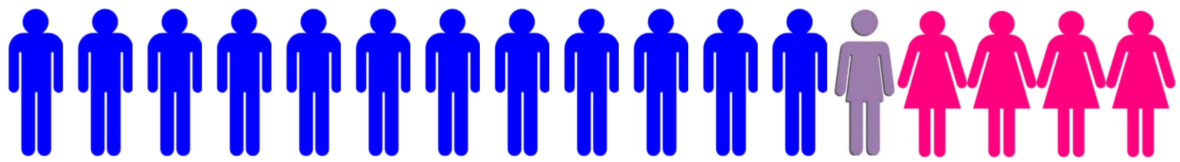

Fig. 1. Gender identification selected by respondents

Table 2. Age of respondents

Age	**<25 years**	**25 – 34 years**	**35-44 years**	**45-54 years**	**55 or older**
Number of respondents (%)	0 (0%)	21 (7.7%)	84 (30.8%)	114 (41.8%)	54 (19.8%)

2.4 Educational Qualifications

Respondents were asked to select all of their academic achievements. This was to identify those members of staff who had gained a PhD and those who had undertaken an educational qualification such as the Postgraduate Diploma in Third Level Learning and Teaching. *Figures 3 and 4* indicate the percentages of respondents who have gained various qualifications and those whose qualifications are in 'Engineering', 'Engineering and Education' or 'Other'. There was a wide range of qualification types selected by respondents with 87% (n=268) having an engineering qualification of some type. Respondents who answered 'Other' (n=39) indicated qualifications in the following broad categories; Science and Mathematics (n=23), Architecture and Construction (n=10), Business / MBA or Economics (n=3), Arts and Sociology (n=3).

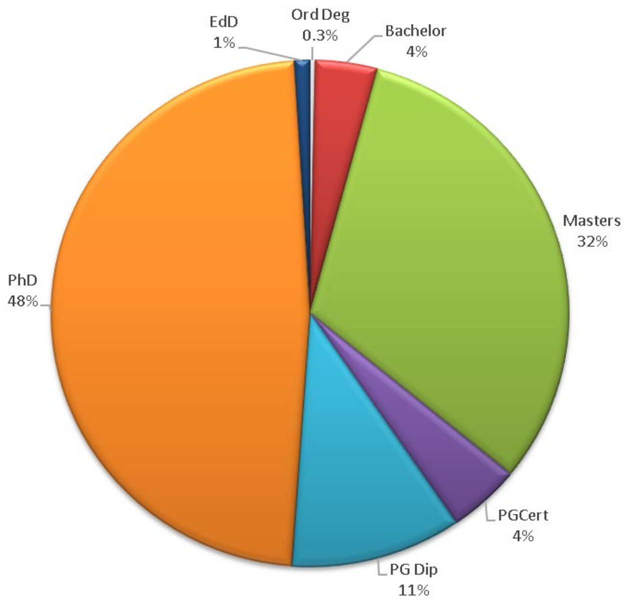

Fig. 3. Highest Level of Qualification

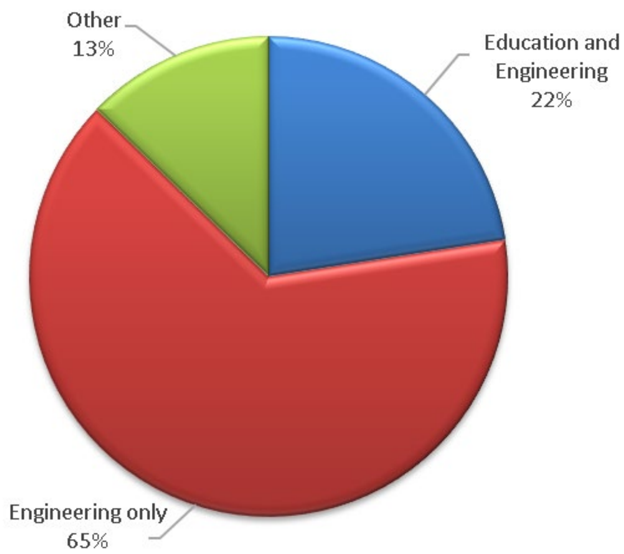

Fig. 4. Types of qualification gained

There was also a wide range of additional qualifications noted for those who selected 'Engineering' as a primary qualification. These included specialist subject areas such as regenerative medicine and software engineering, however 26 of the engineering respondents (8.5%) also indicated they had obtained either an MBA or Business/Management qualification.

