Understanding Pedagogical Content Knowledge for Engineering Education: The Effect of Field and Habitus

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Abstract

Pedagogical Content Knowledge (PCK) is a concept that has long been used to explain the professional knowledge and habits of effective teachers, but is yet to be studied specifically for teaching in applied disciplines. For applied disciplines, especially in the academy, what students do when learning and what they do when they reach the workplace can be quite different. The demands on teachers in helping students to develop the requisite knowledge, skills and processes for use in industry are therefore likely to be different than for ¨pure¨ disciplines. This research uses the test-case of engineering education to examine this issue. Both industry and the engineering education research community have been consistently calling for change towards more student-centred and practice-oriented methods of teaching for a number of decades. Despite these calls, the field has made little progress towards significant and lasting change in the methods of teaching that predominate engineering curricula, suggesting a gap between the ideal PCK in the discipline and the realistic possibilities for developing teaching practices in universities.

To understand this, this research focuses on the mechanisms by which teaching practice is realised in the university context. The social site and the knowledge and beliefs which underpin a discipline inevitably affect teaching practice, and this is explored using the theoretical framework of Pierre Bourdieu; the concepts of *field, capital* and *habitus*. This approach to the research necessitated an ethnographic methodology in which data was gathered about participants, their teaching and the contexts of their work. A staged research design was used starting with a targeted pilot study, followed by a questionnaire of a broader group of academics, and culminating in a series of three in-depth ethnographic case studies. This design was developmental in that each stage of the process allowed the subsequent stages of data collection to be more effectively targeted and carried out.

The results of this research show that it is possible for engineering educators to develop highly sophisticated bodies of PCK, with significant capacity for teaching about practice in industry. A model for this body of PCK is suggested. However, where those bodies, or aspects, of PCK were seen in the cases, it was the result of participants´ particular *habitus* for acting in the *field,* rather than being the result of characteristics of the *field* itself. In fact, it was found that the university *field* created significant disincentives for the development of PCK, especially through the dominant forms of *capital* which privilege attention to research activities over teaching and teaching development. As such, teachers in applied disciplines face a double barrier for PCK development, both through the extra demand for developing their processes of teaching-for practice, and through significant discouragement from the university context for time spent on doing so.

Certification of Thesis

This thesis is entirely the work of Hannah Jolly except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

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I would like to acknowledge the generous assistance I have received throughout the preparation of this thesis, in particular from my family, critical friends, supervisors and from the case study participants. Without their support throughout the process, this work would not have been possible.

Table of Contents

List of Figures and Tables

1.0 - Overview of the Research

1.1 - Introduction

It is now widely accepted in educational theory that teachers need more than content knowledge and general teaching knowledge in order to teach optimally in any given subject area. For instance, a mathematics teacher with a general knowledge of history is not automatically prepared to teach history. Teaching optimally in a given discipline requires specialised knowledge that goes beyond general pedagogical training. Pedagogical Content Knowledge (PCK) refers to the specific expertise required to transform disciplinary, pedagogical and other teaching knowledge areas into appropriate and effective teaching practices that are ideal for specific subject matter or topics (Shulman, 1986).

This research aims to understand PCK for engineering education. Much work has been done on describing PCK for other disciplinary areas such as the "pure sciences," but never comprehensively for engineering. Understanding PCK is vital for understanding the processes and mechanisms by which engineering can be most effectively taught, especially as it is an applied discipline in which teachers must prepare students for practice in industry. How engineering is practiced is quite different to how it is studied, unlike subjects like mathematics or chemistry; therefore engineering PCK may contain a special category of teaching knowledge. Uncovering the nature of this knowledge will yield insights into what constitutes best-practice in the field of engineering education, as well as insights about how to work towards achieving it whilst acknowledging the constraints on practice which academics generally face. This is particularly significant as both industry and the engineering education research community have been consistently calling for change towards more student-centred and practice-oriented methods of teaching for a number of decades (Heywood, 2005, Reidsema, Hadgraft, Cameron and King, 2011). Despite these calls, research has also shown that the field has made little progress towards significant and lasting change in the methods of teaching that predominate engineering curricula (Graham, 2012).

Accordingly, this study pays particular attention to how engineering educators' PCK is both responsive to and dependent on the contexts in which they are working. For example, it explores how universities and engineering industry each play a role in determining the teaching practices that are possible in an individual engineering teacher´s classroom. This allows the research to develop explanations of how aspects of teaching performance are determined by contextual factors which are beyond individual teachers' control. This has significant implications for how institutions and/or industry must change if they are to help teachers achieve best-practice in teaching for industry, both for engineering and other applied disciplinary areas. This perspective on the issue constitutes a shift from the prevailing view that expecting teachers to simply insert new pedagogy into the curriculum is all that is required for achieving significant change in instructional and curricular design.

1.1.1 - The problem in the world

Simply put, engineering as an academic discipline traditionally privileges a positivist epistemology, and subsequently, the transmission of codified knowledge in didactic learning contexts (Heywood, 2005, Hills & Tedford, 2003; Godfrey & Parker, 2010). As a result, engineering curricula tend to emphasise the importance of content (especially the theory of science and mathematics), with relatively little scope given to developing the real-world application of engineering knowledge (however that may be defined) and the practice of engineering tasks and roles for industrial settings (Heywood, 2005). Despite consistent calls in the engineering education literature for this to change, studies such as Graham's (2012) and Reidsema, et al. (2011) show that progress is slow and that there are significant barriers to be overcome.

In contrast to the current state of engineering education, expertise in teaching (according to widely accepted educational theory) is characterised by practitioners assuming a focus on the contextual, interactive and cognitive elements of learning, with less importance placed on the content of learning (Brown, Collins & Duguid, 1989; Bransford, Brown & Cocking, 2000; Killen, 2007). Teachers with well-developed pedagogical content knowledge are those that understand and account for these elements of the educative process in their planning, practice and reflection (Major and Palmer, 2006). It is therefore hypothesised herein that the discipline of engineering education in the academy and the discipline of teaching therefore emphasise (and reward) very different types of knowledge and expertise.

This constitutes a fundamental mismatch between the prevailing epistemology of engineering education and the epistemology of recent learning theory. Therefore, how, and how well, can engineering teachers manage the demands of teaching and the learning needs of their students? Engineering teachers may not be able to sufficiently manage these competing epistemologies at the same time as remaining competitive in their academic discipline, thereby restricting their bodies of PCK, and the ongoing development of their teaching. Subsequently, this is expected to also restrict their capacity to optimise their students' learning, and to carry out the processes of educational change that engineering education research advocates. This should be understood as the result (at least in part) of the cultural contexts in which they are working, rather than just the result of their personal choices. If this hypothesis is borne out, efforts at change should be targeted accordingly.

Whilst authors such as Reidsema et al (2011) suggest that overcoming these barriers requires some kind of transformative change, I contend that for this to occur it is necessary to explore the mechanisms that mediate between individual teachers' beliefs and specific practices and the characteristics of the contexts in which they teach. Without an understanding of the causes of the barriers to change it is not possible to understand where and how change strategies should be directed. It is also necessary to better understand what teaching expertise can and should look like for engineering education, so that the link between best-practice and the contexts that create it can be established and explored. This should not be confused with the need to identify and develop ideal pedagogies for the discipline. Instead, we need to know what engineering PCK looks like and *how it can enable* the ideal pedagogies and practices that the engineering education research literature so often recommends but cannot seem to bring to fruition. This is the contribution to knowledge that is made herein.

1.1.2 - Understanding PCK for applied disciplines

To date, in disciplines where the nature of PCK has been explored in depth (for example, in history, science, and mathematics), there is a close similarity between how the discipline is studied and how it is practiced. In engineering the study of the discipline and the practice of it are very different (as discussed in Chapter 3). This has considerable implications for the nature of PCK in engineering, including creating a tension between the need for a strong theoretical and technical grounding (content) and the practical skills and knowledge (processes) that are emphasised by industry. This emphasis is reflected in Engineers Australia's (EA) Stage 1 Competencies; required of graduates on completing a Bachelor degree. These three core competencies describe the necessary knowledge, skills and attributes, and the application of these knowledge skills and attributes to instances of practice (Engineers Australia, n.d.). It is also reflected in the US accreditation body ABET's EC2000 criteria which similarly emphasise the importance of the practice oriented skills and knowledge involved in engineering (Prados, Peterson & Lattuca, 2002) and in other similar accreditation standards around the world.

The implications of these accreditation structures in terms of their demands on teaching and learning may be best understood by considering the discussion of Hills and Tedford (2003) about the nature of Mode 1 and Mode 2 knowledge:

> All forms of scientific knowledge [can be categorised] into two sets, termed Mode 1 and Mode 2…Mode 1 describes the factual knowledge that most people recognise as such…[it] is the world's collection of systematic, explicit, codified knowledge…Mode 2 covers the contextualisation of knowledge…[and is] context driven, not subject driven…[includes] personal skills… personality skills… intellectual skills… professional skills… [and] craft skills…This is the world outside academia. (Hills & Tedford, 2003, pp. 23-24)

At a basic level, Engineers Australia's three core competencies can be viewed as emphasising Mode 1 knowledge only in the first competency ("knowledge and skill" about theory), and Mode 2, applied knowledge in the second and third ("engineering application ability" and "professional and personal attributes") (Engineers Australia, n.d., p. 2). According to Hills and Tedford (2003), this is as it should be, because in comparing the knowledge required for engineering to that of science, engineering is ¨mission-oriented, heavily contextualised and undoubtedly Mode 2. There is a sense in which science is a product and therefore a noun whereas engineering is primarily a process and therefore a verb¨ (Hills & Tedford, 2003, p. 25).

Therefore, although engineering inevitably draws on the Mode 1, scientific knowledge that its practice is predicated on, its distinction from the Sciences comes from the application of that knowledge to instances of engineering practice. Despite this, there is an enduring trend of engineering curricula moving away from an emphasis on practice and application. Although prior to the 1950s the curriculum combined both lecture style and hands-on practice that focussed clearly on industrial practice, subsequently, as ¨engineering science¨ began to be perceived as more important, the focus on engineering practice within the curriculum was significantly diminished (Wankat, Felder, Smith & Oreovicz, 2002, p. 218). As a result, a tension exists between the Mode 1 knowledge emphasised in higher education and the Mode 2 knowledge relevant to practice in industry. The skill of teachers in managing this tension is highly relevant to what and how students will learn in the engineering classroom.

Graduating students moving into industry commonly remark on the differing emphasis on theoretical versus practical skills between education and industry, and a key success factor in making the transition to industry is their ability to cope with this shift (Scott & Yates, 2002). Given that engineering curricular structures continue to emphasise learning the theoretical foundations of the discipline over its application (Wankat et al., 2002, Heywood, 2005; Graham, 2012), a large burden of the responsibility of meeting EA's Mode 2-related core competencies must fall to the skill of teachers in operating curricula in appropriate ways for the discipline, by using whatever pedagogical content knowledge they have been able to develop for and in their contexts.

A further issue that has been identified is that the practice of engineering in industrial settings is rapidly evolving (Cameron et al., 2011), whereas, in engineering education there are significant structural and institutional barriers which work against innovation (Graham, 2012). Therefore, the study of engineering and its professional practice in industry may be becoming increasingly divergent. To date, no research has examined the effect that a difference between study and practice within a discipline can have on the demands it places on the teacher in terms of developing practice-ready students. It is likely that a number of factors operate differently in these instances. Such factors may include: an educator's prior experience in industry; their knowledge or beliefs about the nature of their discipline; the currency of their experience, belief**s** and practices compared to the practices of industry, and; how well the educational institutions and curricula that they are working within are keeping pace with change in industry for their given discipline.

The work of Fernandez-Balboa and Stiehl (1995) examined the commonality of processes used to transform knowledge of a discipline into viable teaching practices across a range of higher education disciplines. They identified five common components of PCK and list these as "knowledge about a) the subject matter, b) the students, c) numerous instructional strategies, d) the teaching context and e) one's teaching purposes" (Fernandez-Balboa and Stiehl, 1995, p. 293).

The authors assert that PCK constructs can be seen as fairly constant across disciplines, although the actual knowledge involved in bodies of PCK differs among both teachers and disciplines. However, there may be significant differences in the nature and attainment of PCK in disciplines where the practice and study of the discipline are quite different, which these authors did not study. Existing theoretical frameworks for understanding PCK (such as those identified by Fernandez-Balboa & Stiehl, 1995, or others such as Grossman et al., 1989, Major & Palmer, 2006) may not apply in such contexts, or may need to be adapted to accommodate a greater range of significant factors or variables and their effects.

The work of Fernandez-Balboa and Stiehl (1995) does demonstrate that the models of PCK which apply in tertiary settings are comparable to those that apply in secondary school settings. For instance, although these authors' labels for the components of PCK are slightly different to those of other PCK theorists, they are broadly analogous, suggesting that the model proposed by the latter is likely to be equally valid for tertiary settings.

1.1.3 - Understanding teaching for practice

In order to use the PCK construct to understand teaching practice in engineering education specifically, we need to account for how educators manage to teach about practice in engineering industry. Cameron et al. (2011) assert that teachers' professional experience in industry is necessary for preparing students for work in the field. This assertion is supported by the findings of Graham (2012), who highlighted the important role of faculty members who have industry experience in ensuring the success of curricular and pedagogical innovations. The work of Shreeve (2010) suggests that the issues surrounding teaching about practice are likely to be quite complex and contingent on other aspects of teachers' PCK. She shows that the relationship between teachers' industry experience and how they teach about practice is not straightforward (Shreeve, 2010). For instance, simply having experience in industry does not directly determine if and how that experience is applied to the task of teaching the curriculum.

In the phenomenographic study designed to address variation in approaches to teaching about practice, Shreeve (2010, p. 694) derived from observation "five distinctly different categories of variation in experiencing the relationship between practice and teaching." These categories describe a spectrum of approaches, from a transmission model in which knowledge of practice is seen as simply being passed on to students, to an integration model, in which the teacher's knowledge-of-practice and knowledge-of-teaching interact to create a simulation of the role of a practitioner for students to experience in the classroom (Shreeve, 2010). Clearly, the teaching practices involved in operating at one end of this spectrum would be very different from those involved in operating at the other. Shreeve (2010) did not attempt to explain the reasons for the differences in how practitioners taught, however the study has significant implications for understanding PCK for engineering education because ¨understanding that the relationship between practice and teaching may need to be addressed, rather than assumed as a natural outcome of [disciplinary] expertise, [and doing so] may lead to…improvements in the way that students learn about practice-based subjects¨ (Shreeve, 2010, p. 701).

As such, this research investigated a theorised *teaching-for-practice* domain in the PCK constructs of engineering educators. This is considered to be a domain of knowledge which allows teachers to manage the tension between teaching for the acquisition of Mode 1 knowledge, and teaching for the application of Mode 2 knowledge in instances of practice. Further, this domain may involve knowledge of how to manage the fundamental differences between the classroom environment, and that of the workplace. This is discussed herein in the findings of the case studies.

1.1.4 - The specific challenges for engineering teachers

When considering the nature and development of PCK for engineering, a number of disciplinary-based issues and challenges present themselves. The ultimate aim of engineering education is to prepare students for work in industrial settings as professional engineers. This is an increasingly complex undertaking because "engineers are [now] called upon to develop innovative products and processes, exercise new and unfamiliar technical and professional skills, and function in an increasingly global environment" (Adams & Felder, 2008, p. 239). Despite this, it is widely recognised that the current curricular emphasis is on the development of technical knowledge above professional skills. "Although engineering education is strong on imparting some kinds of knowledge, it is not very effective in preparing students to integrate their knowledge, skills and identity as developing professionals" (Sheppard, Macatangay, Colby & Sullivan, 2009, p. 6).

Of Engineers Australia's three core Stage One Competencies (required of graduates on completion of a Bachelor level degree,) only the first deals with the development of theoretical or technical knowledge and skill, whilst the second two deal with "engineering application ability" and "professional and personal attributes" respectively (Engineers Australia, n.d., p. 2). The nature of the knowledge implied by these categories will be discussed in the chapters that follow, however it is clear that the first competency is explicitly valued in university learning, whilst the second two are clearly valued in practice-based learning in industry (Hills & Tedford, 2003). The need to prepare students in both of these types of knowledge implies a need for ongoing pedagogic reflexivity about engineering practice and, arguably, a need for change in current teaching and curricula (Heywood, 2005; Graham, 2012). This implication is consistently supported in the engineering education research literature (Heywood, 2005), but the process of change has been shown to be slow and difficult (Graham, 2012).

Cameron, Reidsema and Hadgraft (2011) express concerns over the current capacity of engineering teaching staff to develop the necessary expertise to address this challenge, because of a ¨relative lack of…professional experience beyond four years¨ (Cameron et al., 2011, p,109). According to these authors, any lack of experience working as a professional in industry ¨casts doubt¨ on engineering teachers´ ability ¨to define and *operate* curricula more strongly in areas of authentic engineering problem solving, engineering application and practice¨ (Cameron et al., 2011, pp. 109-110).

Finally, engineering educators, like other academics, commonly have little or no training in teaching prior to entering the field. As such, there are unexplored questions about their level of pedagogic preparation for the teaching task. Solving the problem of the incompatibility of current engineering curricula and the imperative to teach about practice in industry will involve acknowledging and overcoming these significant barriers.

1.2 - Investigating the problem

To deal with these barriers systematically, our research efforts must begin to account for the actual mechanisms by which teaching and learning are realised in the social sites in which they are undertaken. This is what is meant by the phrase *operating curricula.* Teaching practices, as well as the knowledge and beliefs which underpin them, are dependent on and responsive to social and contextual factors, because both the social site and the knowledge and beliefs which underpin teaching in a discipline inevitably affect actual teaching practice. This research explores the relationships between these domains.

Because these domains are likely to vary slightly from country to country, according to the nature of university teaching in each, this study confines itself to an examination of the Australian context. Whilst a multi-national study was originally planned, as the research question and plan developed it was recognised that the complex nature of the problem required a data-intensive, ethnographic study, and that dealing with the variables of context presented by different national sites would simply present too much data for the scope of the present research.

Shepperd et al. (2009) see the greatest challenge for engineering teaching is to ¨teach key concepts for use and connection, integrate identity, knowledge and skills through approximations to practice and place engineering in the world to encourage students to draw connections¨ (Sheppard et al., 2009, p. 9). These principles clearly relate to the practice of engineering, and learning about practice, and yet the vast majority of formal engineering education takes place in classrooms and not in industry. Considerable skill is therefore required of engineering teachers if these principles are to be realised in the classroom.

Proponents of PCK research take the view that this is a complex undertaking, involving skilful, intentional and reflexive teaching expertise (Park & Oliver, 2008; Hashweh, 2005). Thus, the challenge for improving engineering teaching goes beyond questions of curricular design, to the know-how which allows teachers to enact the *potential* of curricular design. Insights from broader research in engineering education, such as those which discuss which pedagogies are most appropriate and why, cannot be fully utilized unless attention is also paid to how, and how much, teachers are able to operate such pedagogies and curricula, using their expertise for teaching. Engineering teaching expertise is therefore an important focus for research, if the arguments for change put forth in engineering education research are to be taken up and progressed.

To advance this work, it is necessary to develop a theory which has the capacity to explain the complex patterns of factors affecting teachers' thoughts and behaviours with respect to teaching. Research into the general affordances of different pedagogies does not on its own improve engineering teaching (Grenfell & James, 2004). Research must also bridge between the theory and empirical knowledge of *how* engineering teachers can apply such theory in their specific contexts. This involves viewing teaching as a practice which is dependent on the background and knowledge that teachers bring with them to their role, but also on their particular position within the wider socio-cultural *field*. In this view, teaching is seen as a system of social action, and should be analysed as such. Therefore, this research will consider:

- the effects of the epistemologies of engineering educators; their beliefs about the nature of engineering and of teaching and learning for engineering;
- the effects of the institutional context in which engineering educators find themselves teaching, including how teaching is viewed, valued and rewarded; and,
- the effects of the degree of preparedness for teaching that engineering educators possess or are able to develop, both in terms of knowledge of how to teach effectively in a general way, and how to teach effectively for engineering practice in industry.

These three variables therefore constitute the dimensions of contrast underpinning the case study phase of the research, outlined in chapters eight, nine and ten.

Although the conditions for teaching and learning at university is likely to vary from country to country, this study confines itself to an examination of the Australian context. Whilst a multi-national study was originally planned, as the research question and plan developed it was recognised that the complex nature of the problem required a data-intensive, ethnographic study, and that dealing with the variables of context presented by different national sites would simply present too much data for the scope of the present research.

1.2.1 - Theoretical framework of the research

In planning to study PCK in this manner it is important to attend to two factors. First, it is essential that the approach has the capacity to reveal the relationship between patterns of individual agency, and patterns of institutional culture. This is because, in terms of determining teaching practice, any teacher may have carefully examined their assumptions and beliefs about teaching and learning and have devised an approach to teaching accordingly. ¨However, curricular structures and organisational conditions may bring about constraints that do not necessarily leave enough space for the implementation of teaching in [this manner]¨ (Postareff et al., 2008, cited in Mälkki & Lindblom-Ylänne, 2011, p. 45). Second, ¨assessment of PCK requires a combination of approaches that can collect information about what teachers know, what they believe, what they do, *and the reasons for their actions*¨ (Park & Oliver, 2008, p. 267).

The theoretical framework offered by the work of Pierre Bourdieu allows for both of these conditions to be met. The particular strength of Bourdieuvian theory is in describing how individual agents' patterns of habitual disposition (*habitus)* interact with structures in the wider social context (*field)*. This theoretical approach is supported by Grenfell and James (2004, p.514), who argue for an overall need for a "*relational* approach to educational questions, emphasising the mutual interdependence of social constraint and individual agency." In contrast to substantialist approaches, this relational way of thinking:

> accepts that such [patterns in] 'activities and preferences' as the research uncovers are understandable in terms of social spaces, positions and relationships pertaining in a particular time and place…Thinking relationally…[means] seeing [learning and teaching] in relation to people, organisations, times and places…; in other words, the *field* site or context. (Grenfell & James, 2004, p.515)

However, Grenfell and James (2004, p. 515), also assert that "good teaching has characteristics that are broadly common across situations." Thus, there is an interplay between the ways in which pedagogical content knowledge is common across sites, contexts and actors, and the ways in which it is variable. Analysing patterns in teaching practice in terms of *field*, *capital* and *habitus* allows us to unpack and explain both the overlap and the particularity in the patterns of practice observed.

In summary, Bourdieuvian theory allows for the examination of PCK in terms of:

1. Patterns in individual behaviour
2. The specificities in practice created by the discipline and epistemology of engineering
3. The influence of context
4. How these factors interact to determine patterns in teaching practice.

A comprehensive research question which can account for the many dimensions of the problem at hand is therefore necessary and reflected in the wording of the research question shown below.

1.2.2 - Research questions and sub-questions

As a result of the abovementioned points, this research investigated the following questions:

Research Question:

What is the influence of field and habitus on the nature and composition of the PCK of engineering educators?

Research sub-questions:

- *What is the nature and composition of PCK for engineering education?*
- *What is the link between a teacher's habitus in the engineering field and their PCK?*
- *What possibilities for habitus does the engineering education field allow for?*

1.2.3 - Researcher stance

In undertaking this topic, I acknowledge that my personal epistemology in conducting this research has been influenced by my background in education and the social sciences generally. My epistemological perspective on this topic is very much in line with the constructivist view of learning and education, that is, that "knowledge is obtained and understanding is expanded through active construction and reconstruction of mental frameworks", and that "learning is not a passive process of simply receiving information –rather it involves deliberate, progressive construction and deepening of meaning." (Killen, 2007, pp. 4-5, 7). I view learning and the educative process as an enterprise of meaning making that is socially-situated; understandable only in terms of the specific contexts in which it takes place.

Whilst of course I recognise that this perspective on the topic has undoubtedly affected the way in which this research has been carried out, I argue in detail for the conceptual and theoretical validity of this approach throughout the dissertation, and present my results in these terms. Further, I describe in the methodology chapter how the research design was developed and executed according to principles of trustworthiness (Sturman, 2007). The epistemological basis of the research is discussed in further detail in that chapter.

2.0 - The nature of engineering and engineering education

2.1 - What is engineering? The history and philosophy of the discipline

In order to understand how the concept of pedagogical content knowledge can be usefully applied to engineering, some foundational understandings about the nature of the discipline must be established. Engineering as a human endeavour is ancient. In fact, one could argue that it is the act of developing technology to meet some physical need or problem in the world that makes us human. Engineering as a structured profession, on the other hand, is a relatively recent development (Wankat, et al., 2002). A range of views exist which tend to emphasise different aspects of the nature of the discipline. Such views can be best understood by first examining the historical development of engineering education.

2.1.1 - The history of engineering education

A study of the history of engineering education provides a useful perspective on the sources of the contrasting views of the nature of the discipline that persist today. This history shows a distinct trend away from its roots of learning by apprenticeship, towards a heavier emphasis on formal schooling and the acquisition of codified knowledge of mathematics and science (Wankat, et al., 2002). Originally, engineering educators ¨were expected to have industrial experience¨, and the students that education programs produced needed to ¨be able to function immediately in industry¨ (Wankat, et al., 2002, pp. 217-218). Furthermore, ¨teaching was what professors did, and the research done by a small percentage of engineering professors was strictly applied¨(Wankat et al., 2002, pp. 217-218).

However, even early in the 20th century, the discipline began to experience tension between two schools of thought about the basis of engineering education and the profession as a whole. On the one hand, the formal, school-based system developed in France emphasised the Mode 1, mathematical-scientific bases of the discipline, whereas the apprenticeship system more widely used in England focussed on developing Mode 2, applied skills through direct work ´on the job´ (Prados, et al., 2005, p. 166). A variety of events in the 20th century, including the World Wars and the space race of the 1950s and 60s precipitated a more definite shift in emphasis towards establishing the discipline as a bona fide (and white collar) profession rather than a trade. This shift, crucially, was concerned with establishing that engineering deserved its place in the academy, and founded such claims on the notion of 'engineering science' as the legitimate basis of the discipline. Whereas originally, institutions attempted some kind of compromise between the Mode 1 and Mode 2 approaches, later in the 20th century they increasingly emphasised the mathematical and scientific foundations of the discipline, and ¨involvement in disciplinary research came to be expected of most engineering faculty members instead of remaining the province of a very small percentage of them¨ (Wankat, et al, 2002, p. 218).

As will be discussed in Chapter Four, the requirement for substantial and ongoing research outputs by teaching staff has significant implications for the development of teaching expertise in the discipline. Furthermore, these changes had profound impact on what it was to learn in engineering classrooms, and what was considered valid engineering knowledge within engineering education institutions. Whereas earlier curricula included courses in ¨machine shop, mechanical drawing and surveying¨, these more manual (and by implication, blue collar) skills were pushed out in favour of studying ¨differential equations, control systems theory, and transport phenomena¨ (Prados et al., 2005, p. 167). This meant more lectures, as opposed to hands-on classes, and ¨an unexpected side effect of more lectures was an increase in the passivity of students in class¨ (Wankat, et al., 2002, p. 218).

However, "the changing emphasis from applications to fundamentals in engineering schools did not reflect a similar pattern in the practice of engineering" (Wankat, et al., 2005, p. 218), and the tensions between theory and practice in the profession persisted, and continue to be debated globally today. By the late 1980s, both industry and engineering education were recognising that ¨the engineering science emphasis had produced graduates with strong technical skills, but these graduates were not nearly so well prepared in other skills needed to develop and manage innovative technology¨ (Prados et al., 2005, p. 167).

These problems are still reflected in the results of research into curricula, instruction and accreditation in engineering education today (Wankat, et, al. 2002, Graham, 2012). Recent changes in the standards of accreditation of engineering programs, such as ABET's (Accreditation Board for Engineering and Technology) EC2000 Criteria and Engineers Australia's Stage One and Two Competencies, indicate that the focus is shifting once again towards the practical application of engineering knowledge. Despite this, there is also ample evidence that curricula and instruction are failing to reflect this shift, and university procedures for developing the Mode 2 competencies of students are inadequate (Graham, 2012; Male, Bush & Chapman, 2010).

2.1.2 - Defining the discipline

The history of engineering education reveals fundamental and ongoing problems with how both engineering and engineering education should define and understand themselves. Discussion of the question of defining engineering can raise as many definitions as there are practitioners in the field, and consensus over definitional issues is yet to be reached. The simplest and most common assertion about the nature of the discipline is as follows:

> Although engineering is considered, today, as clearly distinct from science, the predominance of the components of basic science in the education of engineers implicitly contributes to convey the idea that engineering is, in essence, little more than the mere application of the exact and natural sciences to the reality of practice. (Figueiredo, 2008, p. 94)

This definition reflects the Mode 1, codified knowledge emphasis of the 20th century view of the discipline. Professional engineers working in industry (and many engineering academics for that matter) take issue with this representation, on the basis that it is insufficient for describing the characteristics of skilful engineering practice in industry, including ¨an understanding of the non-technical forces that profoundly affect engineering decisions¨ (Prados, et al., 2005, p. 168). Broader perspectives on the nature of engineering work propose more complex and comprehensive definitions:

> Engineering is a profession directed towards the application and advancement of skills, based on a body of distinctive knowledge in mathematics, science, and technology, integrated with business and management and acquired through education and professional formation in an engineering dimension. Engineering is directed to developing and providing infrastructure, goods, and services for industry and the community. (Nguyen, 1998, pp. 65-66)

Definitions like this attempt to capture both the formal knowledge (engineering science) aspect of the discipline and the practice-oriented (Mode 2) skills involved in applying it. However, it has been argued that this only compounds rather than solves problems of developing a coherent understanding of the discipline, because the effect is to make the aims of the discipline too broad and all encompassing. Thus, engineering becomes ¨an open-ended Profession of Everything¨ and this only acts to ¨add logs to the curricular jam.¨ (Williams 2002, p. 70, cited in Christensen & Ernø-Kjølhede, 2008, p. 568). As such, a clearer picture of the necessary changes to engineering curricula do not result from such efforts at redefinition. Christensen and Ernø-Kjølhede (2008) suggest that the lack of consensus over how engineering should understand itself is caused by a lack of reflection from ¨meta-level perspectives…on [how to adjust] to changing conditions in general¨ (Christensen & Ernø-Kjølhede, 2008, p. 568).

On this basis, a number of authors (including Figueiredo, 2008 and Christensen & Ernø-Kjølhede, 2008,) have called for the development of a coherent philosophy of engineering; one which has the capacity to address the epistemological tension in the discipline (discussed in greater detail in the next section of this chapter) and to provide a more coherent and unifying logic to underpin and guide curricular and instructional change. As far back as 1979, Sinclair and Tilston (1979) were arguing for the need for such a philosophy on the basis that without it there is no ¨adequate concept of what constitutes engineering¨ and that therefore ¨the educator is severely handicapped in developing suitable curricula in engineering¨ (Sinclair & Tilston, 1979, cited in Heywood, 2005, pp. 55-56).

Without an established philosophical basis for the discipline, it is left to engineering educators to develop their own philosophical bases for teaching if they wish to shift away from the traditional approaches to teaching in the discipline. This is because the traditional epistemological basis of engineering is not in keeping with the epistemological basis of the calls for changes toward more Mode 2 learning in the curriculum. Engineering educators, by and large, are encouraged to inherit the positivist traditions of the discipline, and this positivist epistemology ¨drives the approaches we adopt to teaching and learning¨ that are commonly seen in engineering classrooms (Heywood, 2005, p, 53). In short, review of the literature about learning in engineering classrooms reveals an understanding of student learning as that of a *tabula rasa* on which the content of the curriculum is written. ¨It was an information-giving model (sometimes called the transmission model) that paid little attention to cognitive processing¨ (Heywood, 2005, p. 55).

This state of affairs is not the inevitable result of the nature of engineering itself, because “engineering is a creative activity, as much as a science. The methodology of science would seem to be a necessary part, but only a part of engineering activity” (Johnston et al., 1989, cited in Heywood, 2005, p. 54). As such, this must instead be seen as the result of the historical and cultural legacy of emphasising the engineering science aspect of the profession, and ¨the result has been a serious limitation in engineers’ capacity to examine the social meanings and effects of their work and to self-consciously reflect upon their practice and professional identity¨ (Johnston et al., 1996, p. 1, cited in Christensen & Ernø-Kjølhede, 2008, p. 569). Instead, the dominant pedagogies of the academy promote ¨a culture of ‘the right answer’ in line with what is often found in the natural sciences which operate in a more decontextualized environment¨ (Christensen & Ernø-Kjølhede, 2008, pp. 568-569).

Not only is this inappropriate for the changing needs of engineering industry (the work of which may never be decontextualized), it is also inappropriate for creating an environment in which teaching practitioners can develop their expertise for facilitating meaning-making among their students. It is in this environment that the ongoing (and often unheeded) calls for innovation in engineering teaching and curriculum towards constructivist principles are finding little traction.

2.1.3 - The epistemological legacy and its implications for teaching

Understanding the issues surrounding questions of practice in the engineering education *field*, requires that we understand the fundamental nature of engineering epistemology and its influence on professional practice. Any professional necessarily operates with a theoretical perspective on their practice, whether they are conscious of it or not; it is their ¨way of looking at the world and making sense of it. It involves knowledge, therefore, and embodies a certain understanding of what is entailed in knowing, that is, *how we know what we know*¨ (Hamlyn, 1995, p. 242 cited in Crotty, 1998, p. 8).

As such, epistemology becomes central to the work of engineering educators, whether their work is concerned primarily with teaching or with research. The epistemology of any discipline is constitutive of the knowledge that is valued in that discipline because "epistemology is concerned with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can ensure they are both adequate and legitimate" (Maynard, 1994, p. 10, cited in Crotty, 1998, p. 8). In other words, epistemology is concerned with what it means to know, what kinds of knowledge count and how they are valued, and how such knowledge is to be acquired and exchanged. Such issues are central to the concerns of teachers in enacting engineering curricula.

Broadly speaking, a variety of tenable epistemological perspectives fall on a spectrum from objectivism to constructionism (or in educational terms, constructivism):

> Objectivist epistemology holds that meaning, and therefore meaningful reality, exists as such apart from the *operation of any consciousness*…Constructionism rejects this view of human knowledge…Truth, or meaning, comes into existence in and out of our

> engagement with the realities in our world… Meaning is not discovered but constructed. In this understanding of knowledge, it is clear that different people may construct meaning in different ways, even in relation to the same phenomenon. (Crotty, 1998, pp. 8-9, 18)

Given its history of privileging "engineering science", the goal of which is the acquisition of ¨scientific¨ knowledge, engineering education therefore privileges what is seen as positivist ways of knowing and learning about the world (Wankatet al., 2002; Crotty, 1998).

> From the positivist viewpoint, objects in the world have meaning prior to, and independently of, any consciousness of them. From this same viewpoint, scientists are required to keep the distinction between objective, empirically verifiable knowledge and subjective, unverifiable knowledge very much in mind. It emerges as the distinction between fact and value and founds the goal of value-neutral science. (Crotty, 2008, p. 27)

Thus, a positivist epistemology is logically associated with a ¨right answer¨ focus. Given that engineering is fundamentally concerned with the control and manipulation of the physical world using the laws of physics, it is logical for engineers to take up an epistemologically positivist standpoint. However, engineering is not reducible to physics, as it necessarily involves the application of some aspect of theory to contextualised problems in the real world. Further, the tenets of positivism become problematic for practice where practice is necessarily concerned with meaning-making: that is, with learning, as is the case for those that need to *teach* the discipline of engineering.

At its simplest level, learning is undeniably "an enterprise of meaning making within particular contexts" (Lovat & Smith, 2003, p. 71, cited in Killen, 2007, p. 3). The dominance of the positivist epistemology in engineering has implications for what counts as engineering knowledge and therefore what it is to learn engineering. Thus, rigid positivism necessarily creates an ongoing *internal tension in the discipline;* a lack of compatibility between the dominant (positivist) epistemology and the task of creating learning, because learning is a phenomenon that is crucially about meaning, and meaning-making.

According to the constructivist view, knowledge about teaching and learning are necessarily predicated on a constructivist epistemology. This is not to say that scientific knowledge, as positivism conceives it, has no place in meaning-making. Rather, constructivism emphasises that the conscious appreciation of facts is required for facts to *become knowledge*, and that scientific knowledge is therefore "not objective and value free; [it is] value laden and this needs to be recognised" (Hall, 2008, p. 54). It is precisely this value-laden and subjective nature of knowledge and learning that positivism does not leave room for.

The limitation of positivism for engineering education, therefore, is that positivism cannot *on its own* provide the theoretical scope for understanding the main object of the field: the learning of engineering by students. I contend that some epistemological flexibility is required if engineering educators are to successfully deal with the inherently constructivist phenomenon of learning in their teaching practices. This proposition is supported by examining the available theory on learning and teaching, which suggests that people ¨learn what is personally meaningful for them…[and] when they accept challenging but achievable goals¨, that ¨learning is developmental…individuals learn differently… [and] through social interaction¨ and that learners ¨need feedback to learn but the feedback needs to be accurate useful and timely¨(Brandt, 1998, cited in Killen, 2007, pp. 4-5). ¨These statements are consistent with the basic principles of cognitive and social constructivist views on learning¨ (Killen, 2007, pp.4-5, 7).

Thus, central to the educative process is the construction of meaning by individuals, rather than the transmission or acquisition of facts (or 'scientific knowledge', in the positivist sense). This epistemological stance rejects the *tabula rasa* view of learning which has been common in engineering education. Instead, it holds that to know something about learning is to know something about how learners come to understand and make meaning from interactions and events. Learning is not about what is known, and, in fact, the "what" of learning is not invariable between and among learners. Comprehending the phenomenon of learning is therefore outside the scope of a positivist epistemology, and by extension, so too is *the development of teaching expertise*. Without some epistemological flexibility, engineering educators are not sufficiently equipped to approach the development of their teaching practice with rigour.

According to Killen (2007), teachers that use strategies that are characteristic of constructivist practices are able to ¨organise learning around ideas…rather than facts,¨ they ¨emphasise the importance of prior knowledge¨ and ¨provide cognitive structures that [learners] can use to make sense of new learning.¨ Such teachers aim to ¨create conceptual conflict…[and] allow for ambiguity¨ and they routinely ¨assess learners´ knowledge acquisition during a lesson so that they can receive immediate feedback and so they are able to see the connection between their learning and the testing of that learning.¨ (Killen, 2007, p. 9). These strategies for teaching are not possible within a strictly positivist epistemology of engineering in which subjectivities are ignored. Despite this, such strategies would clearly be useful and effective for teachers aiming to develop the types of Mode 2, applied knowledge suitable for solving ill-structured engineering problems in instances of practice.

The implications of this epistemological conflict is this: in a field which is founded on an enduring tradition of rigid positivism, by what means can engineering educators develop the requisite flexibility or practical training to execute their teaching practice in such a constructivist manner? This question is particularly pertinent in institutional climates which only reward the positivist: that is, the generation and transmission of scientific knowledge through theoretical research and didactic teaching. As will be argued further on, the nature of the engineering education *field* within the wider *field* of higher education is such that it is difficult for teachers to gain recognition for educational (and constructivist) pursuits. The 'positivist-only' system of rewards has a direct effect on the learning activities that are seen in the higher education classroom; that is, the dominance of the lecture paradigm, in which the professor speaks and the students passively receive what is spoken.

Crucially, the spoken word of the teacher cannot be considered knowledge until the learner has done something with it in order to accommodate it into their existing knowledge frameworks and schema. Unless the teacher can offer students some help in undertaking this part of the learning process, they are not in fact teaching, they are only providing information. Paradoxically, this is the issue that creates the gap between what engineering educators are expected to do independently and without support in the classroom, (i.e. create meaning for their students out of the subject matter of the discipline) and what they are rewarded for in the university system (generating and transmitting the subject matter of the discipline). This point will be returned to in Chapter Four, in considering the types of *capital* that are transacted within the higher education node of the engineering education *field.*

According to Lucena (2003, p. 428) engineering education has not yet sufficiently shifted away from the limitations of the positivist paradigm, because curricular structures and specific teaching practices persist in presenting students with ¨predefined problems – removed from their political, cultural and economic context,¨ using methods that further ¨ isolate the problem from its context and [do] not help students identify and solve problems in different contexts.¨ These methods reinforce ¨engineering science as the only acceptable body of knowledge in the solution of problems¨ and encourage ¨ students to see problems as having only one solution because they are repeatedly rewarded for a singular solution. (Lucena, 2003, p. 428).

According to Felder (1982 p. 24, cited in Lucena, 2003, p. 429) these kinds of approaches to problems require and accept only convergent thinking from students, and do not leave room for the Mode 2 competencies that could help to develop the problem-solving skills that are useful for practice in industry. Thus, the realities of current practices in engineering education do not match well to the nature of engineering practice in industry.

Fenstermacher (1994) argues that this is not a curricular problem, it is an epistemological one, because if efforts to improve the field of engineering education are ¨ grounded in weak or erroneous assumptions about the nature of knowledge,¨ and, by extension, learning, ¨there is a high likelihood that [such efforts] will fail to address the problems and aspirations of education in positive and ameliorative ways¨ (Fenstermacher, 1994, p. 4).

In the present instance the term "the problems and aspirations of education" can be taken as the tension in engineering education between adhering to the epistemological legacy of the discipline, and developing the ability to facilitate meaning making in learners, thereby improving outcomes for graduates and for industry. This tension is expressed in the below diagram. It must be addressed if change is to occur.

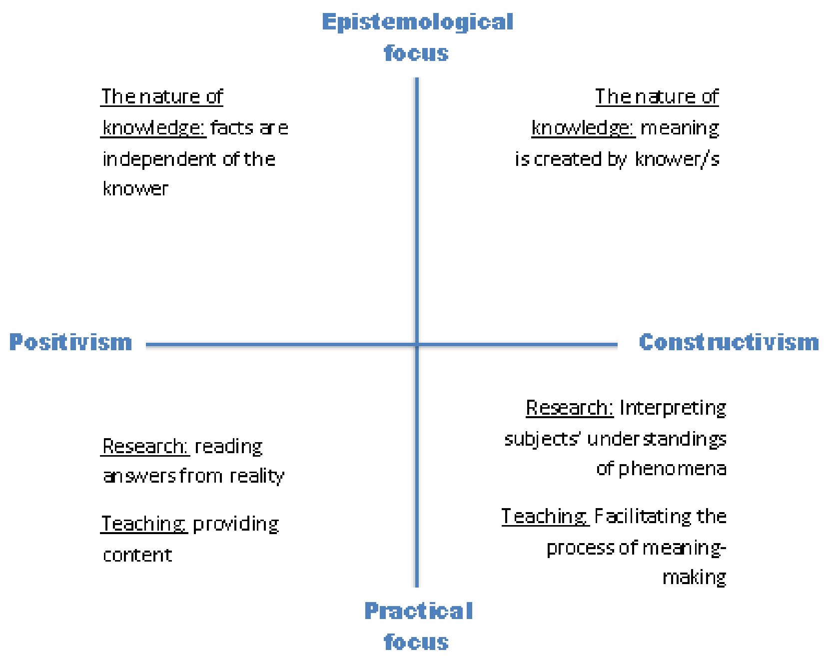


Figure 1 - The dilemma of epistemology in engineering education (Jolly, Jolly & Brodie, 2013)

2.2 - Calls for innovation and resistance to change in the teaching of the discipline

As the above discussion demonstrates, innovation in engineering education is called for and required – but successful and sustainable change has proven hard to implement (Graham, 2012). An oft ignored aspect of change in the field is the expertise required of teachers in the implementation of curricular innovations. The relationship between instructional practices and the wider curricular and cultural structures they occur within is under–theorised and under-examined. As a result, “in most engineering departments, innovative approaches to teaching and learning are typically only found at the margins of the undergraduate curriculum, with their development and continuation resting on a few highly committed individuals” (Graham, 2012, p. 6).

Given the predominance of the positivist epistemological position in the discipline, this is not surprising or difficult to understand. Despite this, processes required for successful change have been largely unexamined in efforts to modify the curriculum. Instead it is assumed that efforts at innovation will ¨naturally diffuse¨ within faculties, regardless of the level of preparedness of individuals, or the nature or amount of support they receive from within their department or faculty (Graham, 2012, p. 8).

Patterns of innovation in engineering curricular do not seem to be subject to significant national differences. Rather, the degree of research intensiveness of an institution was found to be the main factor with a negative effect on the degree of educational excellence within an institution (Graham, 2012). These findings indicate how critical both the individual teacher *and* the institutional culture and climate are to processes of curricular change, particularly change that is geared towards developing a more constructivist curriculum.

The fact that the dominant characteristic determining capacity for change was the research intensiveness of the institution demonstrates the effect of the positivist epistemology, because institutional interest in the research outputs of a faculty is associated with a dominant positivist epistemological stance (Kennelly & McCormack, 2015). Barriers to change exist at structural and institutional levels, regardless of an individual academic’s individual philosophical stance, because university reward systems are ¨the main structural deterrent to faculty who are otherwise disposed to revise their teaching” (Seymour et al., 2011, cited in Graham, 2012, p. 11).

Despite the obvious importance of institutional culture and systems of reward, much of the literature concerning the need for curricular change focuses on pedagogical issues, rather than on curriculum at a more structural and institutional level (Graham, 2012; Heywood, 2005). Of course, even if institutional and structural barriers were suddenly removed, pedagogical development (especially at the individual teacher level) would still be required for curricular changes to be carried out. However, it does not follow that the responsibility for change should fall solely with individual engineering educators, because ¨without changing incentives or making appeals to intrinsic motivators, faculty members inevitably focus on the activities visibly rewarded by their institutions and peers" (Fisher et al., 2003, cited in Graham, 2012, p. 11). Furthermore, ¨this observation is supported by the findings of a study of US STEM faculty, which demonstrated that average faculty teaching hours correlates negatively with salary levels (Fairweather, 2005, cited in Graham, 2012, p. 11).

As such, although philosophy and epistemology of engineering are held at an individual level (albeit with collective patterns within cultures, in this case an academic discipline), it is a chicken and an egg scenario of how change needs to occur. Of course, institutions cannot impose philosophical change on their members, but neither can individuals achieve widespread and enduring change within structures that work against the philosophy behind that change. Change must therefore be gradual and paradigmatic, and understanding how it can occur is therefore (at least partly) a question of understanding distributions of power and patterns of reward in relevant contexts. Understanding where power exists and how it can be used is necessary to seeing how change can be realistically achieved. Thus, we return, again, to the issue of reward systems for academic performance, and the higher education culture that follows from the practices of promoting staff on the basis of their research record and grantsmanship (Splitt, 2002, cited in Graham, 2012, p. 11). We return to this issue in Chapter Four, in discussing the nature of engineering education as a socio-cultural *field.*

2.3 - The implications for engineering philosophy and epistemology for teaching: being an engineer versus teaching engineering

Whilst it is clear that engineering industry recognises and rewards the role of Mode 2 knowledge, it is equally clear that such knowledge is deemphasised in the epistemology, structure and practice of engineering education. How then shall engineering educators marry the nature of engineering work in industry with the tasks they are to perform in the academy, and the tasks that students perform in the classroom? How might they prepare themselves to discuss and facilitate the acquisition of Mode 2 knowledge with their students?

The scientific knowledge aspect of engineering is well and truly covered in the engineering curriculum, not least because this is the aspect of engineering knowledge that is codified. It is set out and set down and can be accounted for and replicated. Although debates about what Mode 1 knowledge the engineering curriculum should cover will always be (and should be) ongoing, this is not the aspect of engineering education that needs to be better understood. Rather, it is the socially and practically-oriented processes of the engineering task that are poorly understood, discussed, and communicated to students. Largely it may be up to industry to develop this aspect of graduates' abilities to act as professionals, because engineering academics lack the requisite epistemological flexibility to give room to these issues (Jolly, Jolly & Brodie, 2013). Neither are they likely to be rewarded for time spent developing teaching in such a way as to better support the acquisition of Mode 2 knowledge.

Whilst there will always be a proportion of engineering learning that is appropriate to take place in the workplace, rather than in the classroom, until principled and empirical conclusions can be reached about this aspect of the engineer's role, there will be no basis on which to decide on such issues as:

- what is the nature of the Mode 2 learning that needs to occur;
- where and when should this happen, and; by what means?

If they are to be answered, it will be engineering PCK that will provide the answers to these questions, because the persons with the capacity to answer them will be the ones who understand not just the nature of engineering and the engineering task, but also the optimal ways to get students to learn them.

In summary, a person with such engineering PCK would need:

- to have the epistemological flexibility to consider the nature of engineering and the engineering task from a context-oriented and constructivist position, in order to comprehend the Mode 2 elements of what it is to know about engineering. This means working outside the status quo of the university and the engineering discipline, because the positivist position rejects other epistemologies and is self-reinforcing.
- to have reached a position about what Mode 2 knowledge students need to attain (including why).
- to have developed the teaching expertise and specific teaching methods required to have reached a position about how this should be optimally done
- to be carrying out and developing their teaching of Mode 2 (as well as Mode 1) knowledge to students, because PCK may only be fully developed through practice, experience, reflection and revision of teaching practice
- to have the time and the inclination to put towards these tasks, in a *field* which seems to have little rewards available for doing so.