2.5 Academic Experience

Respondents were asked to indicate the length, type and number of teaching hours they work in order to obtain a good range of interviewees with a selection of academic experience. *Figures 5 and 6* show the variation in responses to length of time working in academia and type of role selected.

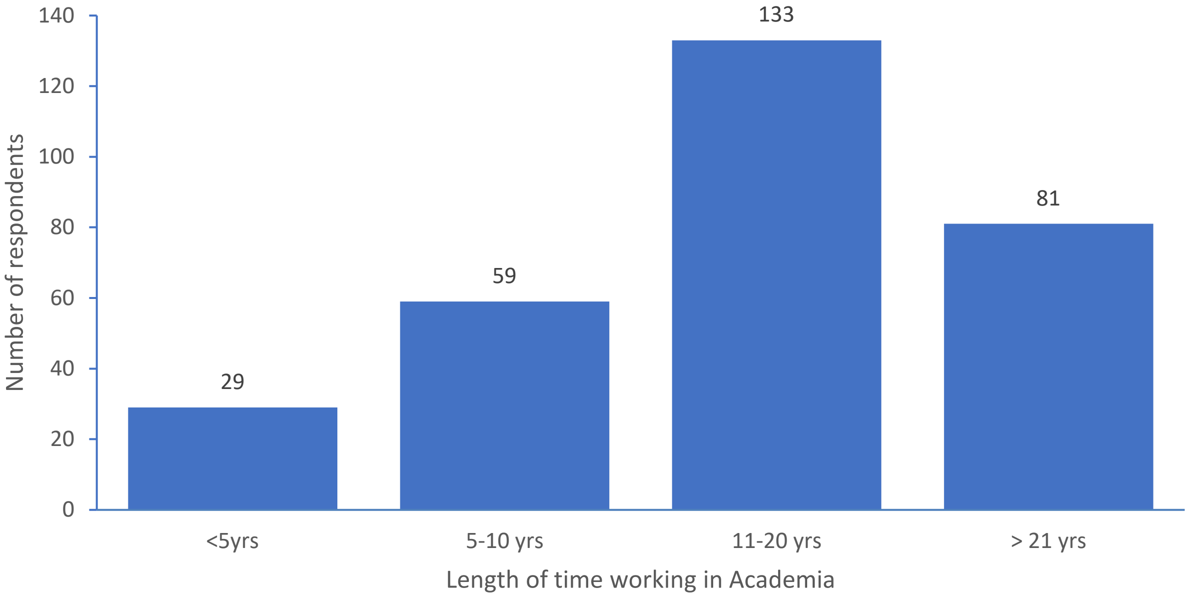

Fig. 5. Length of time working in academia

Type of role	Percentage of respondents	Graphical interpretation
Mainly Administration / Management	11% (n=32)	
Mainly Research	14% (n=43)	
Mainly lecturing	75% (n=221)	

Fig. 6. Type of role in academia selected

Third level education in Ireland is typically delivered within both Universities and Institutes of Technology (IOT). Respondents from each sector were asked to indicate their teaching hours and *Figure 7* shows the disparity between each sector with the clear majority of respondents in the IOT sector teaching greater than 15 hours per week. This is typically 6-10 hours per week for the University sector, 35% of which consider themselves 'mainly researchers' compared to only 5% of IOT staff selecting this option.