These assertions are expanded in the following chapter which explains the existing empirically based knowledge about the PCK of teachers; its nature and composition, and the epistemology and knowledge it is predicated on.

3.0 – The concept of Pedagogical Content Knowledge and available PCK constructs

3.1 - The Pedagogical Content Knowledge Construct

The available literature on the concept of PCK demonstrates its relation to quality teaching. In its original inception by Shulman (1986), it was defined thusly:

> [PCK is comprised of] the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations and demonstrations – in a word, the ways of representing and formulating the subject that make it comprehensible to others…[it] also includes an understanding of what makes the learning easy or difficult. (Shulman, 1986, p. 9)

The value of understanding PCK is predicated on the notion that teachers who possess well-developed pedagogical content knowledge "know their subject matter differently than their less experienced colleagues" (Major & Palmer, 2006, p. 621), affording better outcomes for their students.

Most often, "pedagogical content knowledge (PCK) has been defined as a way of knowing that is unique to teachers, whereby they take an aspect of subject matter and "transform their understanding of it into instruction that their students can comprehend" (Shulman, 1986, p. 8 cited in Fernandez-Balboa & Stiehl, 1995, p. 293). It is this process of transformation of knowledge into knowledge-for-teaching that most definitions focus on, and they tend to include three basic areas of knowledge which are synthesised and transformed during practice into a meta-knowledge category: PCK. These three common component knowledge areas are: knowledge of discipline content (subject matter); knowledge of general pedagogy; and, knowledge of instructional context (for example student characteristics and needs) (Abell, 2008). This conception of PCK is often expressed in terms of the following diagram:

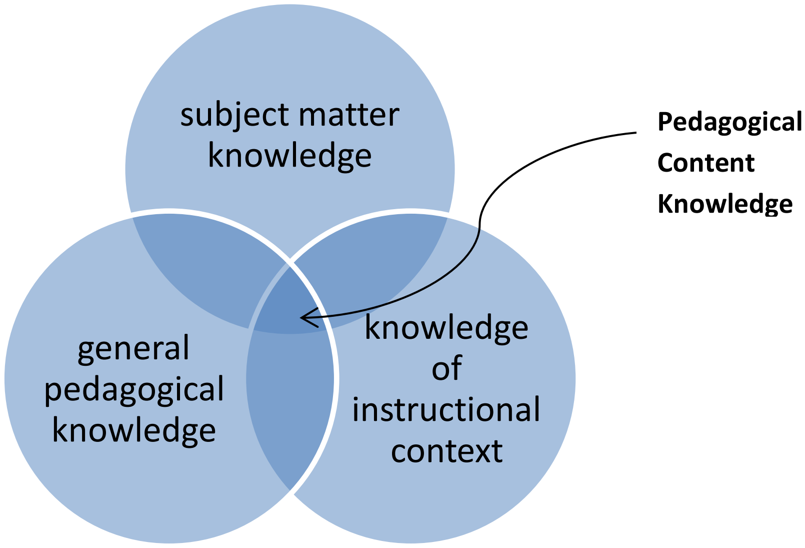


Figure 2 - - Common understandings of the Pedagogical Content Knowledge Construct (Abell, 2008)

This construct has clear relevance for thinking about and researching the role of the teacher in influencing learning. However, since the term was first conceived by Shulman in 1986, the exact nature of the PCK construct has been subject to significant debate and revision in the service of different educational researchers' purposes and interests.

3.2 - The uses of PCK for educational research

Shulman's seminal article on PCK was originally intended to explore the "missing paradigm" (1986, p. 7) of teacher-knowledge-of-subject-matter. "Consequently, pedagogical content knowledge was introduced as a subcategory of teacher content knowledge (the two other subcategories being subject matter content knowledge and curricular knowledge)" (Hashweh, 2005, p. 275). Shulman later revised his own conception to place PCK as a separate category among six other (parallel) categories of teaching knowledge, including content knowledge, general pedagogical knowledge, curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes and values (Shulman, 1987). Confusing the matter further, other researchers proposed that PCK *contains* these categories, rather than standing as a separate and parallel domain of broader teaching knowledge:

> [PCK] had been transformed from that special amalgam of subject matter and pedagogy that Shulman (1986, 1987) described, to a category of teacher knowledge that curiously seemed able to encompass all other categories of teacher knowledge and beliefs …PCK seemed to have lost one of its most important characteristics, its topic specificity, and was being thought of as a broad and general form of knowledge. (Hashweh, 2005, p. 274)

Such divergent views on the exact nature and explanatory purpose of PCK have significant implications for how it can be used to inform educational research. By making the choice to place PCK as one element within a wider repertoire of teaching knowledge, or by understanding the concept to *include* other forms teaching knowledge, educational researchers are taking up the construct in different ways, with different implications for *how* and *what* PCK has the capacity to explain and predict about teaching. Such choices will have logical effects on what research discovers about what a teacher's PCK is, where it comes from, how it operates, by which factors it is determined, and what it can predict about the nature of teaching practice. Thus, there is persistent debate over how the notion of PCK should be used to understand teaching knowledge and practice.

In summarising this issue, Hashweh (2005) identifies a number of different trends in the focus of PCK scholarship and research. These trends include the tendency to include more and more components within the construct, or to emphasise the "influence of other categories of teacher knowledge and beliefs" on the construct, to emphasise the "topic specificity" of the knowledge that is PCK, or to focus on the development of PCK in relation to other knowledge and belief categories (Hashweh, 2005, p. 276). These competing views and interests have emerged largely out of the particular research interests of the writers which discuss them, but do little to help us to arrive at a consistent theoretical construct of PCK which can be consistently applied to answering specific educational research questions.

Although such issues and competing interests cannot be resolved herein, the following discussion in this chapter will outline how PCK is understood for the purposes of this research and the rationale for this approach. An argument is also made that this understanding of the concepts allows us to arrive at an explanatory function for the concept, thereby having uses for other research in the future.

3.3 - An alternative approach to PCK: research oriented constructs

Some progress in understanding and dealing with these conceptual level issues is afforded by considering the arguments of Segall (2004, p. 491) on the capacity of PCK for explaining the "educative process." In critiquing common understandings of PCK, Segal argues that the distinction between the terms 'content' and 'pedagogy' are uncritically understood, and that this undermines the validity of the PCK construct for *explaining* educative acts. Whilst he argues for the significance of the concept of PCK ¨for opening a new lens to explore the educative process¨, he emphasises the need to work with these terms critically in order to achieve theoretical and conceptual clarity. Specifically, he argues that:

> [there is a] need for teachers to read the inherently instructional aspects of content… While much of the literature using pedagogical content knowledge sees pedagogy as external to content "per se," [I argue] that knowledge is never "per se," never for itself… Knowledge is always by someone and for someone, always positioned and positioning and, consequently is always pedagogical. (Segall, 2004, p. 491)

Thus, the common usage of the terms 'content' and ´pedagogy´ in the term PCK is over-simplified and uncritical. It is precisely this over-simplification that has given rise to the divergent views about, confusion over, revision of and ultimately circular nature of the debates surrounding PCK, because the usage of these terms does not match the complexities of the reality of teaching practice. Accordingly, common definitions of PCK become problematic when applied to examining "what (and how) pedagogical content knowledge does and does not measure while used as a measuring tool for the pedagogical act" (Segall, 2004, p. 491). Segall (2004) argues this is because the distinction between content and pedagogy, in practice, is artificial:

> Engaging how one teaches as inseparable from what one teaches, a distinction between pedagogy and content is untenable. With meanings flowing back and forth from what is said or read to what and how things are done, pedagogy cannot be considered simply a method, an after-thought applied to content… But while the idea of pedagogical content knowledge continues to remain fundamental to the thoughtful blending of the "what" and the "how" of teaching, the definitions of pedagogy and content (and the boundaries between them)…do not invite an examination of the various ways in which content and pedagogy may already be interrelated, even before either enters the classroom. (Segall, 2004, pp. 495, 498)

Thus, inappropriately defined, the explanatory power of PCK (as it is most simply and uncritically understood) becomes limited at best and at worst invalid. It is not observable because the distinctions between the domains of knowledge that popular versions of the PCK construct depict do not exist in actual practice. Despite this, Segall himself argues for the benefit of continuing to explore the notion of PCK, on the basis that, properly (and empirically) defined, it can be a valuable tool for explaining teaching when used consciously and critically. Hence, we need to move away from such conceptions, towards exploring PCK in ways that can account for the diverse, dynamic, contingent, fluid and fluent nature of teaching-knowledge-in-use.

Having themselves completed a comprehensive review of the PCK literature, Park and Oliver (2008) developed a fundamentally different approach to understanding PCK which is able to handle the conceptual difficulties that Segal discussed. Their definition is that ¨PCK is teachers' understanding and enactment of how to help a group of students understand specific subject matter using multiple instructional strategies, representations and assessments while working within the contextual, cultural and social limitations in the learning environment¨ (Park & Oliver, 2008, p. 264). It is this definition that this research proceeds upon.

In this definition, PCK is seen as dynamic and contingent on the possibilities and limitations of the context for teaching. Instead of focusing on how something called content and something called pedagogy are combined, Park and Oliver (2008) propose a construct of five categories of interrelated and interdependent practice-oriented knowledge areas. These component domains of PCK interact variably to comprise teachers' overall bodies of pedagogical content knowledge. Each of these areas of knowledge is influenced by the teachers' own prior experiences, the context in which they work and teach, as well as the disciplinary structures which define the subject matter being taught. However, each the domains of PCK are not reducible to these influences. The five domains are:

1. Orientations to teaching the discipline
2. Knowledge of students' understanding in the discipline
3. Knowledge of discipline curriculum
4. Knowledge of instructional strategies and representations for teaching the discipline
5. Knowledge of assessment of discipline learning. (Park and Oliver, 2008, p. 266).

This construct (depicted in full in Figure 3) deviates from the approach of previous models by focusing on the types of knowledge that exist in relation to practice. Although subject matter knowledge and pedagogical knowledge are recognised and represented as influencing PCK, they are not considered as constitutive of PCK or as hierarchically related to it. They represent forms of knowledge that are qualitatively different to PCK; they are forms of teaching knowledge that exist only at an abstract level, whereas PCK exists only in practice. As Hashweh (2005) puts it, PCK contains "echoes" of these knowledge bases but is irreducible to them. Park and Oliver explain that their construct was developed as:

> A heuristic device and as an organizational tool for the *observable* components of PCK. Placing PCK at the centre was intended to indicate its potential development from any of these five components …On one hand, the development of one component of PCK may simultaneously

> encourage the development of others, and ultimately enhance the overall PCK. On the other hand, PCK for effective teaching is the integration of all aspects of teacher knowledge in highly complex ways. Thus, lack of coherence among the components would be problematic within an individual's developing PCK and increased knowledge of a single component may not be sufficient to stimulate change in practice. (Park & Oliver, 2008, p. 264)

This construct therefore offers a way to avoid the validity problems highlighted by Segall (2004). It also captures a more sophisticated notion of the nature of teaching expertise and teaching practice than previous models have offered. This is especially convincing because the categories of knowledge proposed were derived from observation of knowledge-in-use by teachers in the context of their practice. Each category has been analytically derived and is *observable.* Whilst each category invariably "echoes" knowledge about content and knowledge about pedagogy, the structure of the construct allows it to be utilised without needing to create functional or conceptual distinctions between content and pedagogy. Importantly, the categories proposed provide a basis for observation of how teaching knowledge *operates* to make teaching successful. The "what (and how) that pedagogical content knowledge does and does not measure while used as a measuring tool for the pedagogical act" (Segall, 2004, p. 491) is clear in this construct.

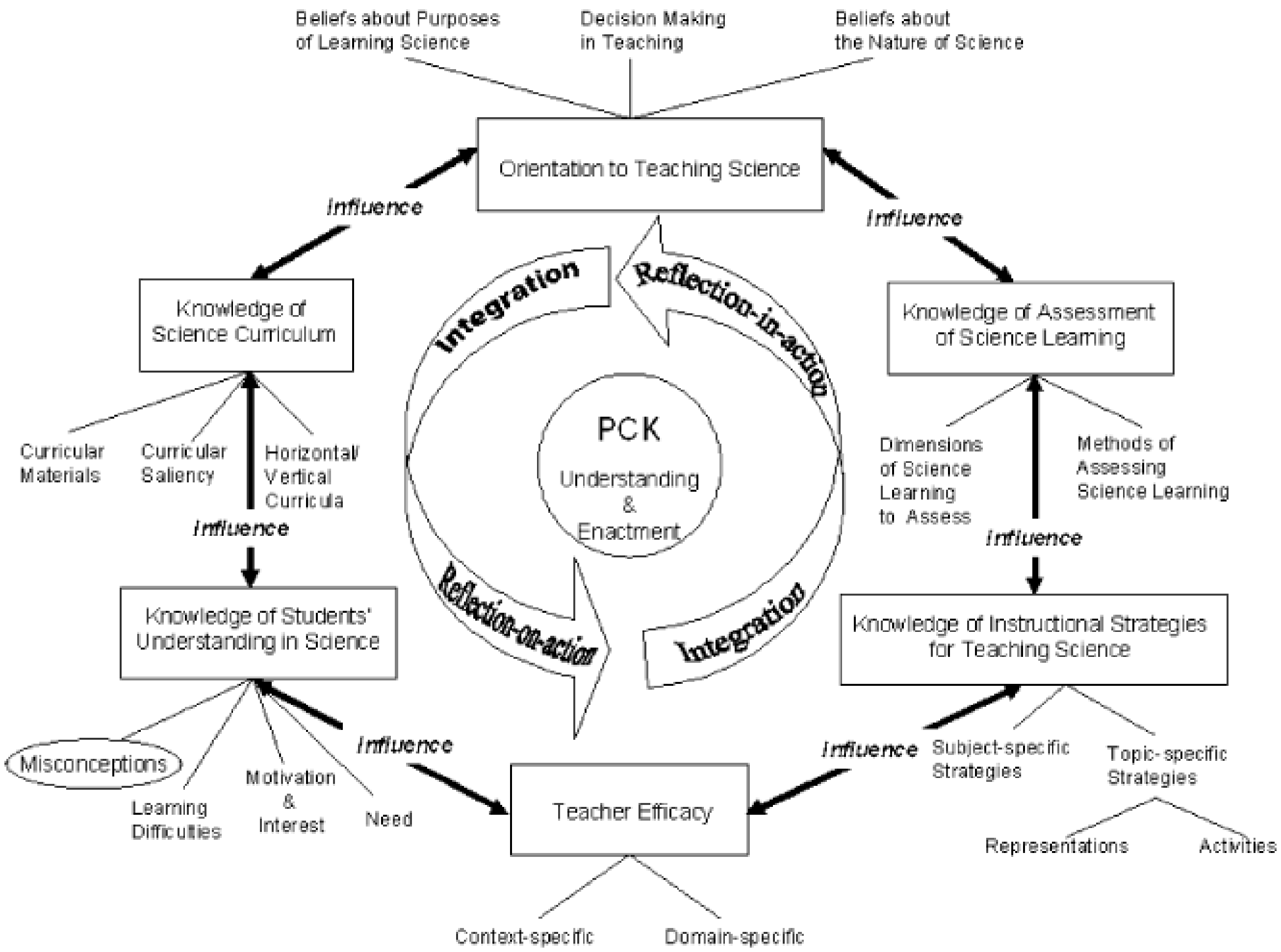


Figure 3 - Park and Oliver's (2008) PCK construct

Despite this, one of the problems with applying the PCK construct to educational research questions, particularly when the aim is to understand or explain instances of teaching practice, is that the construct is expressed in terms of categories of knowledge that are possessed by the teacher. The very notion of knowledge is that it is a noun, a thing to be possessed, whereas teaching is an act; a process. Therefore, for observational purposes it may be useful to insert the prefix "using" in front of each of Park and Oliver's PCK knowledge categories. Hence, "knowledge of students' understanding of the discipline" would become "using knowledge of students understanding of the discipline." This modification helps to express that PCK is not just a collection of inert forms of knowledge. Rather it comes into existence when these forms of knowledge are utilised, synthesised and transformed during the process of teaching. PCK is then made susceptible to empirical observation, because the knowledge that teachers use in undertaking their practice is revealed by the practice itself (Nash, 1999).

In a similar approach to Park and Oliver (2008), Hashweh (2005) attempts to address the conceptual issues with the notion of PCK by similarly reconfiguring the construct. He proposes the following definition:

> Pedagogical Content Knowledge is the set or repertoire of private and personal content-specific general event-based as well as story-based *pedagogical constructions* that the experienced teacher has developed as a result of repeated planning and teaching of, and reflection on the teaching of, the most regularly taught topics. (Hasweh, 2005, p. 277)

Hashweh's approach shows a clear alignment with Park and Oliver's (2008) work, who described their construct as a "heuristic device" with PCK at the centre of five interrelated component knowledge areas indicating its "potential development from any of these five components" (Park and Oliver, 2008, p. 264). Similarly, Hashweh's reconfiguration of PCK concept places multiple "teacher pedagogical constructions" (TPCs) at the centre of a web of interrelated areas of teaching knowledge. As with the view of Park and Oliver, PCK is seen to arise out of these knowledge areas because "pedagogical constructions result mainly from the interactions between different kinds, or categories, of teacher knowledge…they contain the traces of these original knowledge categories" and "components of the general knowledge categories are echoed, at a more concrete or in a more local level in the TPCs" (Hashweh, 2005, pp. 281-283). Hashweh's visual representation of this reconfiguration is depicted in Figure 4:

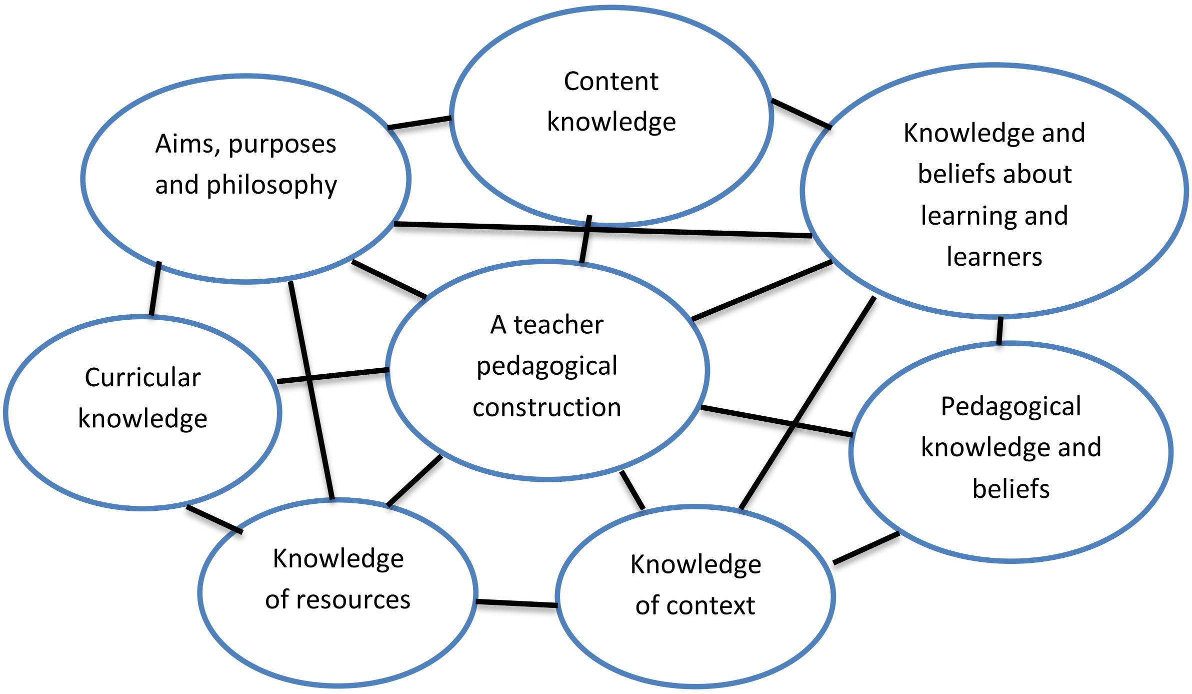


Figure 4 - Hashweh's reconfiguration of PCK (Hashweh, 2005, p. 282)

Comparison of Hashweh's and Park and Oliver's categories of knowledge for PCK reveals strong similarities. The categories within each construct can be seen to be broadly analogous, as per Table 1. Although Hashweh's seven categories present the components in greater detail, there are clear parallels in the component knowledge areas for the two models.

Table 1 - Comparison of Park and Oliver's (2008) and Hashweh's (2005) categories of teaching knowledge for PCK

Categories of teaching knowledge affecting PCK	
Park and Oliver (2008)	**Hashweh (2005**
Orientations to teaching the discipline	Aims, purposes and philosophy
	Pedagogical knowledge and beliefs

Knowledge of students' understanding in the discipline	Knowledge and beliefs about learning and learners
	Knowledge of context
Knowledge of instructional strategies and representations for teaching the discipline	Content knowledge
Knowledge of discipline curriculum	Curricular knowledge
Knowledge of assessment of discipline learning	Knowledge of Resources

The similarities do not end there. As per the arguments of Park and Oliver, Hashweh emphasises that his reconfiguration represents:

> The dialectical relationship between PCK, or TPCs in particular, and the different knowledge categories. [The PCK construct] should be viewed as a snapshot of the teacher's 'conceptual ecology' (Strike and Posner, 1992) at a certain point in time. While the figure shows the interactionist view of these ecologies, it fails to show the developmental view of these ecologies. (Hashweh, 2005, p. 282)

Thus, the notion of PCK is necessarily dynamic, developing and contingent, and "our view must therefore be… dynamic and developmental, emphasising the shifting patterns of mutual influence between the various components of an evolving conceptual ecology" (Strike and Posner, 1992, p. 163).

Emphasising that PCK exists within an "evolving conceptual ecology" has particular importance for the application of the construct to educational research. In taking this emphasis, PCK becomes particularly relevant to research which seeks to understand teaching practice in the contexts in which it occurs, and in terms of the factors and structures that influence patterns of practice. Although PCK is never static, the constructs that Hashweh (2005) and Park and Oliver (2008) present may be considered valid at any point in time for a given teacher's 'conceptual ecology'. This is because the categories of knowledge within these constructs remain the same, although the exact knowledge contained within them, and how these interact within a given teacher pedagogical construction (TPC), will differ.

Discussion from both Hashweh and Park and Oliver about the findings of their research lends insight into how these PCK constructs are:

- analytically and empirically derived from; and,
- applicable to the observation of teaching practice.

They provide examples of how their constructs become explanatory of teaching practice and how observable teaching practice is revealing of PCK. For example, Hashweh comprehensively presents the findings of a biology teacher's detailed "teacher pedagogical construction" about teaching the topic of photosynthesis (Hashweh, 2005, p. 284). Park and Oliver's data analysis reveals very similar evidence of what PCK looks like in practice for secondary chemistry teachers. Both sets of authors present the salient features of PCK that they have derived from their observations of teacher thinking and behaviour. Table 2 presents the considerable overlap between these empirically derived features of PCK.

Table 2 - Comparison of the salient feature of PCK between Park and Oliver (2008) and Hashweh (2005)

<table>
<tr><th colspan="2">Salient features of PCK – derived from observational data</th></tr>
<tr><th>Park & Oliver (2008)</th><th>Hashweh (2005)</th></tr>
<tr><td></td><td>PCK is a collection of basic units called teacher pedagogical constructions…which better indicates the conceptualisation of PCK as a set of entities and not as a whole unit.</td></tr>
<tr><td rowspan="2">PCK development occurs as a result of reflection related to both knowledge-in-action and knowledge-on-action</td><td>Teacher pedagogical constructions result mainly from planning, but also from the interactive and post-active phases of teaching</td></tr>
<tr><td>Pedagogical constructions constitute both a generalised event-based and a story-based kind of memory</td></tr>
<tr><td>Teacher efficacy was evident as an affective affiliate of PCK</td><td></td></tr>
<tr><td>Students influenced the ways that PCK was organized, developed, and validated</td><td rowspan="2">Pedagogical constructions result from an inventive process that is influenced by the interaction of knowledge and beliefs from different categories</td></tr>
<tr><td>Teachers' understandings of students' misconceptions was a major factor</td></tr>
</table>

that shaped PCK in planning, conducting instruction and assessment	
PCK was idiosyncratic in some of its elements	PCK represents personal and private knowledge [rather than public and objective knowledge]
	Pedagogical constructions are topic specific
	Pedagogical constructions are (or ideally should be) labelled in multiple interesting ways that connect them to other categories and subcategories of teacher knowledge and beliefs

The significance of the specificities and similarities of these two models is two-fold. First, both models demonstrate in greater detail the nature of the PCK construct, and the ways in which PCK is observable as knowledge-in-action in teaching practice. Second, the similarity between the two models which were developed separately show that they are complimentary rather than contradictory – they offer substantively similar ways of understanding the same phenomenon in the world. Their similarity is an argument for their validity: each construct describes what it attests to describe, because research has given rise to two very similar conceptions and constructions of PCK in separate research projects.

The empirical approach to the application of PCK constructs provides the conceptual basis for the research methods used in this research, and is reflected in later discussion of how observation of participants' teaching during the case studies is revealing of their PCK. This also allows for explanatory models of different forms of engineering PCK to be developed out of these case studies.

Given the present focus on the application of the PCK construct to understanding teaching in applied disciplines, I have proposed a modification of Park and Oliver's (2008) and Hashweh's (2005) models of PCK to include an extra component: "using knowledge of teaching about practice." How this extra component affects teaching practice will be shown to have a significant effect on how the PCK construct can be used to understand patterns in engineering teaching. How it exists as a distinct domain of PCK for different individual teachers will be explained in the discussion and findings section. Furthermore, the kinds of specific knowledge (and uses of this knowledge) that this proposed component involves when it is seen to meaningfully inform teaching will also be explained in the findings.

3.4 - On the difference between PCK and teaching expertise

Teachers with well-developed PCK (such as those discussed by Park and Oliver (2008) and Hashweh (2005)) demonstrate behaviours for thinking and practice which have significant parallels with the behaviours of teaching "experts". In his seminal article of 1988, Berliner describes six key behaviours that raise teachers to the level of "expert". These behaviours are:

1. Interpreting classroom phenomena
2. Discerning the importance of events
3. Using routines
4. Predicting classroom phenomena
5. Judging typical and atypical events
6. Evaluating [teaching] performance (Berliner, 1988)

Each of these behaviours is evident in the detailed PCK observations presented by Park and Oliver and Hashweh (2005). Ropo (2004) also argues that expert teachers are more sensitive to individual students in class situations and the characteristics of task situations. Each of these six behaviours is implied or explicit in the features of PCK outlined in table 2, and each evident in the detailed PCK observations presented by Park and Oliver (2008) and Hashweh (2005).

However, it would be premature to conclude that effective PCK and teaching expertise are synonymous. Whilst sophisticated PCK is likely to be strongly associated with high level of expertise in teaching, expertise is also known to involve a number of other behaviours which the PCK concept does not necessarily encompass. For instance, according to Ropo (2004), expert teachers compared to novices:

- Have automatic ways of reacting to frequently recurring situations
- are faster and more accurate in their observations

- take longer to represent a problem to themselves, but end up with a better representation (Ropo, 2004, pp. 165-168)

These behaviours are not necessarily accounted for by the PCK construct. Therefore, herein the terms PCK and teaching expertise are considered as two distinct but related concepts. Whilst PCK and expertise may often go together, they are not the same thing.

3.5 - Epistemology in PCK, epistemology of teaching, and of engineering education

For some time, educational research and the scholarship of teaching has shown strong paradigmatic trends towards a constructivist philosophy of teaching (Bransford, et al., 2000; Killen, 2007). The research on PCK is no exception. Throughout this discussion, and dominant in the literature on both PCK and wider educational research for many decades, is a constant focus on teaching in ways that helps students to negotiate, construct and reconstruct their understandings of subjects and topics. In this philosophy, learning is not about the passive receipt of knowledge. Rather, constructivism emphasises that ¨learners actively construct knowledge for themselves by forming their own representations of the material to be learned, selecting information that they perceive to be relevant, and interpreting this on the basis of their present knowledge and needs¨ (Dart, 1994, cited in Killen, 2007, p. 7).

This philosophy can be understood by considering the ontological, epistemological, methodological and axiological perspectives it contains (Figueiredo, 2008). The ontological perspective implied is that learning and teaching necessarily involve the negotiation, construction and reconstruction of knowledge in a social and interactive process. The epistemological correlate of this ontology is that teachers and educational researchers necessarily concern themselves with evidence of such processes of negotiation and construction of knowledge. In fact, it could be argued that it is largely this epistemological view that has given rise to interest in PCK as a means of developing and interpreting evidence for and about effective teaching. Thus, the development of PCK can be seen to fall within the field of the "scholarship of teaching," in which the aim is that university teachers explore and pursue theoretical perspectives on teaching and learning in their disciplines so that they can ¨collect and present rigorous evidence of their effectiveness, from these perspectives, as teachers. In turn, this involves reflection, inquiry, evaluation, documentation and communication¨ (Trigwell, Martin, Benjamin & Prosser, 2000 p. 156).

The teaching methodologies necessitated by the constructivist philosophy are student-centred pedagogies; approaches to teaching and learning that involve active rather than passive learning, with an emphasis on interaction among students, their peers and their teachers. The axiological perspective here is that such learning has inherently more value for a student (than passive receipt of information) because the knowledge and meaning it yields for students has more depth and is more enduring in nature, it is more generalizable and transferable to other contexts, and it is more adaptable to some form of practice in the world (Killen, 2007). Within this constructivist paradigm the teacher is a vital instrument determining the processes of learning that are taken up in the classroom.

Hashweh argues that the development of effective PCK is inherently a constructivist pursuit because ¨teachers who are able to detect student alternative conceptions in photosynthesis, and who have developed superior strategies for engaging these student prior ideas, are not only knowledgeable about photosynthesis; they also hold constructivist epistemological beliefs¨ (Hashweh, 2005, p. 279). This begs a question about the effect of epistemology on the development of PCK when the practitioner belongs to a discipline that is positivist and mechanistic, rather than constructivist, in its philosophy of knowledge and learning, such as in engineering. Epistemology is known to be a strong determinant of both the content of the discipline and nature of teachers' PCK (Major & Palmer, 2006). Thus, the nature of a specific teacher's PCK must be closely related their enduring beliefs and conceptions of learning *for* their discipline, which derive from their own experiences of learning in their discipline. In fact, Stark (2000) found that teachers´ ¨beliefs about knowledge in their disciplines were the strongest influence on planning at the course and lesson levels¨ (Major & Palmer, 2006, p. 622). Similarly, expectations about how students learn in the discipline meant that teachers had developed strong beliefs about the link between the nature of the discipline and the need to teach it in a particular way (Major & Palmer, 2006).

In other words, the epistemology of the discipline is known to have a direct effect on the teaching practices adopted in that discipline, because it is fundamental to determining how PCK is comprised and used. This is of particular significance in engineering which is traditionally mechanistic in its approach to learning and positivist in its view of the nature of knowledge. Engineering does not tend to concern itself with individual subjectivities, experiences and processes of meaning making, nor does it privilege (learning) theory or qualitative research (Beddoes, 2012, pp. 4-5). The scholarship of teaching, by contrast, is necessarily concerned with these things, being predicated on a constructivist epistemology (Trigwell, Martin, Benjamin & Prosser, 2000). Thus, the discipline of engineering and the discipline of teaching may be seen to be somewhat at odds, raising interesting questions about tensions in the composition of PCK and how it functions for engineering. Such issues will be discussed further throughout the dissertation.

3.6 - PCK or TPCK (TPACK)?

A large body of work now exists which proposes an extension of the PCK construct to include the domain of technology knowledge for teaching (for example, Koehler & Mishra, 2009; Graham, 2011; Archambault & Barnett, 2010). This body of work has clearly developed in response to the increasing importance and ubiquity of technology in society, and the need for students in any discipline to be technologically literate (whatever that might mean for their discipline). The TPACK framework attempts to describe the ¨complex interaction among three bodies of knowledge: content, pedagogy and technology. The interaction of these bodies of knowledge, both theoretically and in practice, produces the types of flexible knowledge needed to successfully integrate technology use into teaching¨ (Koehler & Mishra, 2009, p. 60).

Because technology is never neutral or unbiased, its effective incorporation in teaching is not automatic or straightforward (Koehler & Mishra, 2009). However, in the vein of Segall (2004) arguing for the distinction between content and pedagogy being untenable, it could be viewed that teaching knowledge about technology does not exist as distinct from other teaching knowledge bases. Given that technology use for the purposes of teaching must always occur in the form of either teaching *with* technology or teaching *about* technology, or both, technology-knowledge-for-teaching is not practically separable from teachers' knowledge structures about either pedagogy or content. This view is reinforced if you accept the discussion of technology presented by Hills and Tedford defining it as:

> A bundle of practical and intellectual skills essential to the solution of any kind of practical problem. It is an action word wholly defined by its context and never by its content. It is as implicit as scientific knowledge is explicit. It is experiential, tacit and the source of all wealth. (Hills & Tedford, 2003, pp. 22, 27)

Just as technology only exists and may only be understood in reference to the context of its use, likewise the knowledge structures which allow it to be taught cannot be conceptually separated from broader teaching knowledge in the contexts in which it is apparent. Whilst the advent of the TPCK or TPACK models may certainly be useful for pursuing questions about the particular difficulties surrounding developing and applying technology knowledge to teaching, the distinction between technology, content and pedagogy that these models are predicated on is not conceptually useful for pursuing this research question. It is for this reason, as well as the others stated above, that Park and Oliver's (2008) and Hashweh's (2005) PCK construct have been adopted here, rather than one that separately addresses the technological elements of teaching knowledge. However, it is anticipated that each of the domains of PCK that this research seeks to explore can and will incorporate instances of knowledge about teaching with and teaching about technology. This is especially significant for engineering, in which technology is fundamentally central to the pursuits of the discipline.

4.0 – Bourdieu's Theory of Practice

"Research in terms of Bourdieu's Theory of Practice offers insights and understanding [of educational questions that are] not readily visible in other approaches" (Grenfell & James, 1996, p. 2). In particular, the strength of Bourdieuvian theory is in describing how individual agents' patterns of habitual disposition (*habitus)* interact with structures in the wider social context (*field)* to produce regular modes of practice. This position is supported by the work of Fanghanel and Trowler (2008, p. 311), who state that:

> The conditions in which academics work impact on their approaches to teaching in ways that are generally unacknowledged…Looking at teaching as something other than simply a commodity would enable an engagement with the realities of practice…Apprehending practice complexity and within it, the full socio-cultural dimension of teaching and learning might provide a more realistic basis for enhancing teaching and learning practices. (Fanghanel & Trowler, 2008, p. 311)

In this vein, Bourdieuvian theory can be used to explain the relationship between teaching practices that occur in the academy, and the contexts in which that teaching takes place.

4.1 - Field and Capital

Bourdieu´s theory proposes that actors in a *field* compete *for* and *with capital* in order to improve their position in the *field* (Bourdieu, 1990), according to their goals of practicing in the *field*. The *field* itself can be understood as a "configuration of relations between positions objectively defined, in their existence and in the determinations they impose upon the occupants, agents or institutions" (Bourdieu & Wacquant, 1992, pp.72-73). In interpreting the work of Bourdieu, Webb et al (2002, pp. 21-22) describe *field* as:

> A series of institutions, rules, rituals, conventions, categories, designations, appointments and titles which constitute an objective hierarchy, and which produce and authorise certain discourses and activities. But it is also constituted by, or out of, the conflict which is

> involved when groups or individuals attempt to determine what constitutes capital within that field, and how that capital is to be distributed. (Webb et al., 2002, pp. 21-22)

Therefore to understand the configuration of any given *field*, we must understand the forms of *capital* that are available within it, the sources of this *capital* as well as how this *capital* may be competed for. It is in the competition for and distribution of the various forms of *capital* that the ¨configuration of relations¨ that make up a *field* is observable. ¨The medium of…relations [in a field]…is capital, which is hence both product and process within a field. All capital – economic, social and cultural – is symbolic, and the prevailing configurations of it shape social practice¨ (Grenfell & James, 2004, p. 510).

Bourdieu's Theory of Practice (1992) suggests that the *field* of engineering education will have a continuous and reciprocal relationship to the patterns of teaching practice that occur within it, because it will at once create them and be created by them. That is to say, how teachers operate within the *field* to position themselves and accumulate *capital* is both determined by and revealing of the *field* itself.

4.2 - Habitus

The purposes, decisions and actions of engineering educators; their strategies, (themselves contingent on and responsive to the structures present within the *field*), can be discerned and explained in terms of Bourdieu's notion of *habitus*. "According to Bourdieu, practices are generated by a certain habitus…and, therefore, all practices give evidence of the structures of the habitus that generate them (Nash, 1999, p. 178). The *habitus* should be understood as:

> A system of dispositions to a certain practice, [it] is an objective basis for regular modes of behaviour, and thus for the regularity of modes of practice, and if practices can be predicted…this is because the effect of the habitus is that agents who are equipped with it will behave in a certain way in certain circumstances. (Bourdieu, 1990, p. 77)

In another explanation of this notion of *habitus*, Reay (2004) explains that:

> Bourdieu views the dispositions, which make up habitus, as the products of opportunities and constraints framing the individual's earlier life experiences. They are: "durably inculcated by the possibilities and impossibilities, freedoms and necessities, opportunities and prohibitions inscribed in the objective conditions" (Bourdieu, 1990a, p. 54). As a result, the most improbable practices are rejected as unthinkable, but, concomitantly, only a limited range of practices are possible. (Reay, 2004, p. 433)

This description of *habitus* is explanatory of much of what we know about what influences how teachers go about teaching, for example, the role of prior conceptions about teaching and learning, the epistemological basis of a discipline which is being taught, and the effects of the contextual and institutional conditions in which teaching takes place. This makes the theories of *field* and *habitus* particularly useful for explaining teaching practice, as it allows for analysis to take place without divorcing the thoughts and actions of practitioners from the context in which their action takes place. This theory also establishes that there is a reciprocal connection between the *field* of engineering education and the teaching practices which occur within it, via individual teachers' *habitus* with respect to teaching. This allows for an exploration of how the expertise for teaching within a particular discipline (PCK) occurs and is continuously negotiated within the wider context. Thus, in studying engineering education and engineering educators in terms of *field* and *habitus* (respectively), the links to corresponding patterns in PCK (and consequent teaching practice) may be established and predicted.

4.3 - The Theoretical Approach

In addition to the proposed research questions and sub-questions (above), investigating the topic using this theoretical framework involves exploring the following conceptual issues.

- *How do Engineering teachers position themselves for success in the field? (E.g. the strategies and types of capital used)*

- *In what ways is PCK responsive or resistant to a teacher's habitus within their socio-cultural field?*
- *Are there types of habitus which are supportive of or inhibiting to the development of PCK for engineering education?*
- *In what ways is the engineering field supportive of or inhibitive to the development of effective PCK?*
- *What barriers exist to the development of effective PCK for engineering teachers?*
- *What strategies are available to overcome these barriers?*

Figure 5 proposes six potential domains of the *habitus* of an engineering teacher. The relative presence, nature and interaction of these domains of the *habitus* can be seen to provide the foundations from which participants´ possibilities for practice are developed. These aspects include a teacher's:

- epistemology of engineering (including what engineering is, what counts as knowledge and evidence in engineering);
- their epistemology of teaching and learning (including the teaching and learning of engineering as a specific and distinct discipline, as well as teaching and learning in a general sense);
- their background of training and experience in teaching;
- their beliefs and attitudes within their faculty role (specifically, their role in terms of their duties to the university/institution);
- their beliefs and attitudes within their teaching role (specifically, their role in terms of their duties to their students and the curriculum), and;
- their background of training and experience in professional experience (including their currency of experience in engineering industry).

Each of these domains of the *habitus* are expected to combine to influence the "system of dispositions" which creates regular patterns of behaviour for that actor in the *field*. Each of these aspects can also be seen to dovetail with the proposed aspects of PCK to be investigated.

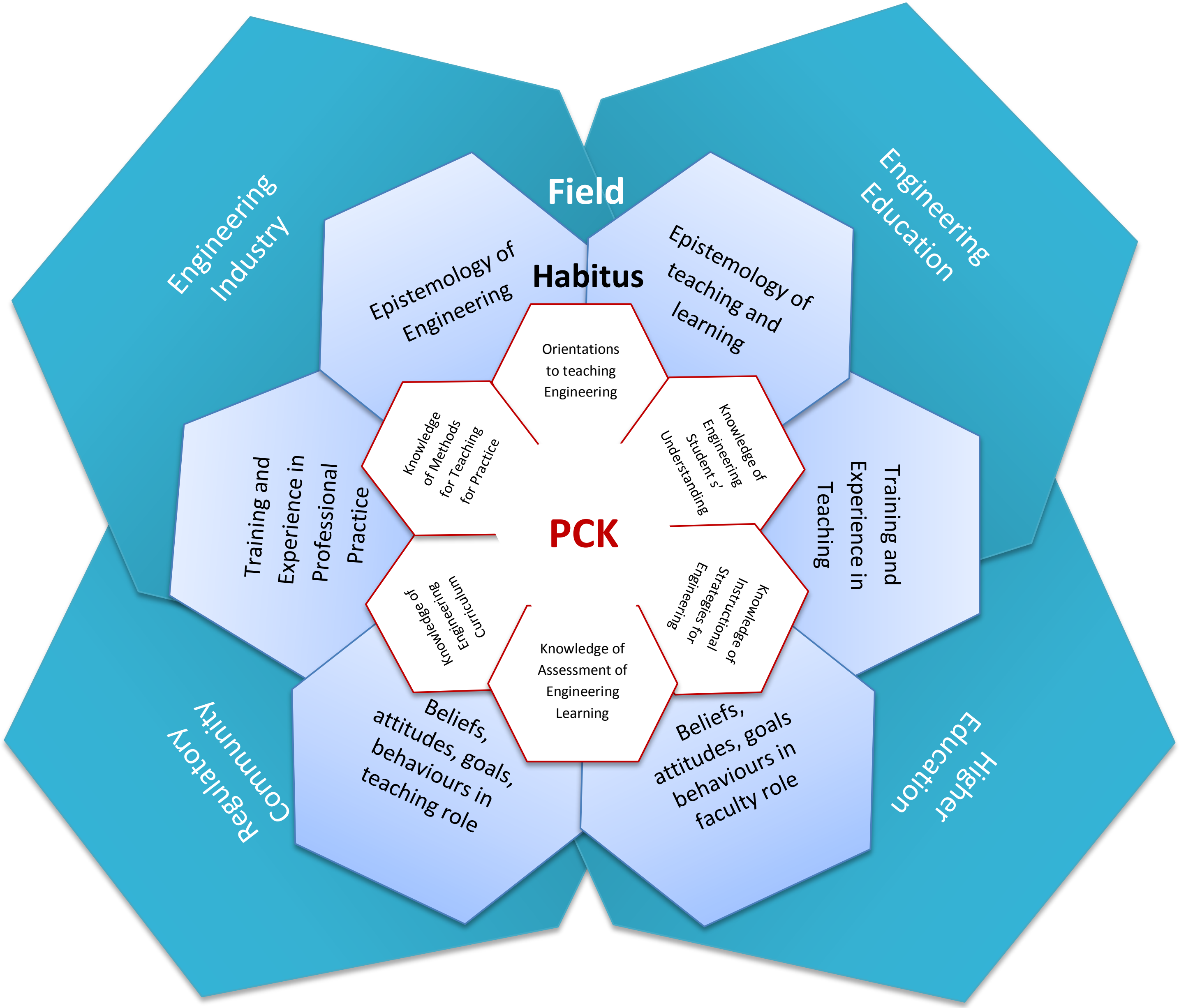


Figure 5 - Proposed relations among field nodes, habitus and PCK (author´s own figure)

4.4 - The role of the nodes of the field

In exploring the notion of *field*, it should be understood that *fields* are not bounded. Rather, they are dynamic, have fuzzy edges and are constituted by various realms of influence which are particular to the *field* itself (Bourdieu & Wacquant, 1992). Any given *field* is inevitably influenced by wider society, but will also take influence from other entities according to the nature and goals of the *field* itself. These nodes operate at the fuzzy edges of the *field* and take a role in determining the *capital* which is relevant in the *field* and how such *capital* is valued. For example, the *field* of engineering education is known to be influenced by engineering industry, by higher education generally and by the regulatory bodies (such as Engineers Australia, ABET, etc.) which define and regulate standards of practice for accreditation into the profession. The *field* is also influenced by engineering education research, such as that undertaken within and for scholarly associations and journals (Graham, 2012). Bourdieu refers to such areas of influence as nodes (Bourdieu & Wacquant, 1992).

Crossley (2001, p. 86) interprets Bourdieu´s theory of the nodes of a *field* as the interlocking domains of modern society that ¨can coincide with institutions…but can assume sub and trans-institutional forms, too.¨ For engineering education, the *field* will inevitably take some influence from the broader *fields* of ´science´ and ´scholarship´, ¨characterised by competition for prestigious titles, honors and positions (Crossley, 2001, p. 86), but it will also be configured by the *capital* made available by the specific nodes of the *field* to be discussed below.

4.4.1 - The nodes of the field: engineering industry, regulatory and accreditation community, higher education and engineering education research

Figure 5 depicts the theorised *field* nodes which are expected to influence the overall configuration of relations at a given site in the *field*, the aspects of *habitus* that are relevant for participation in the *field*, and proposed components of PCK that dovetail with the relevant aspects of the *habitus*. For different actors at different sites in the *field*, it is to be expected that the petals of the diagram will be comprised and represented differently, leading to different regularities of practice being observed for that participant at their site in the *field*.

The combined influence of each node within the *field* is expected to operate differently for different sites of practice or position occupied within the *field*. (Note, an actor's site within a *field* should be considered distinct from their position. The former relates to their specific context, such as the institution/s that they work within, whereas the latter refers to the quantity and kind of *capital* they possess which allow them to strategise and practice in particular ways). However, it should also be noted that participants may themselves choose to draw on the *capital* available from these nodes of the *field* differently, thereby employing different strategies for positioning themselves in the *field* and to differing effect. In understanding the links between such actions by participants in the *field* and the bodies of PCK which coincide with them, we can begin to explain the links among the entities of *field, habitus* and PCK. The following sections draw on available literature to hypothesise how each node can be expected to influence the configuration of relations seen at given sites in the *field*.

4.4.2 - The node effect of engineering industry

The central concern and aim of engineering education must always be to graduate students with the qualifications and capacity to work as professionals in engineering industry. Therefore, the wider *field* of engineering industry will always constitute a node in the *field* of engineering education. It is the node of industry that ultimately has the capacity to determine which practices (and which underlying beliefs, values, knowledge and skills that such practices are predicated on) will be recognised as most appropriate and authentic for engineering as a profession. For example, types of *capital* that are competed for within industry can be concerned with efficiency and effectiveness (getting the job done on time and on budget) and producing tangible and functioning objects or technologies (such as building bridges or buildings for Civil engineering, as opposed to a discipline such as Architecture which does not in itself produce tangible objects). However, the activities surrounding these forms of *capital* simply are not replicable in the education domain of engineering, and therefore must be represented by proxy, such as through negotiations about what constitutes an authentic engineering identity and how it may be rehearsed by students. An example here could be the building of a prototype bridge (as opposed to a full scale, real world one) including rehearsal of the ¨real engineering¨ practices and processes that go into producing that artefact. In engaging with and negotiating what constitutes ¨real engineering¨ practices and processes for their performance, both students and staff draw on *capital* from the engineering industry node of the *field*.

In many instances, universities can be seen to pay attention to this node of the *field* by seeking to replicate the practices of industry, albeit in limited ways. For example, Trevelyan (2010) argues that ¨academics seldom understand engineering practice beyond design and technical problem solving¨ (Trevelyan, 2010, p. 383). There is also much attention given across the *field* of engineering education to what constitutes ¨real engineering¨ and how this may be best represented in the classroom, as has been seen in earlier discussions herein. In this sense, the word ¨engineer¨ is ascribed to persons with a particular identity and worldview, and who possess a subsequent set of skills and practices, and in many instances this is discussed in terms of how students can practice for what happens in industry. Ultimately, such definitions of what makes an ¨engineer¨ and ¨real engineering¨ take their source from the node of industry because it is here that this identity is acted out. Whilst the meaning of ¨real engineering¨ continues to be contested territory, it is significant that it is only through practice in industry that it may be tested and validated, and that (at least in the US, but likely here also) many employers ¨don´t believe that engineering graduates understood the context and constraints that govern engineering¨ (Trevelyan, 2010, p.383).