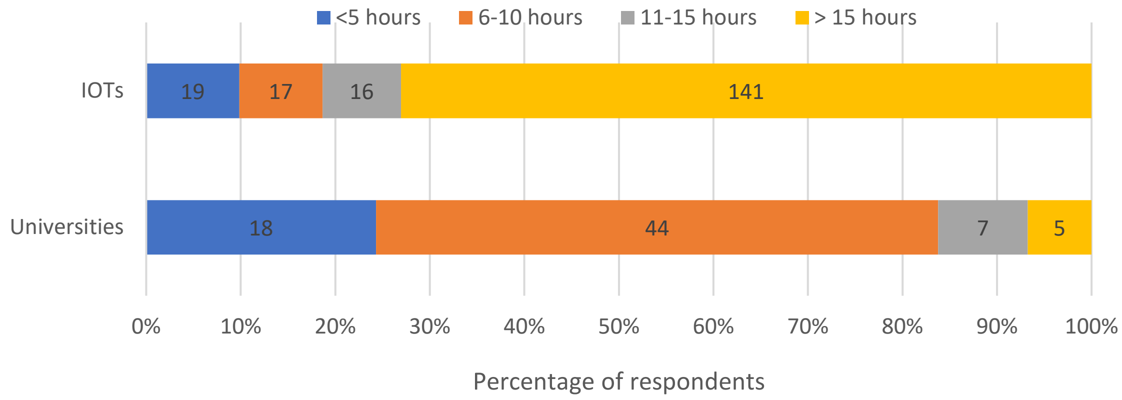

Fig. 7. No of teaching hours differentiated by University and IOT.

2.6 Industry Experience

Respondents were also invited to comment on their previous industry experience, the type of role they held and whether they were involved in the recruitment or training of new graduates. Many respondents have held roles in industry, as indicated in *Figure 8,* with 34 academic staff still working or consulting in industry.

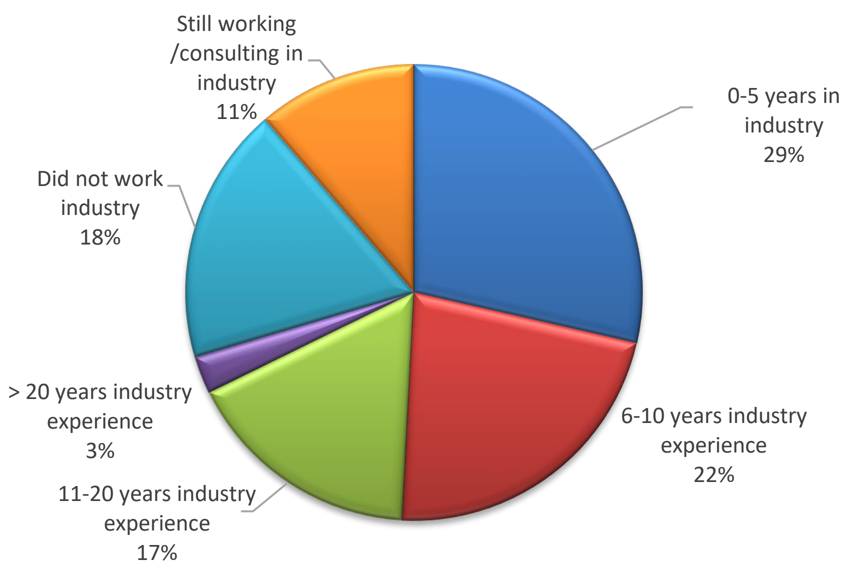

Fig. 8. Range of industry experiences noted by survey respondents.

The University sector holds proportionally more of the 53 respondents who have never worked in industry (38% of University responses compared to 13% of IOT responses). Conversely, approximately the same percentage (12%) of IOT staff and University staff are still working or consulting in industry. It is important to consider here that academic staff who are undertaking research projects with industry input may have answered the “still working / consulting in industry” option in this question.

2.7 Membership of professional bodies

Approximately 60% of respondents indicated that they were members of professional bodies, of which 38% are members of Engineers Ireland. Of the Engineers Ireland

Members, more than half are Chartered Engineers or Fellows as indicated in *Figure 9.* In order to become a Chartered Member, applicants must show evidence of specific objectives, many of which are aligned to practicing as an engineer. Those with Chartered or Fellowship membership therefore, would typically indicate a level of industry engagement and experience. Seventy-six percent of respondents indicated that they had contributed to an Engineers Ireland Accreditation in the past 5 years.

Type of Engineers Ireland Membership	**Percentage of respondents**	**Graphical interpretation**
Fellow	14.0% (n=16)	
Chartered Member	41.2% (n=47)	
Ordinary Member	40.4% (n=46)	
Associate Member	2.6% (n=3)	
Other (Graduate, Student, Affiliate)	1.8% (n=2)	

Fig.9. Type of membership of Engineers Ireland noted by survey respondents.

3 FINDINGS IN RELATION TO SPECIFIC RESEARCH QUESTIONS

The survey findings were also reviewed to assess the research questions;

- What is the relationship (if any) between approaches to teaching and the level of programme being taught?
- What is the relationship (if any) between approaches to teaching and educational qualifications of respondents?
- What is the relationship (if any) between approaches to teaching and educational experience?

3.1 Scoring of Approaches to Teaching Inventory

The Approaches to Teaching Inventory [1] used in the survey included 16 questions with statements pertaining to how an academic might approach teaching. The outcomes can show whether an academic has a Conceptual Change / Student Focussed (CCSF) approach or an Information Transmission/Teacher Focussed (ITTF). The respondent was asked to consider just one module, the one with which they have most contact time and so it is acknowledged that the responses are contextual; that responses for a different module may give a different score. The questions were in the form of statements, for example; "In teaching sessions for this subject, I deliberately provoke debate and discussion", or "It is important to present a lot of facts to students so that they know what they have to learn for this subject" [1]. Respondents select from 5 options from 'only rarely' (scored as zero) to 'almost always' (scored as 4). Hence the lower and upper bound scores are zero and 32, as each inventory scale has 8 associated questions.

All responses were scored and the results for the CCSF and ITTF calculated for each respondent. The following plot (*Figure 10*) shows the range of scores with each point representing the CCSF and ITTF score for one respondent. Whilst statistical analysis was not carried out, the trend line indicates that when one becomes more aligned with a Conceptual Change/Student Focused model, the score on the Information Transfer/Transmission Focused reduces.

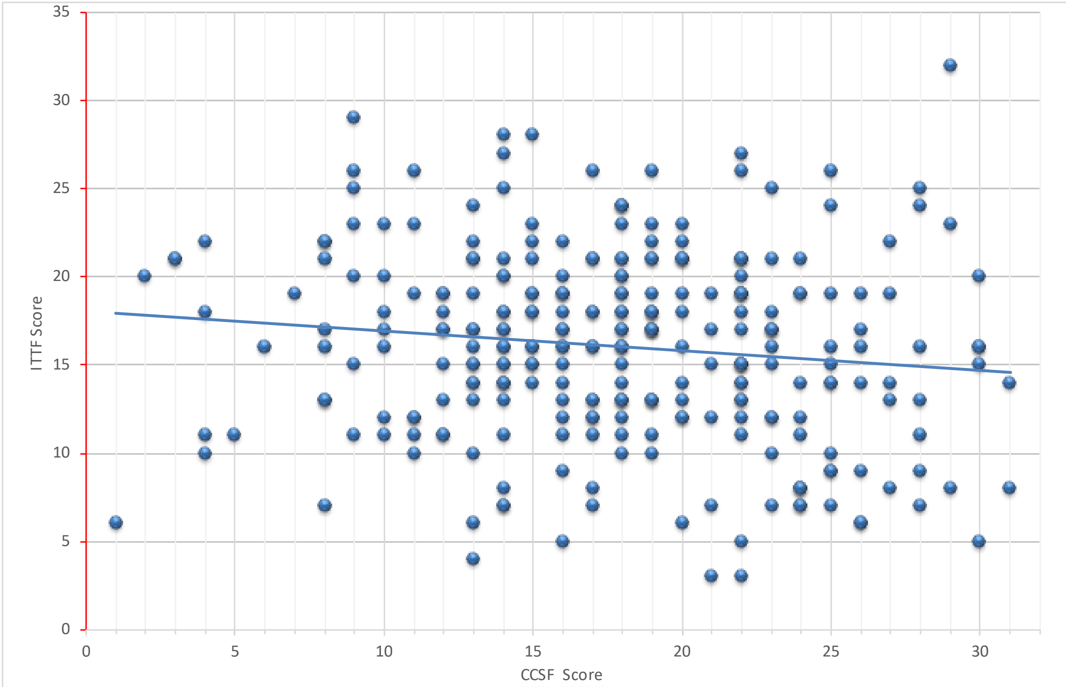

Fig.10. CCSF and ITTF scores for each respondent.