However, given what is known from the available literature about engineering education *as an academic discipline*; its history and fundamental epistemology, and in particular its concern with authenticating itself as a valid, white collar profession within the academy, the influence of the industry node on the may also be seen to be patchy or superficial at the sites in which engineering education actually takes place. This is particularly pertinent at the level of curriculum, which despite the inclusion of guest speakers, project-based courses and internships at many sites, remains focused on the transmission of Mode 1, ¨engineering science¨ forms of knowledge, according to authors such as Graham (2012). In fact, interest in Mode 2 knowledge and the development of employment related skills is sometimes dismissed as ¨vocational¨ and therefore not a worthy focus of the higher education academy (Fanghanel & Trowler, 2008, p. 304). Industry influence on forms of *capital* of the *field* therefore may not be direct, consistent or significant, except in the sense of how industry is involved with accreditation processes (for example, via Engineers Australia setting the requisite competencies for graduates). Because this influence is not direct, it may not often or always exert a constitutive or structuring influence on the forms of *capital* and strategizing that are seen within the *field*. In part this is due to the overwhelming influence of the higher education node on structuring the *field*, discussed in detail below.

4.4.3 - The node effect of engineering regulation and accreditation bodies

Despite the fact that accreditation bodies such as Engineers Australia exert a direct influence on the *field* in the form of determining the graduate attributes that are required of students leaving university, the influence of this node on curriculum is less significant than would be expected because of the ways that universities are required to show how graduate outcomes are being met in engineering programs. Some authors argue that this manifests as a ¨tick and flick¨ or ¨lip service,¨ rather than a substantive approach to delivering the Mode 2-related accreditation outcomes which, as was seen earlier, make up the bulk of the Stage 1 Competencies that universities are responsible for producing in students. Recent work by Male and King (2014) describes what a more complete approach to developing these competencies would need to look like, including a series of systematic and holistic recommendations that engineering faculties would need to implement. Presently, such an approach is not in place according to Graham (2012).

At present, the influence of this node of the *field* may be much less significant than would be expected. Instead of leading to fundamental change in the way that engineering curricula are designed and executed, this node of the *field* seems to have had its greatest influence so far through the engineering education research taking up their accreditation agenda in discussions of ideal pedagogies for the discipline, rather than in fundamental changes to the approach to curriculum (Heywood, 2005). As such, this node does not seem to contribute a distinct form of *capital* to be competed for by most engineering academics in the *field*, however the following phases of the research have the opportunity to test otherwise.

4.4.4 - The node effect of engineering education research

This node of the *field* has created an impetus for change in teaching and curricula that is slowly gaining traction in the *field* as a whole, *insofar as academics take part in the engineering education research community or make use of its outputs* (such as by reading, accepting and acting on research findings). Despite the gradually increasing momentum of engineering education research as a distinct domain of research, significant change as a result of this research has not been seen according to authors such as Graham (2012), suggesting that the influence of this node is not significantly changing the structure or configuration of the *field*. Again this can be seen to be due to the dominance of the higher education node on the structure of the *field* and the fact that participation in engineering education research by engineering academics is often isolated to a few staff within each engineering faculty.

Whilst the engineering education community is well established in Australia (for example through participation in the Australasian Association for Engineering Education and a number of engineering education journals), membership to or participation in this community is not representative of the body of engineering academics as a whole, because most engineering education faculties will only have a few members who are interested in engineering education research specifically. Also, their colleagues in their faculties may have very little awareness or involvement in their activities in this node of the *field*, meaning that the forms of *capital* that this node contributes are not universally shared or competed for. Even though this node of the *field* places a value on (and therefore operates with forms of *capital* surrounding) theories of education and learning, and empirical evidence about optimising the educative process, this *capital* only extends into the wider *field* of engineering education to the point that its participants share and transmit such ideas and values into their wider collegiate networks. Given that an interest in the education aspect of engineering education is currently seen within engineering faculties as somewhat optional for engineering academics, this form of *capital* cannot be said to have a consistent effect on the *field* as a whole.

Despite this, individual academics may elect to strategise for position using engineering education research activities and outputs. Their success in doing so will depend on the degree of recognition that they can achieve for this *capital* at their particular site in the *field*. For example, it may depend on if promotion committees will recognise engineering education as ¨real research¨ compared to more theoretical or technical forms of research.

4.4.5 - The node effect of higher education

The strength of this node for structuring relations is expected to have the greatest effect on the configuration of the *field* of all of the nodes. A variety of research literature points to the strength of the structures of *capital* surrounding academic work on shaping and restricting the possibilities for practice of individual academics, and acknowledges the difficulties for academics in resisting such structures (Kennelly & McCormack, 2015). Crucially, it is how such *capital* is measured and relatively valued that has the greatest effect on structuring the *field*.

It makes sense that the tasks and duties that academics routinely undertake in their roles will be closely associated with the ways that they pursue goals, strategise for position and work with available *capital*, because it is in performing the daily tasks of their jobs that academics in the engineering education *field act upon and act out* the *field* itself. Academics generally have three main aspects to their roles, these being teaching, research and service, the relative weighting of each depending on the particular institution, faculty, department and individual position of the participant. However, as a number of studies have argued, in reality teaching related activities are supported and rewarded far less than activities associated with research, in particular, those which bring an institution prestige:

> To be successful nowadays, a university needs to play a number of different games. Each game has different goals and involves different rules…the goals are often incompatible…winning at one may involve

> compromising others…this does not always, or even often, include enhancing teaching and learning. (Trowler, Fanghanel & Wareham, 2005, p. 440)

As a result of these forces, institutions and departments bring considerable pressure to bear on individual academics through workload allocation models, through funding tied to national research evaluation frameworks and ¨quality audits of teaching and learning¨ (Hemer, 2014, p. 484). These structures are used to measure and reward particular forms of *capital* of the *field*, and become the medium by which *capital* must be transacted by individual academics. The degree of regulation imposed by such structures negatively correlates to the degree of control by participants over their individual trajectories in the *field*. A higher degree of structure in assessing performance arguably leads to ¨terrors of performativity´, a ´technology, a culture and a mode of regulation that employs judgments, comparisons and displays as a means of incentive, control, attrition and change based on rewards and sanctions¨ (Hemer, 2014, p. 484). The strength of this structuring effect is such that individual academics have significantly less agency in selecting the strategies that they can use in ´playing the game´ of the *field*. As Fanghanel and Trowler (2008, pp. 310-311) put it, ¨collective and individual coping strategies were devised to address these structural factors, but the filter of academic labour is highly structural in nature, and agents have very little room to manoeuvre.¨

The necessity to work with restrictions from the structures of the *field* that determine how *capital* can be used means that an agenda of teaching development or excellence is likely to be severely limited. There are ¨growing and widely expressed concerns that teaching is not sufficiently rewarded and recognised in universities, particularly in comparison to research¨ (Chalmers, 2011, p. 25). Further, ¨although Skelton has identified recognition of teaching as a crucial mechanism in developing cultures of teaching excellence, to date only very few distinguished careers have emerged through the teaching route¨ (Fanghanel & Trowler, 2008, p.305).

As such, if academics wish to focus on teaching related activities in order to develop their teaching practices (and their Pedagogical Content Knowledge for teaching in their discipline), they are likely to be either severely limited in their ability to do so, by having to continue to compete for other forms of *capital*, or will undertake significant personal risk by disregarding other forms of *capital*. Devlin, Smeal, Cummings and Mazzaloni (2012) found that ¨a major cultural impediment to enhancing teaching and learning is the privileging of research over teaching¨ (Devlin, Smeal, Cummings & Mazzaloni, 2012, p. 4, cited in Kennelly & McCormack, 2015, p. 944). Even research into education was found to be circumscribed by this privileging of research over teaching in a study by Ginns, Kitay and Prosser (2010): ¨Scholarship of teaching and learning was perceived to be valued even less than teaching because it was seen as not paying ´adequate dividends´ in terms of career advancement or not being recognised by others ´as ¨real¨ research.´¨ (Ginns et al. 2012, p. 244, cited in Kennelly & McCormack, 2015, p. 944). This is because ¨external pressures such as Performance Based Research Funding draw academics away from teaching concerns [because] to publish in their content area results in a higher payoff to them and the institution, than publishing in education-related areas¨ (Spiller, Ferguson, Pratapsingh, Lochan & Harris, 2010, p. 2, cited in Kennelly & McCormack, 2015, p. 944).

According to Kennelly and McCormack (2015, p. 944) ¨some steps have been taken to redress the teaching/research imbalance…however, not all universities have turned this apparent commitment into a genuine priority.¨ For example, in receiving teaching awards some academics report experiencing ¨negative perceptions…by colleagues, deans, heads of discipline, and a lack of enthusiasm for celebrating [such] awards¨ (Kennelly & McCormack, 2015, p. 94). Chalmers (2011) reported that ¨while teaching awards have been established with the best intentions, there is little evidence that these have contributed to any substantial change in the culture and substance of rewarding and recognising the status of teaching relative to research¨ (Chalmers, 2011, p. 29).

It is therefore through research activities that academics in higher education stand the best chance of attracting scholarly prestige and reputation to themselves and their institution, and each academic discipline has well established structures for determining which activities and outputs have the capacity to be transformed into this form of *capital* by participants in the *field*. For engineering education, this is undoubtedly through positivist (usually quantitative) theoretical and technical research, particularly when that research attracts funding through grants, or when it results in publications in highly rated scholarly and peer reviewed journals (Jolly, et al. 2013). There are a number of studies which point to the difficulties in challenging or circumventing this epistemology of research within a discipline (Gonzales & Rincones, 2011). These studies discuss clearly the factors that contribute to failure of projects that take up an alternative research epistemology and methodology, especially the loss of a sense of academic legitimacy that comes through being involved with research projects that do not adhere to the home discipline´s strict epistemologies of research (Gonzales & Rincones, 2011)..

All of these issues combine to show that the reward system of promotion based on research efforts of academics is likely to overwhelmingly influence the forms of *capital* in any academic *field* – to the point that such forms of *capital* become dominant in their structuring effect on the *field*. This is regardless of the role of industry in the discipline that it relates to (for example the importance of industry for the profession of engineering). Strategies that would involve using other forms of *capital* for position taking (and advancement in the *field*) are expected to be overshadowed by the strength of this form of *capital*, or to be risky if they are seen to challenge this status quo.

4.5 - Using Bourdieu as a lens on teaching practice

Despite this structure and relative influence of the nodes of the *field*, there exists an interplay between *field* and *habitus* to be interpreted, particularly in terms of the effect they have on the teaching practices that are possible in a given context, and the nature and composition of the PCK that is created for and through those practices. As Skelton (2012) explains:

> Teachers are people so it is understandable that teacher identities are inevitably shaped by personal biographies and significant life experiences. In the light of these experiences individuals develop a

> personal theory of teaching and a stock of familiar pedagogical practices [their *habitus* with respect to teaching]. Individuals therefore possess a potential for agency: an ability to pursue valued goals in the way they teach and support student learning [*habitus*]. (Skelton, 2012, pp. 26-27)

Nevertheless, teaching practice is also inevitably influenced by the wider context in which it takes place and ¨ the influence of disciplinary cultures, occupational contexts and departmental (and other significant) communities of practice …will have a significant impact on how an individual understands, practices and evaluates their teaching.¨ (Skelton, 2012, pp. 26-27). Examining this range of variables and their interrelationships is required in order to explain the links among *field, habitus* and PCK for engineering education.

5.0 - Methodology and Research Design

5.1 - Overview

The following diagrams summarise how the concept of Pedagogical Content Knowledge and Bourdieu's Theory of Practice was applied to investigating this topic. Figure 6 proposes the basic elements of a learning environment, showing that it requires inputs and outputs from and to both students and teachers, and that there are elements of context, and objects and processes within the learning environment which will affect the learning that is afforded therein. It also proposes the processes and factors which affect how the teacher undertakes to teach; through a process of transforming available inputs and outputs into decisions about teaching. It is in this domain that Pedagogical Content Knowledge (PCK) is utilised for the creation of learning experiences. This figure is intended to explain that Pedagogical Content Knowledge is understood here as the expertise which informs the decisions about teaching during this process of transformation. It is the mechanism required to convert the available inputs into usable objects or processes in both the specific learning environment and the wider context in which the teacher is working.

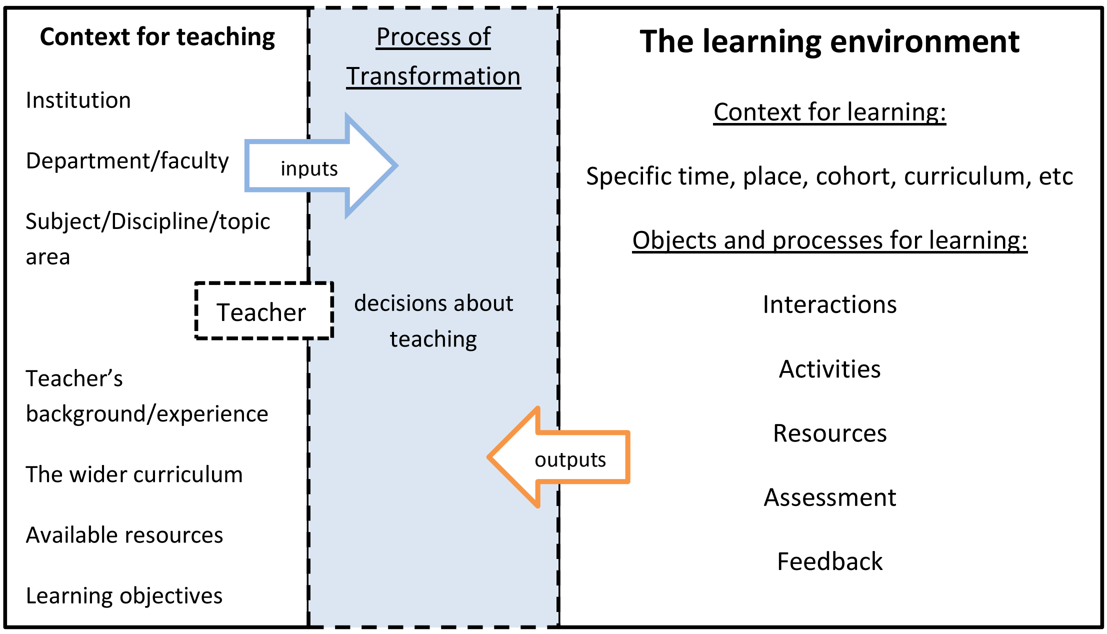


Figure 6 - The teacher's role in the creation of learning

Further to the above definition, PCK is understood to encompass six domains of knowledge which interact to constitute a dynamic body of overall knowledge used to inform decisions during teaching practice. These categories are based on prior work on PCK by Park and Oliver (2008), but also included is the category of knowledge surrounding the knowledge required for *teaching-for-practice in applied disciplines.* This final category of knowledge has been proposed by the present author.

Table 3- The 6 proposed domains of PCK for engineering and applied disciplines

The 6 proposed domains of Pedagogical Content Knowledge
Using orientations to teaching the discipline
Using knowledge of students' understanding of the discipline
Using knowledge of discipline curriculum
Using knowledge of instructional strategies and representations for teaching the discipline
Using knowledge of assessment of discipline learning
Using knowledge of teaching-for-practice in the discipline

The validity of these categories and how they interact during the use of PCK for teaching practice in engineering education is investigated and discussed below.

5.2 - Epistemology and methodological perspective of the research

I view the topic of this research to be inherently socio-cultural in nature, in which explanations of teaching practice should be understood in terms of the purposeful behaviour of individuals acting under the conditions of the socio-cultural sites in which their practice takes place. This research can therefore be understood to sit within the paradigms of interpretivism and critical realism. Interpretivism sees the social world as being "made up by people who act in purposeful ways" and therefore seeks to "interpret their understandings because they use these understandings to guide their practices" (Hall, 2008, p. 53). Critical realism takes this further, and views the social world as ¨irreducible to individuals, just as individuals are irreducible to physical or biological entities¨ (Hall, 2008, p. 55). Reality must therefore be understood as ¨constituted by generative mechanisms that operate to produce observable events¨ (Hall, 2008, p. 55). Such generative mechanisms can include but are not limited to economic and institutional structures which shape the practices of agents in a given social *field*. The task of research is therefore to understand the nature, range and effect of such generative mechanisms and ¨ascertain their mode of operation in determining events¨ (Hall, 2008, p. 55). Bourdieu's Theory of Practice embodies this methodological perspective, because it explains the functions of generative mechanisms within a defined social world. This perspective necessitates the use of an ethnographic approach to data collection, the aim of which is to describe and explain the patterns of practice present within a culture or social group.

In undertaking the research using this methodology, I acknowledge the potential criticisms that may be directed at the rigor of the study, for example that it is subjective or not generalizable and therefore is less ¨scientific¨ than a quantitative approach would be. I argue that this difference of perspective is an epistemological one, and that the epistemological position that is taken up herein is appropriate for *the nature of the research question being investigated.* Prus (1996, p. 9) argues that it is appropriate that the interpretivist approach acknowledges and deals with subjectivities and participants´ own frameworks of meaning and behaviour because:

> *The study of human behaviour is the study of human lived experience and that human experience is rooted in people's meanings, interpretations, activities and interactions.* These notions…are the essential substance of a social science. (Prus, 1996, p. 9)

5.3 - Methodological Approach

The ethnographic approach captures holistic data from contexts of practice which give rise to the generative mechanisms the project is interested in. Whilst entire text books have been devoted to understanding the nature and process of ethnography, it can be understood in brief as the "art and science of describing a group or culture…[in order to explain] predictable patterns of human thought and behaviour" (Fetterman, 1998, p. 1).

A wide range of research methods may be used in an ethnographic approach, but the exact nature and combination of these methods should always depend on specific problem or focus of investigation. As such, the research design is explained below in terms of the questions needing to be answered, rather than in terms of ethnography as a pre-set method, although they all belong to the canon of ethnographic methods.

Despite the fact that the research design involves adopting an ethnographic approach to the collection of relevant data, it should not be considered as constituting a complete ethnography. Although the case studies take an ethnographic approach, the entire domain of the cultural sites in question are not being mapped, because the aim of the research is not to produce an entire ethnography of a culture. This, in fact, is not required in order to answer the questions of this study because the specific aspects of practice that are relevant have already been identified and defined. In other words the research does not need to understand the entire domain of the practice of engineering education. Rather, it only seeks to understand how the specific practices of teachers relate to their *habitus* in their wider *field*. Theoretical propositions about the patterns in these relations have been developed using Bourdieu's Theory of Practice and the prior knowledge of the *field* developed in the literature review. Sturman (1997, p. 62) describes this as a method founded on "theory generated from logical deduction from *a priori* assumptions." The research is deductive rather than inductive; the aim of which is to test the accuracy of these *a priori* assumptions (Yin, 2003). In other words, the research aims to test if such assumptions hold up to empirical examination.

In this way, the prior theoretical development has allowed for the development of a targeted research design (particularly in the way that the three stages develop and test the propositions that each subsequent stage is dependent on – see Figures 7 and 8). Thus, this study has used a strategy that "begins with a logic of design…a strategy to be preferred when circumstances and research problems are appropriate." (Yin, 2003. p. 13). The affordance here is that the case study strategy enables the investigation of "a contemporary phenomenon within its real-life context… when the boundaries between phenomenon and context are not clearly evident" (Yin, 2003, p. 13), however it can do so without gathering huge volumes of data which would be impossible to handle within the scope of the project.

As per Yin (2003), the case study method allows the research to "cover [specific] contextual conditions – believing that they might be highly pertinent to [the] phenomenon of study" (Yin, 2003, p. 13). This method also allows the research to:

- cope with the technically distinctive situation in which there will be many more variables than data points, and as one result
- rely on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
- benefit from the prior development of theoretical propositions to guide the data collection and analysis. (Yin, 2003, pp. 13-14)

Each stage of the research design needs to be carefully planned and executed in order to achieve these affordances whilst maintaining the rigor of the study.

Despite the appropriateness of the case study method for the types of research questions being asked herein, it is necessary to give some explanation of how the specific design and methods used have given rigor to the study, including accounting for issues of validity, confirmability, trustworthiness, credibility and data dependability (Yin, 2003, p. 33).

First it is necessary to deal with common criticisms of the case study method. This often boils down to an epistemological concern with the presence of subjectivity or a perceived lack of generalizability the effects of these on the rigor of a research study. Studies of subjectivity should not be considered automatically or necessarily unscientific: subjectivity is not arbitrary and neither is the interpretation of subjectivity, because ¨Interpretation, explanation and understanding in social science contribute to prediction – they are not at odds with it¨ (Parsons, 1976, p. 133, cited in Sturman, 1997, p. 62).

For this reason, case study researchers are far more likely to be "concerned with pattern explanation than deductive explanation, because the pattern model is more appropriate when there are many diverse factors and where the pattern of *relations* between them is important" (Sturman, 1997, p. 62). This is exactly the case for the present study and an argument for its internal validity.

Research that lends itself to a case study approach is unlikely to be concerned with *statistical generalizability*. This is not to say, however, that case studies do not lend themselves to *scientific* generalisation. It is just that:

> Case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. In this sense, the case study, like the experiment, does not represent a "sample," and in doing a case study [the] goal will be to expand and generalise theories (analytic generalisation) and not to enumerate frequencies (statistical generalisation). (Yin, 2003, p. 10)

This is particularly appropriate for the present study, where the aim is to test specific theoretical propositions that have already been developed concerning the influence of *field* and *habitus* on the specific teaching practices of engineering educators. Concerns with the rigor of case study research on the basis of generalizability are unfounded, provided the research is conducted correctly in that it has the capacity to test such theoretical propositions.

Concern about the presence of bias in case study research, particularly in the selection of cases, or how the researcher conducts the case, is another common criticism of the case study method. However ¨what is often forgotten is that bias also can enter into the conduct of experiments and the use of other research strategies, such as designing questionnaires for surveys or conducting historical research (Yin, 2003, p. 10). In discussing the role of the researcher in the research process, Sturman (1997) points out that:

> Personal judgement forms an essential part of all science and is neither objective nor subjective. An assertion is an act of believing – to this extent it is subjective – but that assertion, whether it emerges from ethnographic research or multivariate statistical modelling, rests on personal judgment which includes an appraisal of evidence within the

> tenets of acceptable practice as perceived by the research community – to this extent it is objective. (Sturman, 1997, pp. 64-65)

As such, any concern with the bias and rigor of case study research should be with how the research is planned, conducted and reported, the degree to which it is open to scrutiny, as well as the defensibility of how any conclusions are reached (Sturman, 1997). Yin recommends five components that are crucial to account for in planning and explaining the rigor of case study research design. These are:

1. a study's questions
2. its propositions, if any;
3. its unit(s) of analysis
4. the logic linking the data to the propositions; and
5. the criteria for interpreting the findings (Yin, 2003, p. 21)

The research design described herein is developmental in that each stage of the process allowed the subsequent stages to be more accurately and effectively designed and executed. Stages One and Two allowed for the development of a case study protocol for Stage Three in which each of these components of case study research design are accounted for. The following summary explains how these principles were met in Stage Three of the research.

As stated in Chapter One, the research questions for the study are:

Research Question:

How do engineering educators' field and habitus interact with the nature and composition of their PCK?

Research sub-questions:

- *What is the nature and composition of PCK for engineering education?*
- *What is the link between a teacher's habitus in the engineering field and their PCK?*
- *What possibilities for habitus does the engineering education field allow for?*

Propositions

As a result of the review of relevant topics in the research literature (described in Chapters One through Four) a number of propositions relating to these research questions can be made. The calls for change within engineering education (towards more student-centred learning and support of Mode 2 knowledge) create contested territory, in which engineering teachers have to decide how to position themselves and how to respond in their teaching practice (e.g. how much to change and how much to resist). Factors creating resistance include the history and epistemology of the engineering discipline and its consequent legacy of accepted methods for how to train engineers, the inherited and incumbent curricular structures, and the fact that higher education institutions may not sufficiently reward efforts to develop teaching effectiveness. Factors encouraging change include scholarly findings from learning theory and from engineering education research specifically, about the need and potential benefit of change, the calls from industry for the better development of the Mode 2 skills of graduates, and from the regulatory body (EA) in the form of the emphasis that is placed on Mode 2-type graduate attributes in the Stage 1 Competencies. Accordingly, it is hypothesised that:

- PCK is the mechanism by which teachers can better help their students to learn – in this case in particular, learn how to develop Mode 2 knowledge and skills in an educational environment which emphasises transmission of Mode 1 knowledge.
- Where PCK is well developed for engineering educators, it is as a result of their own interest and initiative *(habitus)* to improve their teaching effectiveness, despite the constraints created by *field* (such as those described above). Where PCK is well developed, these constraints are not absent, but are mediated by the participant´s *habitus*, especially through their choice of strategies and position in the *field* (such as by choosing to not pursue promotion once tenure is gained, because they would prefer to focus on teaching)
- Where PCK is under-developed, this can be linked to the effect of *field*-related constraints such as the rewards for research activities outstripping

teaching development activities in higher education, the effect of disciplinary loyalty to "what we do in engineering" (such as high emphasis on and value for didactic methods and transmission of content, prevalence of specialisation in terms of subject or topics), or lack of time or access to support and opportunities to develop teaching methods specifically for the topics and subjects being taught.