Figure 11 shows the CCSF and ITTF histograms overlaid with distribution curves, based on frequency. In this instance both scales have been scored positively. This result shows that on average there are higher CCSF scores meaning people tend to score higher on the CCSF scale compared to the ITTF scale. This suggests that most engineering academics in this sample are more inclined towards a Conceptual Change / Student Focussed model of teaching approach, albeit within the midrange of the scale and contextual to the module they considered when answering the question.

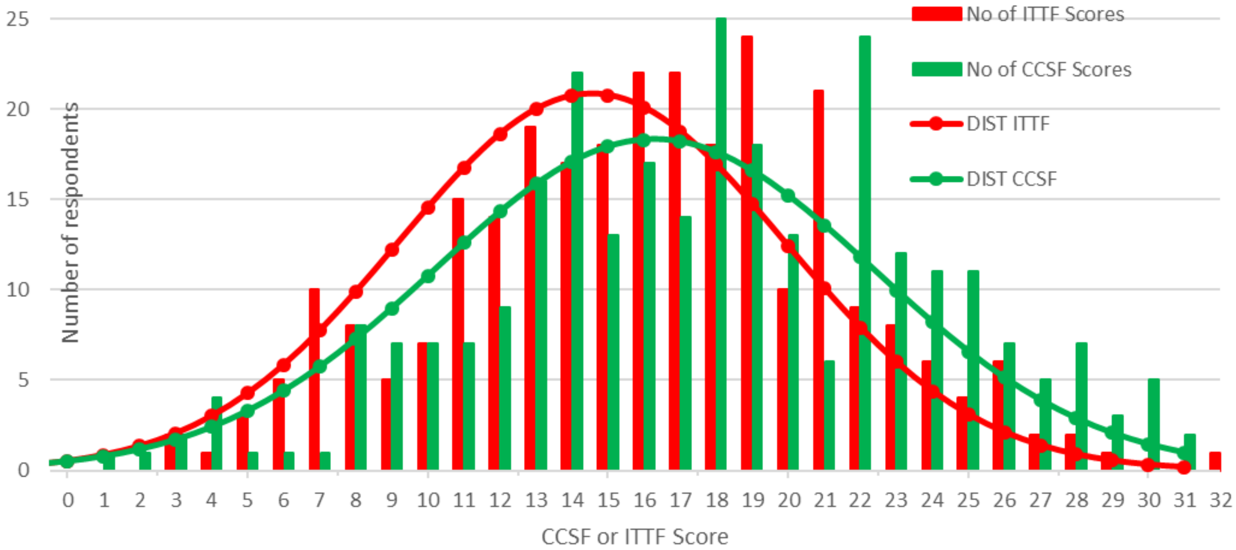

Fig.11. Histogram showing the number of each CCSF and ITTF scores.

In Ireland, the National Framework of Qualifications describes the various levels of academic programmes which include a Level 6 Higher Certificate, Level 7 Ordinary Degree, Level 8 Honours Degree, Level 9 Masters Degree and Level 10 PhD [11]. It appears from the results in *Figure 12*, that an ITTF approach can be quite common when teaching Level 6 and 7 students, which were typically described as large classes within a lecture theatre setting. A CCSF approach was more likely to be used in Level 8 and 9 modules which typically included a mixture of group work, studio classes, tutorials and laboratories. Both Problem Based Learning and Project Based Learning were also mentioned specifically in regard to a CCSF approach. *Figure 12* shows the spread of ITTF and CCSF approaches by Academic Level of programme.

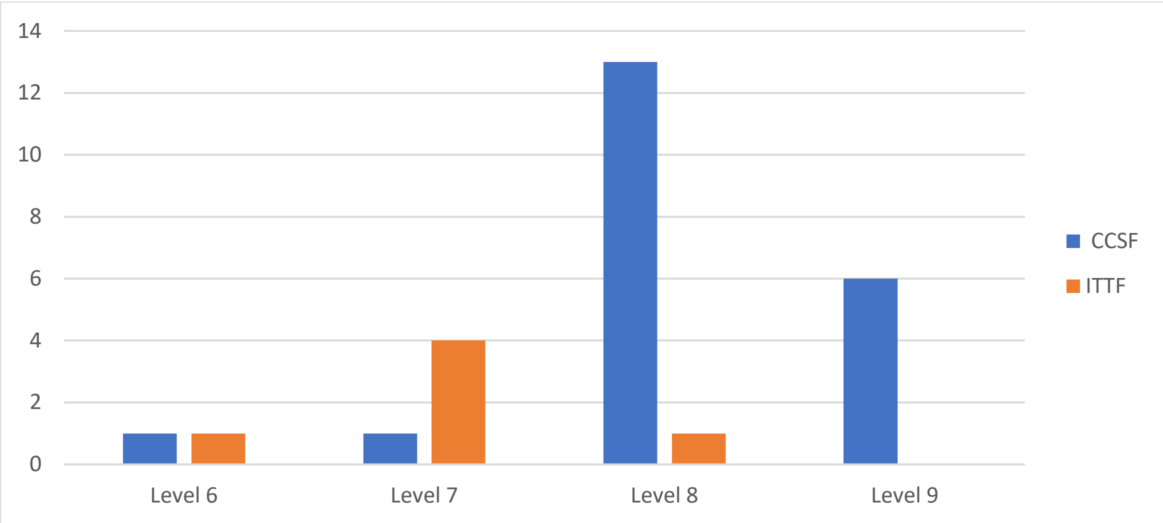

Fig.12. CCSF and ITTF scores for the modules selected by each respondent.

3.2 Approaches to Teaching Inventory scores versus Educational Qualifications

The next question sought to ascertain if there was a relationship between those academic staff with CCSF approaches to teaching and any evidence of an educational training record. Various thresholds were considered within the CCSF scale to identify those academics with a pronounced CCSF score. Table 3 shows the number of respondents who exceeded the thresholds in each of the ITTF and CCSF scales.

Table 3. Number of respondents exceeding various thresholds

Threshold Value	No of respondents who exceeded threshold in ITTF scale	No of respondents who exceeded threshold in CCSF scale
Greater than 20	60	93
Greater than 26	6	22
Greater than 28	2	10
Greater than 30	1	2

On this basis, a threshold value of 26 was chosen as providing a sensible selection of respondents for this question, which resulted in 22 CCSF and six ITTF scores greater than the threshold. Of the 22 CCSF allocations, eight had obtained educational qualifications (36%). Of the six ITTF allocations, two respondents had obtained Educational Qualifications (33%) approximately similar to the CCSF case, suggesting that the mode of teaching may be more attributed to context than knowledge of pedagogical approaches which may be gained through an Educational Qualification.

3.3 Approaches to Teaching Inventory scores versus Educational Experience

The next comparison sought to confirm if there was a relationship to show that as an academic gains experience through teaching a range of classes under different conditions and on different levels that their approach to teaching moves towards a CCSF approach. *Figure 13* shows the distribution of length of experience against those respondents who have been allocated a CCSF approach or a ITTF approach greater than a threshold score of 20. The threshold of 20 was used in this case to provide a more robust number of data points. However, this also means that in some cases a respondent had both an ITTF score and a CCSF score of greater than 20. In effect they use a combination of the two approaches and they are noted as 'Both' in this graph.