Units of analysis in the case studies:

As a result of exploring the apparent values and strategies used by engineering teachers in "playing the game" of operating in the *field* (in Stages One and Two of the research), dimensions of analysis were chosen from which selection of case studies could be framed. These are described as categories of possible strategies and are mapped in relation to one another in Chapter Six, Figure 21. Given that the categories of strategies are indicative of differing types of *habitus* in the *field* (in that participants who favour one type of strategy are likely to have a markedly different *habitus* for "playing the game" than participants who favour another), these strategies provided an aspect of the units of analysis in the case studies. The other was the characteristics of particular sites in the *field*. Combinations in these variables provided a rationale for the cases that were chosen for Stage Three of the research. These cases are outlined in Table 4.

Table 4 - Units of analysis for the case studies

Case Study A **Case Description**	**Case study B** **Case Description**	**Case Study C** **Case Description**
<u>Site:</u> Conservative engineering program and curricular structure in a research intensive university <u>Participant:</u> Teaching and Learning evaluation and reflection strategy	<u>Site:</u> Industry focussed engineering program and curricular structure in an Australian Technology Network (ATN)(industry focussed) university, included internships structured into the undergraduate engineering program	<u>Site:</u> Partially online engineering program, but traditional curricular structure in an enrolment dependent regional university <u>Participant:</u> Teaching and Learning performance strategy but with an interest in

(Constructivist, Mode 2 focussed)	Participant: Research publication strategy (didactic, non-Mode 2 focussed)	engineering education research
Focus for the case: The effect of high level interest in effectiveness of teaching on engineering PCK in an individual academic The effect of conscious development of teaching on individual position in the *field*, in a research intensive site in the *field*	Focus for this case: The effect of an industry focus in the program on the culture of the site in the *field*; The effect of both the industry focus of the program and the culture of the site on the PCK of the research- focussed academic	Focus for the case: The effect of engineering education research activities on the PCK of the engineering teacher The effect of the online provision of courses on the PCK of an academic with an interest in engineering education research
Possible outcomes of variables for this case: Academic chooses to forgo opportunities for promotion or other types recognition of their efforts in their role Academic chooses to spend time on actively reflecting on teaching and collecting feedback on teaching, with subsequent development component knowledge areas of PCK	Possible outcomes of variables for this case: Increased attention to industry relevance and structure of curriculum units? Adherence to or differentiation from traditional notions of engineering learning/ teaching, High importance placed on establishing the industry relevance of topics/ specific concepts being taught	Possible outcomes of variables for this case: Increased emphasis on quality of teaching as a result of engaging with engineering education research? Adherence within the faculty to traditional/alternative notions of engineering curriculum/ teaching? Willingness/reluctance to try new things? Presence or lack of interest in developing aspects of teaching or alternative teaching methods?

The logic linking the data and propositions:

The adapted PCK construct of Park and Oliver (2008) described in Table 6, Chapter 5, provides the logic for the observation of the knowledge and processes that comprise PCK. This theoretical construct holds that PCK is the mechanism that allows teachers to make learning easier or more effective for their students. This model (including beliefs, processes and component knowledge) accounts for how well teachers are able to respond to the demands of engineering curriculum, to honour the values and emphases of the engineering discipline, whilst meeting the needs that industry has of graduates, and the difficulties and misconceptions of their students in achieving learning.

Bourdieu's *Theory of Practice*, specifically the concepts of *field, habitus* and *capital,* provides the theorised mechanism for *how* the context in which teaching practices take place (*field*) affects and effects the habitual dispositions of teachers (*habitus*), particularly with respect to their teaching practice, and consequently the nature and development of their bodies of PCK. The relationship among these elements is described in the Figure 5, which depicts the nodes of *field* that are of relevance to engineering teaching (and whether they create an impetus for resistance to or support for pedagogical change), the components of *habitus* that are of relevance to teaching beliefs, attitudes and behaviours, and the component knowledge areas of PCK.

The criteria for interpreting the findings:

These criteria are provided by the definitions of component knowledge areas of PCK (presented in Table 1 and in detail in Table 6). Findings about the nature and development of PCK in engineering academics will also be interpreted in terms of the known mechanisms of *field, capital* and *habitus,* established in Bourdieu's *Theory of Practice.*

5.4 - Research Design

The tables presented below, titled Stages of Research Design and Phases of Data Collection and Analysis outline a progressive research design in which data are generated and analysed iteratively in order to develop and validate the categories of data required to yield findings about the research questions. This involves breaking the topic down into four phases, some of which concentrate on aspects of *habitus* and/or *field*, and some of which focus on *habitus*, *field* and PCK (as outlined in Figure 7 Stages of the Research Design). These foci are necessitated by the knowledge that needs to be developed in each phase in order to lead on to the next. Each phase of the process was developed out of the analysis that occurred in the previous phase and through continual development and consideration of the *apriori* assumptions and propositions discussed earlier in the chapter. Additionally, this progression was completed by breaking the research task down into the overarching questions necessary to be answered at each stage of the research (as shown in the following summaries of each phase, and in Figure 7), in order that the research could be planned and targeted in such a way as to ensure the overall research question was answered.

For each stage of data collection, participants were recruited through my collegiate networks in engineering education, as well as that of my principal supervisor. As much as possible, purposive selection of participants guided who was recruited at each stage (based on the specific units of analysis discussed above), however, to some degree it was necessary to recruit participants based on convenience, subject to who was available and willing to participate. As an overall principle, the basis of selection of specific participants was guided by the ongoing refinement of focus provided by each prior phase of data collection. Whilst it is recognised that the selection of participants will have affected the data that was collected, especially, for example, in the degree of contrast that was achieved among the case studies, this is unavoidable with case study research, as regardless of how they are selected. Furthermore, this is not considered to be a confound in the present instance as the contrast between cases is useful for testing the theoretical propositions that have been established in earlier stages. It was for this reason that dimensions of contrast were considered as much as possible in the purposive selection of participants, as shown in Table 4. In other words, the research sought to demonstrate the kinds of difference among cases that are *possible*, rather than if they are probable or statistically generalizable to the wider population.

5.4.1 - Phase 1 – Pilot study

The aim of phase one was to generate knowledge about the forms of *capital* which may operate in the *field*, and to validate the *field* nodes proposed in Figure 5, including how these nodes influence forms of *capital* and how they are valued. Hence the aim of this phase was to answer the questions:

- *How do the nodes of the field influence the forms of capital available in this site, and how are these forms of capital valued and competed for?*
- *What range of ´ways of playing the game' (including strategies and positions) can be identified among participants?*

Data collection took place in one site in this phase and included:

- Semi-structured interviewing with selected participants to uncover strategies and position taking behaviours within the *field*.
- Free listing by participants to determine the types of *capital* they recognise (by asking them to list items of interest and importance to them in their own domain)
- Ranking tasks by participants to determine the relative value of the *capital* they recognise (by asking them to rank items in their domain by interest and importance to them)

A full copy of the instrument used is presented in Appendix A. The data from Phase 1 was analysed using constant comparative method (Boeije, 2002) in the Nvivo program in order to uncover the *range of capital* that was being competed for in this site in the *field* and *the ways in which* that *capital* was valued and competed for. Examining the nature of that *capital* and how it was derived allowed for an examination of the nodes of the *field* that are proposed in Figure 5, and their relative influence on the *field* as a whole. This data gave a baseline for understanding the ways in which each node´s influence may be relative in a given site.

The data also gave a baseline for how engineering teachers chose to position themselves (in competing for *capital*) in the *field*, and how this positioning related to their own perceptions of the structure of the *field*. This baseline data allowed for the development of the units of analysis necessary for the selection of cases in

Stage Three of the research. These units of analysis will be discussed and explained in detail in the discussion of findings in Chapter Seven.

As a result of this pilot stage of the research was to posit a range of categories of 'ways of playing the game' which are of significance for the broader *field*. These strategies revealed a range of possibilities for competing for *capital* that are available to engineering teachers, according to their site within the *field*. These are represented in the proposed "map of the *field*" included in the discussion of findings from this stage (Chapter 6). The relevance of these strategies for a larger group of engineering educators was tested in Stage 2 of the research.

5.4.2 - Phase 2 – Online Questionnaire

Phase 2 involved developing a questionnaire to be administered to a broader group of engineering educators within the *field*. This questionnaire was developed following Phase 1 in order to answer the questions:

How are the identified categories of 'ways of playing the game' relevant to a broader group of engineering teachers?

The participants for the questionnaire were recruited with the assistance of the Australasian Association of Engineering Education. The President of the Association sent a communique to its members on my behalf, seeking their participation in completing the questionnaire. Participation was conducted online through the means of participants following a dedicated link and completing the questionnaire anonymously.

The questionnaire was individually anonymous, although in some instances it was possible to deduce which institution a given respondent belonged to. The full questionnaire is presented in Appendix B.

The survey responses were analysed using descriptive statistics to determine which of the proposed categories of 'ways of playing the game' were most valid, common and significant in the wider population of engineering teachers, and the forms of *capital* which were most often recognised and valued across this wider population. The trends for 'ways of playing the game' were developed by examining patterns in interest relative to importance for each of the items on the ranking lists produced during the pilot phase of the research. The patterns found allowed for the identification of the most relevant units of analysis for the subsequent case study stage of the research.

5.4.3 - Phase 3 – Case studies

The final phase of data collection examined all three areas of focus (*Field*, *Habitus* and PCK) for three participants in three different institutional sites. The first task in this phase was to design particular fieldwork strategies for undertaking case studies in each of the sites. For each case study, an academic was "shadowed" in their work for the period of a week. This included direct teaching activities but also the related tasks and general tasks that academics undertake.

Fieldwork included collecting relevant documentary evidence about the site in the *field* (especially university communiques, and extracts from their websites) and about the participant's teaching activities, conducting ethnographic interviews, semi-structured interviews (both before and after observations of teaching practice), and conducting structured observations of teaching practice. As with any ethnographic study, these cases represent a snapshot of data about the participant in their site at a given point in time. These fieldwork strategies were guided by the development of specific protocols for the collection of data, such as observational frameworks, codebooks and interview protocols, as well as by attending to the principles by which ethnographic fieldwork should be undertaken. For example, the observational framework for the case studies was developed directly from the model of pedagogical content knowledge adapted from Park and Oliver (2008), including explicit descriptors of observable teacher behaviours for each of the categories of PCK. I was careful to draw on my prior experience in each of these techniques as well as on the scholarly publications about effective fieldwork. These protocols are presented in Chapter 6 and Appendix C, and example of the observational notes taken is presented in Appendix D. Full details about the range and type of data that was collected in each case is presented in the chapters below that discuss the findings of each case.

Overall, this phase of the project was designed to investigate the following questions:

- *What are the variations in capital and how it is competed for in different sites within the field?*
- *What are the variations in 'ways of playing the game' (habitus) for different participants in different contexts?*
- *How do these forms of habitus relate to the possibilities for accruing capital in a particular context within the field?*
- *How do these forms of habitus relate to the nature and composition of PCK that was evident in the participants' teaching practice?*
- *Which of the 6 domains of PCK are in evidence in observed practice and in participants' reflections on practice and how?*
- *Are any of the 6 domains of PCK absent from observed practice or reflection on practice and why?*

<table>
<tr><th>Focus</th><th>Field</th><th>Habitus</th><th>PCK</th></tr>
<tr><td rowspan="2">Pilot Study</td><td>Overarching Questions:
How do the nodes of the field influence the forms of capital available in this site, and how are these forms of capital valued and competed for?</td><td>Overarching Questions:
What range of ´ways of playing the game´ (including strategies and positions) can be identified among participants?</td><td rowspan="2"></td></tr>
<tr><td>Sources of data:
Ethnographic interviewing
Free lists by participants
Ranking lists by participants</td><td>Sources of data:
Semi-structured interviewing
Free lists by participants
Ranking lists by participants</td></tr>
<tr><td rowspan="2">Survey</td><td rowspan="2"></td><td>Overarching questions:
How are these ‘ways of playing the game’ relevant for a broader group of engineering educators?</td><td rowspan="2"></td></tr>
<tr><td>Sources of data:
Questionnaire responses</td></tr>
<tr><td rowspan="2">Case Studies</td><td>Overarching Questions:
What are the variations in capital and how it is competed for in different sites?</td><td>Overarching Questions:
What are the variations in ‘ways of playing the game’ (habitus) for different participants in different contexts?
How do these forms of habitus relate to the possibilities for accruing capital in a particular context within the field?
How do these forms of habitus relate to the PCK evident in teaching practice?</td><td>Overarching Questions:
What is the nature and composition of PCK evident in participants’ teaching practice?
How does the PCK of different participants compare to their ‘ways of playing the game’ for their context within the field?</td></tr>
<tr><td>Sources of data:
Documentary evidence
Ethnographic interviewing
Free lists by participants
Ranking lists by participants</td><td>Sources of data:
Semi-structured interviewing (pre and post observation of practice)
Structured observations of practice
Free lists by participants, Ranking lists by participants</td><td>Sources of data:
Structured observations of practice
Semi-structured interviewing (post-observation)</td></tr>
</table>

Figure 7 - The stages of the research design

Phase 1 - Pilot Study

Task 1 – Defining categories

Developing instruments and sampling frames in order to collect ethnographic interview data, free list and ranking data which can be used to answer:

How do the nodes of the field influence the forms of capital available in this site, and how are these forms of capital valued and competed for? (Field)

What range of ´ways of playing the game´(including strategies and positions) in the field can be identified among participants? (Habitus)

Task 2 - Conducting data collection

At one site , using four participants with different positions in the field and interests in undertaking their roles

Task 3 - Undertaking analysis

Using NVIVO and constant comparative method to determine: the range of capital that can be competed for in that site in the field, and the ways in which that capital is valued and competed over, and; to generate a range of possibilities for position taking and strategizing - 'ways of playing the game' - that may be of significance in the field.

Phase 2 - Survey

Task 1 - Designing questionnaire

Questionnaire data which can be used to answer:

How are these 'ways of playing the game' relevant to a wider group of engineering educators?

What patterns from the pilot data also present in a wider group across multiple sites?

Task 2 - Conducting data collection

Across multiple sites and participants using an online questionnaire. Participants were recruited via email invitation to the membership of AaEe.

Task 3 - Undertaking analysis

Using descriptive statistics (in SPSS) to determine the 'ways of playing the game' which are most significant and common in the wider group of engineering teachers.

Phase 3 – Case studies

Task 1 – Designing fieldwork strategies

To collect data in the form of
- Documentary evidence
- Ethnographic interviews
- Semi-structured interviews
- Structured observations of teaching practice

Which can be used to answer:

- *What are the variations in capital and how it is competed for in different sites?*
- *What are the variations in 'ways of playing the game' (habitus) for different participants in different contexts?*
- *How do these forms of habitus relate to the possibilities for accruing capital in a particular context within the field?*
- *How do these forms of habitus relate to the PCK evident in teaching practice?*
- *Which of the 6 domains of PCK are in evidence in observed practice and in participants' reflections on practice and how?*
- *Are any of the 6 domains of PCK absent from observed practice or reflections on practice and why?*

Task 2 - Conducting data collection

Through participant observation at 3 sites, 3 participants in total

Phase 4 – Analysis and modelling

Task 1 - Discerning themes and patterns in the data

Constant comparative method using NVIVO software

Task 2 - Developing causal propositions and testing their validity in the data

Modelling relationships and patterns among sites and contexts using NVIVO software

Task 3 - Developing explanatory models to explain the causal links between field, habitus and PCK

Figure 8 - Phases of data collection and analysis

5.4.4- Analysis of the data

Phase 4 involved analysing the data (both at the level of each individual case, and across the cases as a whole) and developing explanations of the relationships among the aspects of *field*, *habitus* and PCK that have been identified. These explanations were then used to test the initial theoretical propositions that were derived out of the literature review of the *field* and from Bourdieu's Theory of Practice. The Nvivo program was used to undertake constant comparative analysis (Boeije, 2002) in order to discern patterns in themes and concepts in the data. Patterns in these themes and concepts allowed for the development of causal propositions about relationships among these aspects, and to test their validity with further analysis of the data. The result of this analysis is a description of the findings explaining the relationships and patterns among aspects of *field*, *habitus* and PCK.

Analysis of Data using NVivo and the Constant Comparative Method

Data from the case studies were organised and analysed using the constant comparative method. During the usual iterative process, a node tree was created, expanded and refined, along with a code book of definitions for each node in order to achieve consistency in how each datum point was coded. Data were coded by working through multiple passes of each source of data for each case study as well as across the case studies in comparative iterations. The node tree codebook that resulted from this process reflects the aspects of *field, habitus* and PCK, as follows in Tables 5 and 6, and explains how the findings of analysis arose from specific data.

Table 5 - Node tree code book for field and habitus

Node	Sub-node	Description
	Field	
Teaching *capital*		A form of *capital* accumulated through teaching or teaching related activities and outputs in the *field*. May have a greater or lesser value than other forms of *capital*.
Research *capital*		A form of *capital* accumulated through research or research related activities and outputs in the *field*. May have a greater or lesser value than other forms of *capital*

Responsibility for workload		Persons responsible for meeting excess workload demands of engineering academics associated with doing their job, or going above and beyond in their job
General epistemology of teaching at the site		The generally shared beliefs and values concerning the nature of the engineering discipline and engineering knowledge that is evident at the site in the *field*
General epistemology of research at the site		The generally shared beliefs and values concerning the nature of teaching and learning, and the nature of teaching knowledge that is evident at the site in the *field*
Collaboration over teaching at the site		Instances in which teachers share their beliefs and practices concerning teaching with each other, in order to gain some benefits for their own practice or for their students.
Characteristics of Institutional Context		Institutional characteristics at the site which are relevant to how *capital* can be competed for in the *field*, and how participants can strategise and take positions in the *field*
	Habitus	
Personal epistemology of engineering		Personal beliefs about the nature and value of engineering knowledge and how it should be acquired and exchanged
Personal epistemology of teaching and learning		Personal beliefs about the nature and value of teaching and learning and how they should be pursued in educative processes
Participant´s focus on an aspect of their role (including):		Aspects of the participant´s role that they take greater interest in, choose to emphasise and/or spend greater effort on
	Preparing students for professional practice focus	Interest, emphasis or effort placed on representing and giving access to the nature of professional practice when teaching students about engineering
	Developing their teaching practice focus	Interest, emphasis or effort placed on developing teaching practice
	Undertaking research activities focus	Interest, emphasis or effort placed on undertaking research or research related activities
Participant´s goals in their role (including):		Goals that the participant is acting to achieve in their role

	Teaching goals	Goals related to teaching activities or student learning outcomes
	Faculty goals	Goals related to service to the faculty
	Research goals	Goals related to research activities and research outputs
Strategising for position		Strategies that a participant uses to attempt to change or improve their position in the *field*
Seeking and negotiating *capital*		Working to accumulate forms of *capital* and to improve how that *capital* may be utilized for positioning in the *field*
Finding support for positioning		Seeking support from other participants in the *field* in a form that will allow the participant to maintain or improve their position in the *field*
Sacrificing position in the *field*		Taking actions that may result in a decline in position in the *field*, for example by working with forms of *capital* that are of lesser value due to specific focus or goals in the *field* not aligning with most highly valued form of *capital*

Table 6 - Node tree code book for Pedagogical Content Knowledge

Node	Sub-node	Description
	PCK	
B1 - 0rientations to teaching and learning (including but not limited to):		The participant´s beliefs about the purposes, goals and methods for teaching in the discipline
	Socratic approach	Posing questions to students and encouraging students to ask questions about the learning
	Assessment focus	Assessment is the primary goal and outcome of the learning
	Right answer focus	Getting the right answer is the primary goal and outcome of the learning
K1 - Using knowledge of students´ understanding in the discipline (including but not limited to):		Knowledge about students´ characteristics, what they know and likely areas of difficulty
	Known areas of difficulty for students	Specific conceptual difficulties that the teacher is aware that students encounter

	Understanding and prediction of student misconceptions	The specific misconceptions that the teacher is aware that students have about a topic or concept
	Unknown areas of difficulty for students (negative)	The teacher is unaware of the nature or basis of students´ conceptual difficulties
	Sense of belonging	Understanding when and how students identify with belonging to the discipline
	Specific understandings of a topic	Understanding of how students should understand a topic in a particular way that allows them to progress with the subject matter or avoid confusion
	Characteristics of a cohort or group of students	Understanding of the characteristics of a cohort or group of students that are relevant to how they should be taught
K2 - Using knowledge of discipline curriculum		Knowledge about the horizontal and vertical curricula for a subject, including the teacher´s understanding of the importance of topics relative to the curriculum as a whole, enabling teachers to identify core concepts, modify activities, and eliminate aspects judged to be peripheral to the targeted conceptual understandings
	Understanding of specific learning objectives and skills to be acquired by students	The participant can explicitly identify specific learning objectives and skills that students need to acquire in order to have learned well.
K3 - Using knowledge of instructional strategies and representations (including but not limited to):		Subject specific and topic specific strategies that are consistent with the goals of teaching for this teacher
	Giving explicit instructions	Didactic and prescriptive in order to get students to participate in a predetermined way
	Explaining overall processes	Explaining current activities or concepts in terms of a greater process or conceptual whole
	Choosing to not provide direct answers or explicit instructions to students	Encouraging students to discover processes and outcomes for themselves by avoiding giving explicit instructions or specific answers to direct questions
	Giving content without instructions or	Giving factual information or content without reference to how it fits with a greater whole of processes or conceptual

	explanation of relevance (negative)	knowledge or how it is relevant the context of what is being learned
	Explaining links among ideas	Explicitly highlighting how concepts or procedures link to one another or form part of a whole
	Modelling expert thinking and working processes with verbal reasoning	Explaining or verbalising thinking and working processes in order to demonstrate how an expert would approach a task that is relevant to what is being learned
	Previewing future learning	Explaining what will be covered in future learning events and how it links to what is being learned now
	Giving real life explanations of concepts	Participants give real life explanation that relate the concepts being learned to professional practice in industry, allowing the students to better understand bot the concept being learned and the nature of professional practice
K4 - Using knowledge of assessment of disciplinary learning		Knowledge of the dimensions of disciplinary learning that it is important to assess, and knowledge of methods by which it can be assessed, including knowledge of specific instruments, approaches or assessment activities
K5 - Using knowledge about teaching for practice in the discipline		Knowledge of how to teach about the nature of practice in industry, and the skills required in professional practice, including knowing how to establish links to and demonstrate relevance of teaching topics to future professional practice
P1 - Reflection on action (including):		Knowledge elaborated and enacted through ¨reflection on action¨, undertaken after teaching practice is completed and concerning the need for expansion or modification of their planning or repertoires for teaching a particular topic
	Discussion or consideration of teaching development or change	Additions to, reorganisation or modification to existing teaching practices and knowledge about teaching practices for specific topics or concepts or for teaching generally
	Developing expectations about teaching sessions or student responses to teaching sessions	Participants can reasonably predict how a teaching session will progress and be received by students, especially in terms of how the students will understand the subject

		matter and/or achieve conceptual change as a result
	Understanding specific teaching challenges	Participants have a clear idea of the aspect of teaching a given topic of subject that will present the greatest challenge to them as a teacher in terms of causing their students to understand the relevant concepts appropriately
P2 - Integration of component PCK knowledge areas (as above) and also including:		Integrating multiple components of PCK and enacting them within a given teaching context
	Finding ´teachable moments´ in the form of opportunities for students to learn more about a topic	Participants can negotiate teaching challenges and students misconceptions and difficulties in order to arrive at an effective form of teaching practice for a given concept that allows students to learn optimally

6.0 - Establishing the possibilities for position taking in the field: the pilot study

6.1 - Purpose of the pilot study

Remembering that Webb et al (2002, pp. 21-22) describe *field* as ¨a series of institutions, rules, rituals, conventions, categories, designations, appointments and titles which constitute an objective hierarchy, and which produce authorise certain discourses and activities,¨ the aim of the pilot phase of research was to generate knowledge about such structures and the forms of *capital* that support them for engineering education in particular. This phase sought to validate the proposed dominant structuring forms of *capital* discussed in Chapter Four, especially those contributed by the higher education node of the *field*. It also sought to explore the ways in which the nodes of the *field* had a role in contributing to the forms of *capital* available to specific participants. Finally, it also sought to validate the use of the ranking instruments for generating data about the strategies and position of participants in the *field*, along with the types of *capital* that are relevant to participants.