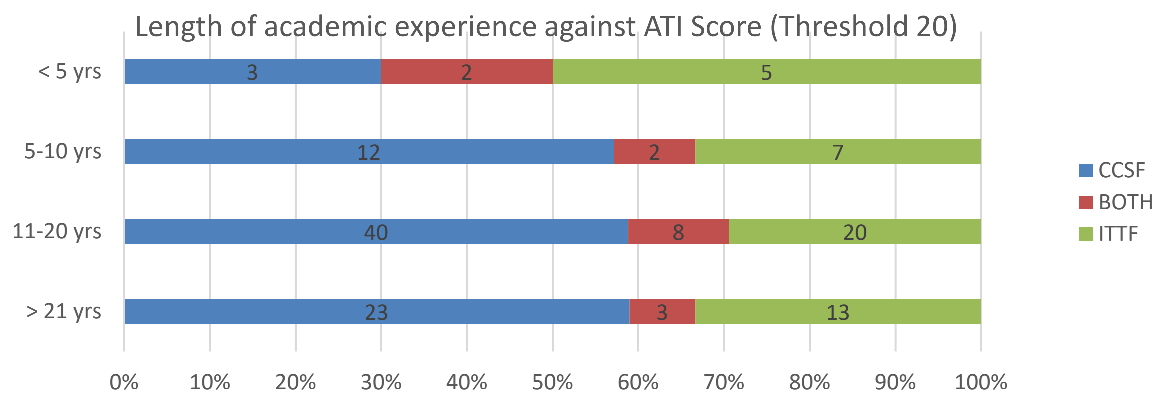

Fig.13. Bar chart comparing those who achieved a (> 20) threshold ITTF and CCSF score against their length of experience in academia.

Whilst the values for members of staff with more than five years experience do not change considerably, it would appear that that those with less than 5 years experience are more likely to have an ITTF approach.

4 CONCLUSIONS AND FURTHER WORK

This paper presents a snapshot of the demographics of academics teaching on engineering programmes in Ireland and provides a basis for ongoing collection of data to show trends in future years. Of particular note is the percentage of female academics (approximately 12% according to the lists provided on HEI websites) but 22% female respondents to the survey. This compares to 17.2% female respondents to the Australian study [2].

The findings in this paper show that there appears to be a contextual relationship to the Approaches to Teaching responses (ATI)and the type and level of academic programme being taught. There is no obvious relationship between evidence of an educational qualification resulting in a tendency towards a CCSF approach, suggesting that the teaching approach may be more aligned to the context of the teaching situation rather than pedagogical knowledge of the lecturer.

It also raises further questions about the relationships between academics' experience in academia and industry and how that influences the approach to teaching used in each context. Whilst conclusions cannot be drawn from the findings presented here, there are several aspects of the teaching context and the academics' experience which can be investigated further in an interview situation, which will inform the main phenomenographic study.

The output of this survey shows a picture of the diversity of academics teaching on engineering programmes in Ireland, and it raises some additional research questions in relation to academics in other countries in Europe and around the world. Further work could include;

- How do Irish engineering academics compare with other academics with regard to gender diversity, academic and educational qualifications and industry experience?
- How do Irish engineering academics compare with other academics with regard to the number of hours they teach and/or their split between teaching and research activity?
- How do Irish engineering academics compare to other engineering academics with regard to the CCSF and ITTF scores noted here?
- Is the relationship between teaching approach (CCSF/ITTF) and level of programme also notable in engineering programmes in other European countries?

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Appendix D - Interview template

A template was used to help direct the format of the interviews in this study. The interview template is included in Table D-1.

Table D-1. Introductory text and outline of questions for interview

BEFORE WE START; Any questions on the information sheet, consent form, ability to withdraw from the study and so on? On that basis, if you could review and sign the consent form for me. START Recording First of all, thank you for your time and agreeing to participate in this interview, it is very much appreciated. The first thing I would like to cover is the information sheet and consent form. I would just like to confirm that we have discussed the consent form and you have agreed to be interviewed in line with all of the details supplied on the form? AWAIT ANSWER So let's get started. I'm undertaking a PhD in Engineering Education and as part of that, my data collection involves interviews with academics teaching on engineering programmes in Ireland. You have kindly agreed to be one. The interview will take around 45mins to 1 hour and I will cover four main areas; • Academic, Industry and Teaching experience, • Teaching approaches • Programme design, • thoughts on a couple of other topics if that's OK?

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Topic	***Key questions***	**Follow up questions**		
Intro	*The first thing I wanted to ask about is your industry and academic experience?*	*"You've recently moved to XXX after some years in industry. How have you found the move?"* *"You've been in XXX for X number of years, have you experienced many changes over that time?"*.		
Now, we'll move on to your teaching approaches.				
Teaching approach	*Can you list the main modules you teach?*	*What is your favourite module and why?*	*Describe a typical session in that module?* *Why do you put them in groups?*	*How did you design that module?*
Assessment	*Describe how the module is assessed?*	*What are the students examined on?*	*How did you design the exam ?*	*How do you assess?*
Other teaching approaches	*Do you do anything differently in any other modules?*			*Why is it different there?*
Lets move on a little more;				

Topic	***Key questions***	**Follow up questions**	
Conceptions of Professional skills	*There's lots of literature out there now about the skills that engineers need for the workplace, sometimes called "professional skills"* *Can you define what the term "professional skills" means to you?* *Can you complete the sentence – "professional skills are the skills that …..*	*What has influenced your view on that?* *Why do you say that?*	
Professional Skills *Where do you think engineers develop those skills?*	*Referring back to* ***the programme*** *you mentioned, where within that programme are those skills taught?*	**Don't know**	*Have you been involved in an EI accreditation, was it mentioned there?*
		Not taught anywhere	*Why do you think that is so?*
		Certain modules (not mine)	*Which modules?* *How effective do you think those modules are?*
		Some of my modules	*Describe a typical session in that module?*
		Not enough modules	*What makes you say that?*

Topic	*Key questions*	Follow up questions
Drivers	*Can you give me an example of any **drivers** that are initiating this push towards profs skills in engineering programmes*	
Professional Skills:	*Have you any experience of teaching students prof skills?*	*Have there been any programme committee discussions about where they are developed?* *In your experience, have you been able to influence this?*
	How important do you think it is that engineering students develop those skills?	*Can you think of any **barriers** that exist that might influence how you can better develop skills within students?*
Programme Design:	*Is there anything you would change about the programme as a whole?*	*Is there anything you would change about assessment in the programme?*
Background in Academia mainly, research	*Have you any examples of where you have used them in your career?* *Where did you learn your professional skills?*	*How , why?*

List of Publications in relation to this study

Beagon, U., & Bowe, B. (2016) Developing Graduate Attributes to meet the Grand Challenges: What Pedagogical Factors Influence the Development of Graduate Attributes and Does Engineering Education Ensure Graduates Can Address The Global Grand Challenges? Presented at SEFI Conference, 2016. Tampere, Finland.

Beagon, U., & Bowe, B. (2017a) A plan for using phenomenography to explore academic conceptions of their role in developing professional skills in engineering students. Presentation to CREATE Research Group, TU Dublin 25th May 2017.

Beagon, U., & Bowe, B. (2017b). Developing Graduate Attributes to meet the Grand Challenges. Presented at SEFI Conference, 2017, Azores, Portugal.

Beagon, U., & Bowe, B. (2018a). The Academic Perspective: A study of academic conceptions of the importance of professional skills in engineering programmes in Ireland. Presented at SEFI Conference, 2018, Copenhagen, Denmark.

Beagon, U., & Bowe, B. (2018b). Teaching Professional skills in Engineering Programmes: The Academic's Perspective. Presented at The UK & IE EERN Annual Symposium, Portsmouth, UK.

Beagon, U., & Bowe, B. (2018c). Workshop: A method of in-depth interviewing: Learning by doing. Presented at The UK & Ireland EERN Annual Symposium, Portsmouth, UK.

Beagon, U., Carthy, D. & Bowe. B. (2019) Graduate Engineering Skills: A Literature Review & Call for Rigorous Methodological Approaches, *47th SEFI Annual Conference in Budapest. 16-19 September 2019.*

Beagon, U., & Bowe, B. (2019a) Engineering Skills Requirements: A systematic literature review (2009-2016), Presented at the UK and Ireland EERN Spring Symposium, Dublin, May 2019.

Beagon, U. & Bowe, B. (2019b) A Demographic Picture of Academics Teaching on Engineering Programmes in Ireland and their Approaches to Teaching (ATI). *47th SEFI Annual Conference in Budapest. 16-19 September 2019.*

Beagon, U. & Bowe, B. (2019c) A Phenomenographic Study to Investigate what we Mean by the Term "Professional Skills" – Preliminary Findings, *47th SEFI Annual Conference in Budapest. 16-19 September 2019.*