Webb et al also say of *field* that it is ¨constituted by, or out of, the conflict which is involved when groups or individuals attempt to determine what constitutes capital within that *field*, and how that capital is to be distributed¨(2002, pp. 21-22). As such, the pilot stage aimed to explore the structures of the *field* by exploring the ways in which participants took part in it. By exploring ways of ´playing the game´ the aim was to reveal how types of *capital* are available (or unavailable) to participants, the strategies available to compete for them, and the positions in the *field* that participants can occupy by using such *capital*. Hence the aim of this phase was to answer the questions:

What range ´ways of playing the game´ (including strategies and positions) can be identified among participants?

How do the nodes of the field influence the forms of capital available in this site, and how are these forms of capital valued and competed for?

How do Engineering teachers position themselves for success in the field? (E.g. the strategies and types of capital used)

Data collection took place in one site in this phase and included:

- Semi-structured interviewing with four diverse participants in order to uncover a range of strategies and position taking behaviours within the *field* and their incidental views about the *field* in general
- Free listing by participants to determine the types of *capital* they recognise
- Pile sorts by participants to determine the relative value of the *capital* they recognise

The site chosen for the pilot study was a research-intensive, ¨group of eight¨ university, with a large engineering faculty and student cohort. This site was chosen in order to yield a greater variety of ¨ways of playing the game,¨ due to the expected variety of position and strategies among the large engineering staff. Whilst the specific context of the site in the *field* was expected to influence the *habitus* of participants, including the strategies available to them for participation in the *field*, differences in conditions caused by the site will be explored in subsequent case studies in the third phase of the research. These case studies will address how the site in the *field* can influence possibilities for practice within the *field*, especially in terms of teaching practices. For Case Study A the site was the same as for the pilot study, allowing the case studies to directly compare data about site from the pilot and the first case to other sites in the *field*. Only one site was used for the pilot due to the data intensive nature of the instruments and limitations on data collection created by the scope of the study. However, this was compensated for through use of the three developmental phases of the research.

6.2 - Data collection instruments

Interviews with participants took place in two sessions. In the first session, participants were asked about their background and specific role within the university, as well as being asked to make a free list of items for three different categories within engineering academics´ roles. Those lists were: tasks/activities to be completed, goals to be worked towards, and indicators of success in the role. This range of lists is designed to elicit the day to day practices, aspirations and perceptions of value and reward that the participants see as associated with the engineering academic role.

By asking participants about their background and current position in the *field*, it was possible to gain insight into their *habitus* for participating in the *field*, especially their reasons for entering academia, the context of their specific role, and their personal interests and focus within their job. The free listing exercise was designed to elicit the range of possibilities for participation in the *field* that the participants themselves were aware of. This relates particularly to their perceptions of the strategies available to academics for successful participation as well as for improving their position in the *field*.

In the second session, having compiled each of the participants´ free lists into one list for each of the three categories, so that participants´ responses could be directly compared, participants were then asked to rank the items on the compiled lists for interest and importance for them in their role. A debrief was also conducted in which they were able to comment on and explain their responses and reasoning for their rankings. The protocol for the interview sessions is included in Appendix A. The purpose of the ranking exercise was to elicit decisions about their priorities in their role, and the difference between those priorities in terms of personal interest to them, compared to perceived importance for doing well in their specific role. The rankings for interest indicate their inclinations for how they would choose to act were they unconstrained in their role, whereas their rankings for importance indicate how they believe they are encouraged or constrained to act according to the circumstances of their position in the *field*.

Theoretically, the degree of agreement between the ranking for interest and the ranking for importance for each item indicates the degree of choice an individual believes they can exert over their position in the *field*, for the item being ranked. It also indicates their perception of their ability to access and use different forms of *capital* within the *field*. This is because those participants with a greater degree of choice over their position in the *field* (i.e. those that can select, accrue and use *capital* the most effectively) are likely to act in ways that match their interests in the *field* to importance for doing well. This is the power of *capital* in Bourdieuvian terms, because *capital* is not just transacted, it is also negotiated on the basis of what is considered as constituting *capital* and how it may be competed for and distributed among participants (Webb et al., 2002). According to Grenfell and James (2004, p. 510), *capital* is therefore ¨both product and process within a *field*.¨

The ranking scores the participants gave, along with the discussion that the ranking exercise provoked can therefore provide a snapshot of the *habitus* of the participant for how they participate in the *field*, particularly their position and strategies for participation, because the *habitus* is determined by the ¨possibilities and impossibilities, freedoms and necessities, opportunities and prohibitions inscribed in the objective conditions" of the *field* (Bourdieu, 1990b, p. 54). This is also revealing of the ways in which the nodes of the *field* can influence participants differently, according to how they access *capital* and in what forms. The pilot data saw distinct differences among participants for how they did this, and these differences were based on differences in strategy and position. This is significant for understanding the *field* as a whole and how the nodes act to influence individual teaching practices according to position.

Analysis of the data in this stage revealed that the participants selected for the pilot encompassed a variety of positions and interests within the engineering education role. Table 7 below shows a preliminary comparison of the participants, including their role in the faculty, length of time in academia as a member of faculty, and their personal interest and/or focus in their role. The results of data collection and comparison of the positions of these participants allowed for the development of a theorized range of possible positions and strategies in the engineering education *field* and how these positions are affected by the *field* structure as a whole, especially available forms of *capital*.

Table 7- Comparison of Participants in the Pilot Study

Participant	Role in Faculty	Time in academia	Personal interest/focus
Participant A	Associate Professor and Director of First Year Engineering	15 years	Curriculum focus and education research focus
Participant B	Senior Lecturer, School of Civil Engineering	13 years	Teaching focus
Participant C	Lecturer, School of Mechanical and Mining Engineering	<2 years	Research focus
Participant D	Professor, School of Chemical Engineering	5 years as full time academic, 5+ years as a university researcher through CRCs	Industry/ education interface focus Research focus

6.2.1 - Free listing exercise

Appendix E presents and contrasts the free lists generated by each of the participants for tasks, goals and indicators of success. Comparison of these lists reveals significant overlap among participants for items on their lists, suggesting that each participant understood the task in the same way, and that they likewise understood participation in the engineering academic role in broadly similar ways, albeit with different wording and relative priority.

The colours in the tables in Appendix E are intended to indicate some of the broadly analogous responses among participants. In the white fields of the table are responses that are particular to one respondent only. The compiled lists of tasks, goals and indicators of success used for ranking purposes use both similar and divergent responses as much as possible to represent the range of participants´ responses to the free listing task, and to encompass the range of ways of participating in engineering education, as understood by these participants. Because it was not possible to include every response in the eventual lists, the wording of overlapping or similar items was adapted to include the range of broadly similar responses that participants gave. This was especially necessary to limit the length of each ranking list to ten items, so that it was not unduly difficult for participants to complete the rankings. For example, where Participant A listed ¨Developing new courses, including learning objectives, setting assessment, making sure there is communication and feedback¨ and Participant C listed ¨assessment design¨ and Participant D listed ¨Setting exam questions and checking that the assessment documents work against the marking scheme,¨ this range of responses was subsumed under the item ¨designing and developing new courses.¨ Whilst combining responses in these ways required some interpretation on the part of the researcher, the eventual lists would always be interpreted subjectively by participants anyway, and it was for this reason that the instrument was designed to be used in combination with other data collection activities, especially the interview in which the participant could discuss their understandings of and reasoning for their eventual rankings. These ranking lists were subsequently used in later stages of the research as a point of discussion and analysis for the case study participants.

The compiled list developed from the free lists of tasks was as follows:

- Preparing and revising lectures/teaching activities
- Lecturing/tutorials
- Writing proposals for grants
- Writing papers for publication
- Reviewing and improving existing courses
- Designing and developing new courses
- Conducting research
- Service to faculty/school
- Eliciting and evaluating feedback from students

- Training tutors or teaching staff

The compiled list from the free lists of Goals was as follows:

- Ensuring my own relevance and currency within the discipline
- Achieving promotion
- Improving my rate of publication
- Educating the next generation of engineers
- Improving student feedback on my teaching
- Developing a good research record and reputation
- Improving the learning outcomes of students
- Increasing the amount of funding I have for doing research
- Enabling young staff to learn how to do research
- Doing a better job of teaching

The compiled list from the free lists of Indicators of Success was as follows:

- Having research published
- Winning citations/awards
- Achieving promotion
- Being asked to collaborate on research projects or publications
- Having teaching innovations or pedagogies taken up elsewhere
- Seeing the outcomes or findings of research being used for industrial applications
- High levels of attendance at lectures or teaching sessions
- Positive feedback from students on teaching
- Being able to use research activities to inform teaching activities and vice versa (e.g. first-hand knowledge of recent developments in research field being passed on to students)
- Getting recognition by professional engineering societies (e.g. demand for consultancy services, fellowships, etc.)

These compiled lists were then presented to participants to rank from one to ten in terms of interest and importance.

6.2.2 - Ranking exercise

For each of the lists of tasks, goals and indicators of success, a table is presented below which shows each participant´s rankings for interest versus importance. By completing the ranking lists in this way, participants revealed their priorities and the *relative value to them* of each item on the list, and by extension, the relative value of the forms of capital associated with those items. Participants were asked to complete the rankings based on the items´ importance to them in their role and interest to them in their role and these terms were not defined for the participants to any greater degree than this. Whilst it is expected that each participants´ interpretations of what interest and importance might mean were different, for the purposes of eliciting participants´ priorities this difference in interpretation is of interest because it is this . In any case, it very subjectivity that leads to the differences of habitus and position that are apparent in the field. In pursuit of the meaning of these subjectivities, the dimensions of difference in participants´ responses to the ranking task were subsequently explored during the interviews about how and why they made the decisions to rank the items the way that they did.

Below each table, a scatter plot is shown for each participant individually which lays out the rankings with interest on the x axis, and importance on the y axis. A diagonal line from bottom left to top right shows the degree of agreement between interest and importance. Where an item from the list falls perfectly on that line it is because interest and importance for that item received the same score, and were in agreement. The further an item falls from that line, the greater the disagreement between interest and importance for that item.

It should be noted that here and throughout the dissertation, these scatter plots are used only as a visual representations to aid in the conceptual analysis of the degree of agreement between interest and importance, as means of analyzing the *habitus* of a given participant. They are not intended to express anything statistically significant about the distribution of data points. Rather, the graphical nature of these charts aids in the interpretation of theoretical patterns in participants´ responses, which is then used to both build and support further theoretical analyses, based on data gathered in the case studies. As such, these data are considered to be theoretically generalizable and not statistically generalizable or significant.

For each participant a list of outliers is presented for consideration. They are presented for those items which fell above the line of agreement, indicating that the item was seen by the participant as more important than interesting, and those that fell below, indicating more interesting than important. An outlier is considered as any item which had a disagreement of two points or more between interest and importance. For each outlier, the degree of disagreement is presented as a number in a bracket, and is calculated by subtracting the higher score (be it interest or importance) from the lower. This numerical score indicates the degree of disagreement for any given item, thereby indicating the significance of that disagreement for the participant in their role. By combining these disagreement scores it is possible to get an overall numerical representation of degree of disagreement for each participant, giving an indication of their overall degree of choice over their position and strategies in the *field*.

For ease of reference, outliers relating to teaching are listed in blue, and outliers relating to research are listed in green. This allows for an easy distinction between the theorized two main forms of *capital* for the *field*, and how they are distributed differently in the rankings of the various participants.

Tasks

Table 8 - Ranking scores for Tasks by Participant

Tasks	Participant A		Participant B		Participant C		Participant D	
	Interest	Import.	Interest	Import.	Interest	Import.	Interest	Import.
Preparing and revising lectures/teaching activities	10	10	8	9	8	1	7	7
Lecturing/tutorials	1	5	10	6	5	7	9	8

Writing proposals for grants	9	2	1	1	6	9	10	10
Writing papers for publication	5	1	2	3	9	10	8	9
Reviewing and improving existing courses	3	7	9	10	3	3	6	5
Designing and developing new courses	4	6	4	2	2	5	5	6
Conducting research	7	3	3	4	10	8	1	1
Service to faculty/school	6	4	5	5	7	6	2	2
Eliciting and evaluating feedback from students	8	8	7	8	4	4	4	3
Training tutors or teaching staff	2	9	6	7	1	2	3	4

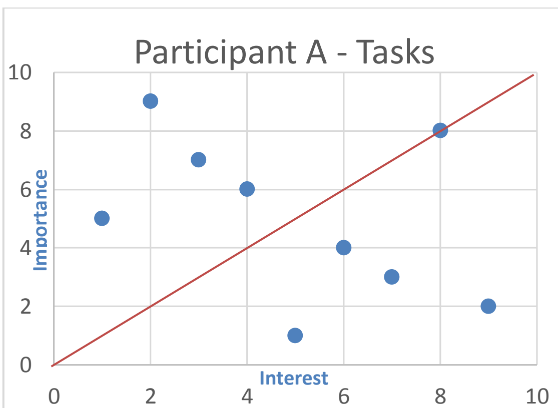


Figure 9 - Scatter plot of Task rankings for Participant A

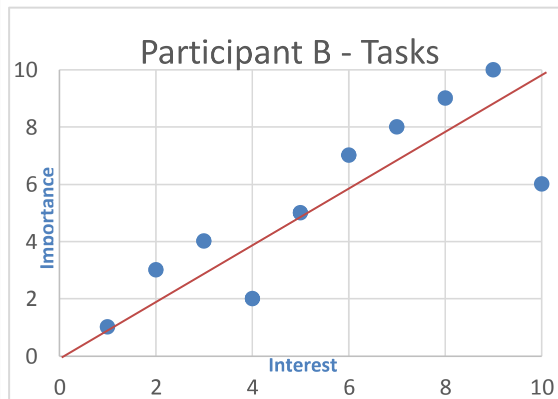


Figure 10 - of Task rankings for Participant B

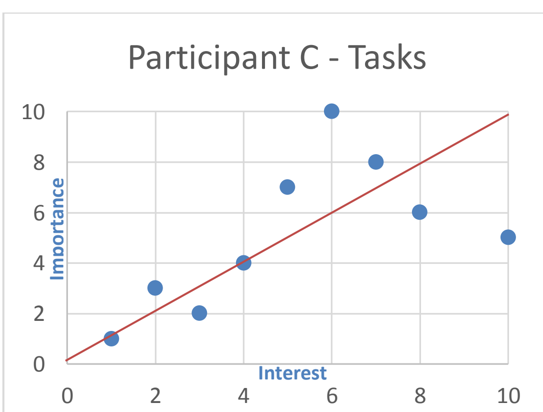


Figure 11 - Scatter plot of Task rankings for Participant C

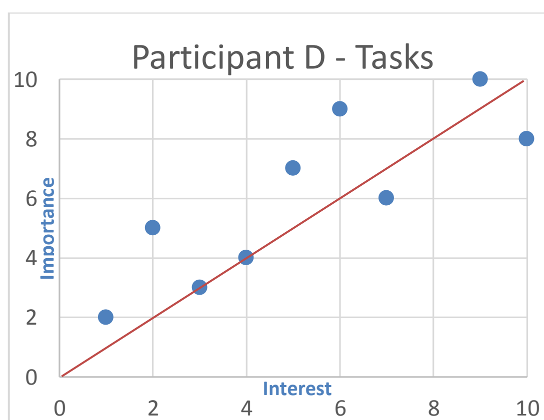


Figure 12 - Scatter plot of Task rankings for Participant D

Table 9 - Participant A Outliers for Tasks

Above the line (more important than interesting)	Below the line (more interesting than important)
Training tutors or teaching staff (7)	Writing papers for publication (7)
Lecturing/tutorials (4)	Service to faculty/school (2)
Reviewing and improving existing courses (4)	Conducting research (4)
Designing and developing new courses (2)	Writing proposals for grants (7)
Total disagreement score - 17	**Total disagreement score - 20**

For Participant A´s ranking of Tasks, all of the outliers that were more important than interesting were related to teaching. This is not surprising given the participant´s official role being one in which teaching is important, as evidenced by her ranking of preparing and revising lectures and teaching activities at 10 for both interest in importance. However, the fact that several teaching related items were seen as less interesting, and that three research related items were seen as more interesting than important, suggests that given greater choice in her role, this participant would take a greater focus on research, especially technical research, as also suggested by her comments in the interview. Her total degree of disagreement score for tasks was 37.

Table 10 - Participant B Outliers for Tasks

Above the line (more important than interesting)	Below the line (more interesting than important)
	Lecturing/tutorials (4)
	Designing and developing new courses (2)
Total disagreement score - 0	**Total disagreement score - 6**

Participant B demonstrated a high degree of agreement for her ranking of tasks, with only two items ranking as more interesting than important, these being related to her teaching tasks. Of these, lecturing and tutorials was considered as four points more interesting than important in her overall role, and her comments during interviews suggest that this is because she enjoys giving them, more so than she gets recognition for doing them, or for doing them particularly well. This aligns with her stated belief that the *field* does not distinguish between teaching that is really good, and teaching which is ¨just adequate.¨ The same applies for the item of designing and developing new courses. Overall this participant´s rankings suggest a high degree of choice in the tasks that she performs in her role. Total disagreement for Tasks for Participant B was 6.

Table 11 - Participant C Outliers for Tasks

Above the line (more important than interesting)	**Below the line (more interesting than important)**
Writing proposals for grants (3)	Preparing and revising lectures/teaching activities (7)
Designing and developing new courses (3)	
Lecturing/tutorials (2)	
Total disagreement score - 8	**Total disagreement score - 7**

Participant C´s outliers also align with his comments during interviews, especially for those tasks that he sees as more important than interesting. In interview he identified that teaching activities such as lecturing and developing new courses were not of particular interest to him, but that he recognized that they needed to be done to an adequate standard as part of his role. Similarly, writing proposals for grants was a necessary aspect of being able to undertake research, but was not as interesting to him as actually conducting research, particularly research that would be seen as high quality and with industrial applications.

The participant´s comments during interviews show that a clear focus for him at the time of the pilot was to improve the efficiency of his teaching activities and that a key way that he had identified for doing this was to spend less time preparing and revising teaching activities, particularly the time it took him to prepare lecture slides. This accounts for the high level of interest he gave this item on the list, although it is not clear why he saw it as less important for doing well in his role. Certainly, his interview comments suggest that it was important to him personally for doing well in his role because it would free up time for him to do more research, however perhaps he gave the low score for importance here because he did not believe that it would be recognized by others that he was doing this task. The total disagreement score for Participant C for Tasks was 15.

Participant D Outliers for Tasks

Participant D had no outliers greater than one point for his rankings of tasks, suggesting a high degree of choice over the tasks that he undertakes within his role. This data is in keeping with data from his interview which suggests he has access to a large amount of *capital* through his research activities, particularly those research activities that bring in high levels of funding, and those that directly inform teaching in his disciplinary area of expertise. This access to *capital* likely gives him the ability to match his interest areas closely to items that are important to doing well in his role. Participant D´s total disagreement score for Tasks was zero.

Goals

Table 12 - Ranking scores for Goals by Participant

Goals	Participant A		Participant B		Participant C		Participant D	
	Interest	Import.	Interest	Import.	Interest	Import.	Interest	Import.
Ensuring my own relevance and currency within the discipline	9	9	2	2	9	3	1	8
Achieving promotion	2	10	6	7	3	7	3	1
Improving my rate of publication	1	1	5	6	4	9	4	2
Educating the next generation of engineers	4	4	10	10	8	1	7	9
Improving student feedback on my teaching	10	8	7	5	2	4	5	3
Developing a good research record and reputation	8	3	4	4	10	10	6	7

Improving the learning outcomes of students	3	2	9	9	6	6	8	6
Increasing the amount of funding I have for doing research	7	5	1	3	7	8	9	5
Enabling young staff to learn how to do research	6	6	3	1	5	5	10	10
Doing a better job of teaching	5	7	8	8	1	2	2	4

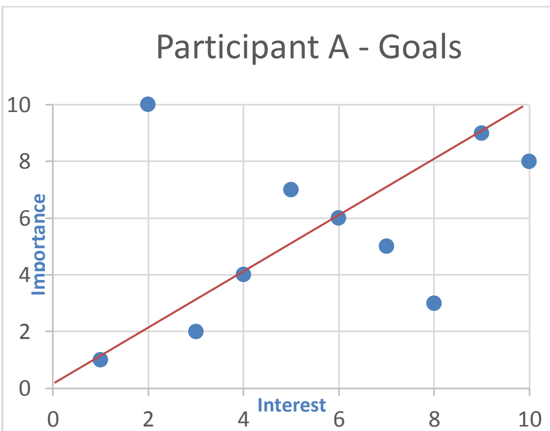


Figure 13 - Scatter plot Goal rankings for Participant A

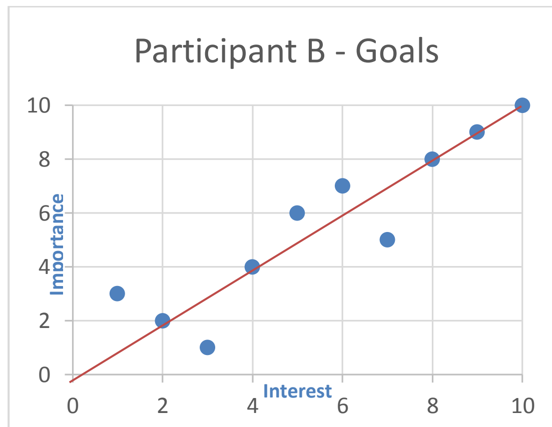


Figure 14 - Scatter plot of Goal rankings for Participant B

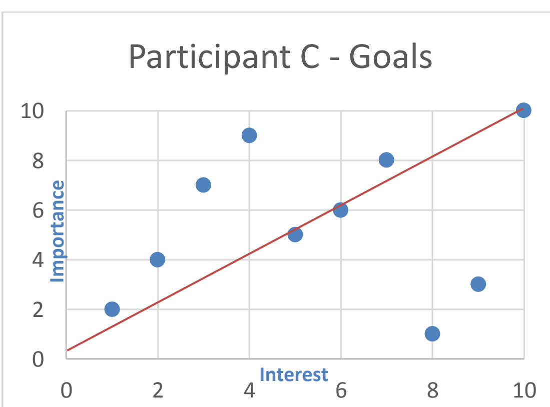


Figure 15 - Scatter plot of Goals rankings for Participant C

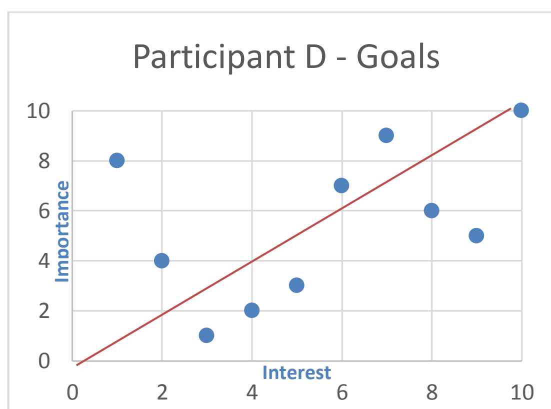


Figure 16 - Scatter plot of Goal rankings for Participant D

Table 13 - Participant A Outliers for Goals

Above the line (more important than interesting)	Below the line (more interesting than important)
Achieving promotion (8)	Increasing the amount of funding I have for doing research (2)
Doing a better job of teaching (2)	Developing a good research record and reputation (5)
	Improving student feedback on my teaching (2)
Total disagreement score - 10	**Total disagreement score - 9**

As with her outliers for Tasks, Participant A indicated a number of goals relating to research as more interesting than important to her teaching-focused role. She also indicated as highly important but not interesting the goal of achieving promotion. This is explained by her comments during interviews that her experience of sexism prompts her to value promotion as very important.

The two outliers relating to teaching present a contrary picture of goals for this participant. First, she sees as more important than interesting the task of doing a better job of teaching. Conversely, improving student feedback on teaching (which given the wording of this item on her free list is interpreted to mean the formal evaluation scores that teachers receive) was more interesting than important. These two items on the list could be seen as closely related given that it is logical that doing a better job of teaching could result in better feedback from students. This may be indicative of the participant´s apparent difficulty in prioritizing different aspects of her role. However, it should also be noted that the participant reported that she found it very difficult to choose rankings for items on the lists, and that the degree of disagreement for each item is only two points. These outliers therefore may not be significant to her overall degree of choice of goals in her role. The total disagreement score for Participant A for Goals was 19.

Table 14 - Participant B Outliers for Goals

Above the line (more important than interesting)	Below the line (more interesting than important)
Increasing the amount of funding I have for doing research (2)	Enabling young staff to learn how to do research (2)
	Improving student feedback on my teaching (2)
Total disagreement score - 2	**Total disagreement score - 4**

In keeping with her comments during interviews that research was not personally interesting to her, Participant B rated higher for interest than importance the goal of increasing her funding for research. Conversely she was more interested in supporting young staff to learn how to do research, although she believed this was less important than interesting. Similarly, improving student feedback was interesting to her but she viewed this as less important to her role. Her total disagreement score for Goals was 6.

Table 15 - Participant C Outliers for Goals

Above the line (more important than interesting)	Below the line (more interesting than important)
Improving my rate of publication (5)	Ensuring my own relevance within the discipline (6)
Achieving promotion (4)	Educating the next generation of engineers (2)
Improving student feedback on my teaching (2)	
Total disagreement score - 11	**Total disagreement score - 8**

Participant C´s outliers for Goals also accord with his comments during interviews, particularly concerning the need to publish research as a means of achieving promotion and ¨runs on the board¨ in terms of research. This participant saw as a more long term goal the need to develop a quality research reputation by developing research with relevance for application in industry. This longer term aspiration explains his increased interest (compared to importance) for ensuring his own relevance within the discipline. The total disagreement score for goals for this participant was 19.

Table 16 - Participant D Outliers for Goals

Above the line (more important than interesting)	**Below the line (more interesting than important)**
Ensuring my own relevance within the discipline (7)	Achieving promotion (2)
Doing a better job of teaching (2)	Improving my rate of publication (2)
Educating the next generation of engineers (2)	Improving student feedback on my teaching (2)
	Improving the learning outcomes of students (2)
	Increasing the amount of funding I have for research (4)
Total disagreement score - 11	**Total disagreement score - 12**

Participant D´s rankings for Goals showed the greatest degree of disagreement between interest and importance of all the rankings he completed. To some degree this can be explained by the fact that the participant had already achieved a very high degree of security in his position in the *field*, as well as his formal role within the university, and had access to a high degree of *capital* associated with this. As a result, although he remained interested in such items as achieving promotion, improving his rate of publications, student feedback on teaching, etc., these things were no longer as important to doing well in his role because of the degree of advancement he had already achieved.

The participant also explained with regards to this list that much of the disagreement was caused by the fact that he was at a point of his career of reassessing his future goals and direction, and was not clear about what he was most interested in doing next. This may explain some of the disagreement in these scores (total disagreement being 23), however in this case a high disagreement score does not necessarily indicate a loss of choice over goals by this participant. Rather it indicates a freedom to make his own choices for goals. This was because his disagreement score was, by his own report, the result of intrinsic factors for him personally, rather than extrinsic factors from his context.

Indicators of Success

Table 17 - Rankings for Indicators of Success by Participant

Indicators of success	Participant A		Participant B		Participant C		Participant D	
	Interest	Import.	Interest	Import.	Interest	Import.	Interest	Import.
Having research published	4	1	5	10	6	10	8	9
Winning citations/awards	10	2	3	9	7	9	3	2
Achieving promotion	1	10	6	6	5	4	4	1
Being asked to collaborate on research projects or publications	2	4	8	8	8	6	7	7
Having teaching innovations or pedagogies taken up elsewhere	3	3	9	7	2	2	2	3
Seeing the outcomes or findings of research being used for industrial applications	9	9	1	1	10	8	10	10
High levels of attendance at lectures or teaching sessions	7	8	7	4	1	1	1	5
Positive feedback from students on teaching	5	6	10	5	3	5	6	6
Being able to use research activities to inform teaching activities and vice versa (e.g. first-hand knowledge of recent developments in research field being passed on to students	6	7	4	2	4	3	9	8
Getting recognition by professional engineering societies (e.g. demand for consultancy services, fellowships, etc.)	8	5	2	3	9	7	5	4

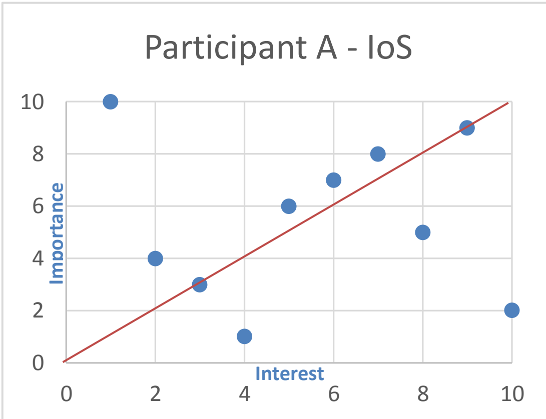


Figure 17 - Scatter plot of Indicators of Success for Participant A

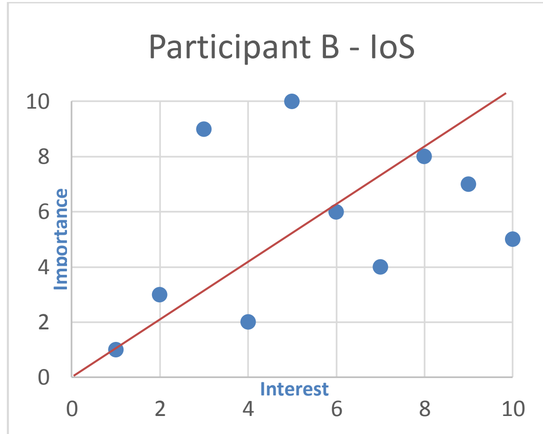


Figure 18 - Scatter plot of Indicators of Success for Participant B

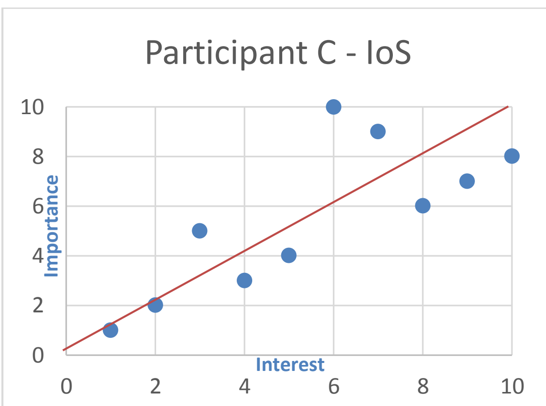


Figure 19 - Scatter plot of Indicators of Success for Participant C

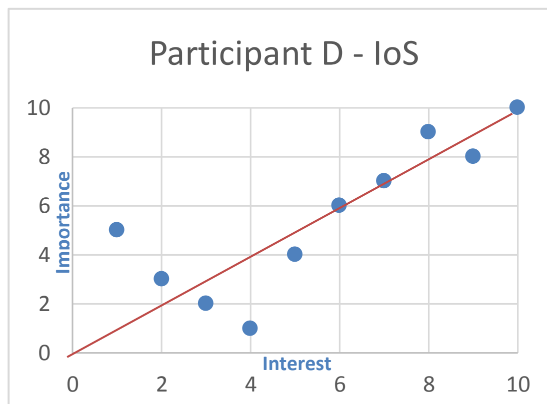


Figure 20 - Scatter plot of Indicators of Success for Participant D

Table 18 - Participant A Outliers for Indicators of Success

Above the line (more important than interesting)	**Below the line (more interesting than important)**
Achieving promotion (9)	Having research published (3)
Being asked to collaborate on research projects or publications (2)	Getting recognition by professional engineering societies (3)
	Winning awards/citations (8)
Total disagreement score - 11	**Total disagreement score - 14**

As stated in interviews, Participant A saw as highly important the indicator of success of achieving promotion. Similarly, she saw that being asked to collaborate on research projects as a validation of success in her role, and therefore more important than interesting. Conversely, having research published, getting recognition by professional bodies and winning awards and citations were personally interesting to her, but much less important given that her role was (by appointment) teaching and curriculum focused. It is not clear why winning awards and citations was rated so highly for interest and so low for importance, and the participant did not explain this during the interviews. It is possible, however that this form of recognition from an external sources is valuable to her personally given that she expressed frustration with internal forms of recognition, such as sexist ideas about the merits of female engineering academics. The total disagreement score for this participant for indicators of success was 25.

Table 19 - Participant B Outliers for Indicators of Success

Above the line (more important than interesting)	**Below the line (more interesting than important)**
Winning citations/awards (6)	Being able to use research activities to inform teaching and vice versa (2)
Having research published (5)	High levels of attendance at lecture/teaching sessions (3)
	Having teaching innovations or pedagogies taken up elsewhere (2)
	Positive feedback from students on teaching (5)
Total disagreement score - 11	**Total disagreement score - 12**

Participant B´s rankings for Indicators of Success showed the greatest disagreement between interest and importance of all the ranking lists she completed. She explained this herself as the difference between her own intrinsic ideas of success (those items that were ranked highly for interest) and extrinsic forms of recognition of success (those items ranked highly for importance). As such, the items ranked higher for interest than importance can be understood as those items she personally values but that she does not see as winning as much external recognition. For those items that are ranked higher for importance than interest, she sees as winning external recognition within the site, but that she does not value as highly herself. For this participant, all the items that she saw as more interesting (and personally valuable in terms of recognition) were for teaching related activities. Given more choice over indicators of success, therefore, she would like to see those items that she focuses on in terms of teaching receive greater reward and recognition. This is in keeping with comments that she made during interview, discussed in further detail in the next section. The total score for disagreement for this participant for indicators of success was 23.

Table 20 - Participant C Outliers for Indicators of Success

Above the line (more important than interesting)	**Below the line (more interesting than important)**
Positive feedback from students on teaching (2)	Being asked to collaborate on research projects or publications (2)
Having research published (4)	Getting recognition by professional engineering societies (2)
Winning citations/awards (2)	Seeing the outcomes or findings of research being used for industrial applications (2)
Total disagreement score - 8	**Total disagreement score - 6**

As with the other ranking lists, Participant C´s outliers for Indicators of success are in keeping with his comments during interviews that his interest in his role was to minimize time spent on teaching and maximize the quality of research. However, he also felt that factors at the site in the *field* emphasized more strongly measures of quantity of research produced (such as having research published and winning citations and awards, such as he sees as more important than interesting on this list). Conversely, items which he associates with quality in research are seen by this participant as more interesting than important. The total score for disagreement for this participant for indicators of success was 14.

Table 21 - Participant D Outliers for Indicators of Success

Above the line (more important than interesting)	Below the line (more interesting than important)
High levels of attendance at lectures/teaching sessions (4)	Achieving promotion (3)
Total disagreement score - 4	**Total disagreement score - 3**

As with his list of Tasks, the agreement of interest and importance for Indicators of Success shows that Participant D exercised a high degree of choice for items on this list. The total score for disagreement for this list was 7.

Degree of choice: agreement between interest and importance

By adding each participants´ scores for disagreement between interest and importance for each of the lists, it is possible to arrive at a numerical representation of their level of choice that they believe they exercise in their role. Theoretically, the lower the overall score for each list and in total, the higher degree of choice a participant can be seen to exercise over their position and strategies for participation in the *field*. This is a useful tool for visualizing the patterns seen in the ranking scores and the issues discussed by participants during interviews, in terms of their effect on overall position. Table 23 below presents the scores for each participant. These scores show the highest degree of choice over position for Participant D, followed closely by Participant B, each of whom discussed their ability to make choices relatively freely within their role, as will be seen below.

In the case of Participant B, while this would tend to suggest a high degree of access to and possession of the *capital* of the *field*, in reality, her degree of choice in her position was brought about by her ability to accept a high degree of risk, due to her ability to leave the *field* if she chose to. In this case, choice over strategy was not directly related to access to *capital*, rather her particular *habitus* in the *field*. Whilst her activities were seen to result in the cultivation of particular types of *capital*, these forms of *capital* were not seen by others to carry as much relative value as the dominant forms of *capital* in the *field*, particularly those forms concerned with research activity and outputs.

The least degree of choice was exhibited by Participant A, for whom interest did not often match importance for tasks, goals and indicators of success. Unlike for Participant B, there were no data to suggest that choice and access to *capital* were not directly linked, and as such it appears that she could access and utilize the least *capital* of all the participants. Similarly, Participant C´s scores suggest a lesser degree of choice than Participants B and D, however, as will be seen in the discussion below, this participant had identified strategies (including improving research quality and developing research with industrial applications) that he hoped would enable him to move into a higher position in the future, in which he could make choices more in line within his own inclinations. By improving his position he hoped he would be able to draw on increased *capital* from engineering industry, and as such, the position he was aiming for would resemble that of Participant D, who consistently derived considerable *capital* from industry in the form of grants for research and industrial applications of research outcomes.

Table 22 - Total disagreement scores across participants

	Participant A		**Participant B**		**Participant C**		**Participant D**	
	Import	**Interest**	**Import**	**Interest**	**Import**	**Interest**	**Import**	**Interest**
Tasks	17	20	0	6	8	7	0	0
Goals	10	9	2	4	11	8	11	12
IoS	11	14	11	12	8	6	4	3
Total	**38**	**43**	**13**	**22**	**27**	**21**	**15**	**15**
	81		**35**		**48**		**30**	

6.2.3 Specific data from Interviews

During interviews in which participants were asked to comment generally on their role and position at the site in the *field*, as well as about their interpretations of the free list and ranking list tasks, a range of data emerged that can help to explain and interpret ranking data, and to give a clearer picture of their positions and strategies for participation in the *field*. These data are presented below for each participant.

Participant A

Having entered academia as a regular academic with a mix of teaching and research duties, at the time of the pilot study Participant A had moved into a role with largely teaching duties. She explained that at this university, the first year of the program was conducted as a common program, with students choosing a specific engineering discipline in their second year. When the common first year was implemented at the site her position was created in order that there was an academic with oversight of the first year program, including ¨putting together a new program guide…getting transition lectures…making sure they have got access to the support that they need, setting up mentor programs, setting up a first year learning space¨ (Pilot Participant A Interview 1). As such, her role takes a particular focus on curriculum and issues for students that are peripheral to curriculum.

In addition to these aspects of her role, the participant commented that when she took the role, ¨it was mandated that I drop my technical research and I become teaching focused¨ (Pilot Participant A Interview 1). Her position now required that her research be educationally focused, although she stated that she missed her technical research focus because:

> You know you become an engineer for a reason and I do miss doing that [research]. I do miss it, not that I don´t enjoy engineering education, but I do miss the chemicals that are meant to be ecologically used… There is something to be gained from both [types of research]. (Pilot Participant A Interview 1)

In discussing her reasons for entering academia, Participant A described the decision as resulting from two factors. First, while working in engineering industry (prior to entering academia) she had had the opportunity to do some teaching and had enjoyed it. Second, she said her decision to leave industry was a reaction to sexist treatment during her employment, especially having returned to work from maternity leave. Regarding this period, she stated:

> When I was on maternity leave and thinking about coming back, I didn't want to come back to consultancy, so there's a whole leap of things that came together. The year that I spent back in consultancy… was sexist and that was the worst year I have ever worked, these people were old school… It was awful and when I got pregnant you know people went around saying oh she's not coming back, she's having babies now and all of a sudden I wasn't [legitimate anymore]...I think it was a backstabbing way to get me out is what it is. Real awful. It was really, really, really bad. (Pilot Participant A Interview 1)

This reaction to sexist treatment was seen to play a part in her *habitus* within her current role, especially that achieving promotion was important to her as both a goal and indicator of success. She states:

> I have got a huge interest in being promoted…because of the things that have been said about women and professors…I didn´t ask to have this fire [in me about gender issues] and it probably would have been much lower but for the fact that I have heard people saying these very sexist things. So it has kind of pushed it way up there [in terms of importance]. (Pilot Participant A Interview 2)

In addition to these issues, the participant commented with regards to the ranking exercise that she found it very difficult to make decisions about her priorities for the items on the list, and that most of the items can be considered as very close or similar in ranking. She considered herself to be very time poor, with not enough time to complete all of the tasks that were expected of her in her role. Along with this, Participant A created the longest free lists for tasks, goals and indicators of success, suggesting that she not only recognized a wide range of possibilities for participation in the engineering academic role, she also had trouble prioritising in this role. Her discussion during interviews and explanations of her free lists and ranking exercises did not enter into how she sought to ameliorate these problems, or tactics she could use to improve her position. It was therefore not clear that she had developed any distinct strategies for attracting more *capital* or changing position in the future. This was particularly clear given that her ranking lists in which items relating to research activities were given a higher level of interest than importance for her.

Of all four participants, she was one of two who did not appear to draw on *capital* from outside of the Higher Education node of the *field* (the other being Participant C), and the higher education domain was the only node of the *field* that her discussion related to during interviews about the nature of her role. Overall, her position can be described as teaching and curriculum focused, with no obvious strategy that the participant identified for future progression or direction in the *field*.

Of all the participants, Participant A demonstrated the greatest degree of disagreement between interest and importance for each of the lists. In her free list for goals she lists ¨challenge the system when not valued¨ as a goal to be pursued in the *field*. Taken together, this indicates a *habitus* and position in the *field* with the least degree of choice (and by extension, *capital*) of all the participants in the pilot study, hence her desire to ¨challenge the system¨. Her results for the ranking activity support the hypothesized structure of the *field* in which teaching related *capital* carries less value than those forms associated with research.

Participant B

As with Participant A, Participant B´s reasons for entering academia were a reaction to engineering industry, although not specifically to gender issues. Rather, she wanted to achieve a greater work life balance, and was offered a faculty position at the same time as she was considering leaving industry.

Participant B´s almost exclusive focus in her role was on teaching, although she reported that she continued to undertake technical research with industrial applications when possible, that she continued consulting to industry, and served on committees for a number of industry groups and associations. Her disciplinary and technical expertise continued to be important to her and she stated explicitly that she continues to identify as an engineer more than a teacher, despite her clear focus on teaching within her role. During her time in academia, other than achieving tenure, her role had not much changed and she continued to teach in the same first year course that she began in, which she stated she enjoyed very much.

Of all the participants, Participant B generated the shortest free lists for tasks, goals and indicators of success. In contrast to Participant A, she was seen to carefully prioritise in her role, and was actively pursuing a particular interest in the teaching aspect of her role, often at the cost of what she described as more extrinsically rewarding research activities. In particular, she discussed having a specific goal of helping to develop the future generation of professional engineers by developing the skills and characteristics in present students that would best serve them in working as professionals in industry. In this respect, her strategy in her role was to draw on *capital* from the node of engineering industry concerning the quality of graduate engineers, and to emphasise the connection between this and quality teaching at university. Whilst it was not clear at the time of the pilot the degree to which she was able to operationalize this *capital* within her position in the *field*, this participant became the subject for Case Study A in the later research phase, and this issue was explored further therein.

For Participant B, on her free list of goals, all of her listed items related to teaching. These were: educating the next generation of engineers, reengaging the student cohort, and improving learning outcomes. She stated that she pursued the overall goal of quality in her teaching through a focus on feedback from students and continual evaluation and development of teaching activities. Despite this, she commented ¨there are no rewards for teaching,¨ except those intrinsic rewards that come through ¨building a rapport with students¨ (Pilot Participant B Interview 1). As such, although she exercised a high degree of choice in her position (as shown by the high degree of overall agreement between interest and importance on her rankings, excepting for indicators of success), her level of choice of strategy in her role did not necessarily indicate a concomitant level of choice of *capital*. Rather her degree of choice came about through her relative independence from the *field* as a whole.

Indicators of success was the only ranked list in which this participant was observed to have a significant degree of disagreement between interest and importance, and, this was because she did not see that she could control indicators of success as an external factor in her role, whereas her tasks and goals were something that she could make choices about. When completing the ranking exercise for Indicators of Success, I commented to the participant that I was interested in the clear difference in rankings between interest and importance. In response, she replied:

> I think because what I am interested in and what people might see as indicators of success are not the same.
>
> Interviewer - So [interest] is intrinsic, and [importance] is extrinsic?
>
> Participant B - yeah, yep. That´s the me not giving a shit. (Pilot Participant B Interview 2)

In this sense, her choice of strategies for acting in the *field* can be considered high risk, because it is possible that if her actions did not result in the acquisition of sufficient *capital* that she would lose position over time. As stated above, she was willing to accept this degree of risk in her role because of her ability to leave the *field* if she wished to. The position that this participant occupied in the *field* can be considered as unique, as it was the result of her own choices and actions, which were relatively independent of the structuring forms of *capital* of the *field*, compared to other participants. As a result, this specific position in the *field* is not generalizable to other sites in the *field*. However, it is possible that other participants at other sites could achieve similar independence and choose to act on this independence according to their own *habitus* in the *field*, and as a result may be seen to develop a position that is similarly independent to the dominant structures of the *field*. Participant B is therefore a useful example of how *habitus*, *field* and *capital* are interdependent, but that a participant´s actions are not pre-ordained in terms of the possibilities for participation in the *field*.

Participant C

At the time of the pilot study, Participant C had been an academic for less than two years and had left his role in industry in which he was in charge of ¨advising others on their research projects¨ (Pilot Participant C Interview 1), rather than working on his own. He had entered academia because he saw it as a chance to develop his own technical research. He said ¨I wanted to be doing more actual research rather than telling people what they should be doing – at which point I kind of decided to try out academia as another approach or another step¨ (Pilot Participant C Interview 1).

Having made the change to an academic position, with a mixture of teaching, research and service duties, he then found that teaching was taking up more of his time than he would like:

> I´m quite aware that I have already spent more time on teaching than research…If you want to do the teaching well, especially with the number of students here, you could easily spend 60% [of your time] on that…and then you find yourself – if I want to do the teaching I can´t do the research. Or

> you need to pull yourself back into the research and kind of let your teaching just be adequate. (Pilot Participant C Interview 1)

As such, although he saw pursuing quality in teaching as a legitimate aim, he was personally more interested in research. His key focus in his position at the time of the pilot was to reduce the time he spent on teaching by becoming more efficient with teaching related tasks. For example, he stated that at the time it would take him around 20 minutes to prepare one lecture slide for a lecture presentation, and he would like to get that time down to ten minutes. Similarly, in deciding how to rank items on the list of goals, he stated ¨improving learning outcomes, improving student feedback to my teaching, and educating the next generation of engineers, that´s really lecture preparation¨ (Pilot Participant C Interview 2). Thus, he felt it was convenient for his purposes to subsume considerations for improving quality of teaching within the task of lecturing and adequate lecture preparation, rather than as a goal in and of itself. Here we see the participant essentially opting to focus on the efficiency of teaching rather than quality. This strategy suited his agenda of increasing his focus and time spent on research, and was apparently supported by the site in the *field*, because he states ¨I have been told to spend less time and to fine tune my teaching, and just get on with other things¨ (Pilot Participant C Interview 1).

Conversely, however, his treatment of research was much more concerned with quality, and he stated, for example, that improving rates of publication was important but not interesting to him because it is easy to publish low quality research, but harder to do good quality research in the first place. Instead of focusing on quantity of publications, he was much more interested in goals such as ¨having real life indicators that my research – to know how [it has been used in engineering and applications]…¨ (Pilot Participant C Interview 1), although he recognized the necessity of rate of publication in the short term. For this reason he rated most highly for interest the goals of ¨developing a good research record and reputation¨ and ¨ensuring my own relevance and currency within the discipline.¨ He saw these as distinct from the goal of a higher rate of publication.

In this respect, it can be seen that in the long term Participant C was interested in drawing on *capital* from outside of the Higher Education node of the *field*, in particular from engineering industry through recognition of high quality research with industry applications. At the time of the study, however, he was not able to do this, and instead had to focus on using *capital* from within Higher Education in order to change his position in the *field* to one in which he would be more able to do so. He could therefore be seen to use a shorter term and a longer term strategy for research-related *capital*. In the short term he felt it was important to improve his rate of publication and to get ¨runs on the board¨ in terms of research. He hoped that in the longer term this would allow him to develop high quality research, research that could attract funding that would have the capacity to be recognized by industry for its quality and industrial applications. In this respect, Participant C occupies a very conservative position within the *field*, by pursuing accepted and dominant forms of *capital* through a traditional, well-travelled (and clearly defined) career path, as is shown in Figure 21, at the end of the chapter.

Participant D

Participant D had entered academia through his involvement in industrially-based research, in particular, through the CRC (Cooperative Research Centre) movement, which sees university-based researchers partner with industrial bodies or associations. In describing the transition, the participant explained:

> [After working in industry for years] I finally decided I really want to work in a university but… I liked the industry interface. And I always think that I was just lucky that they came up with the CRC, so the Cooperative Research Centre movement started and [this uni] had to apply for it and got one on food packaging. And my -- what my interest then was in biodegradable plastics, so I said okay, plastics that are good for the environment…And so that all started and I was like, hey, that sounds like a good career. So I sort of joined those 50 percent CRC, 50 percent academic, and eventually I came on the academic staff. (Pilot Participant D Interview 1).

Throughout his academic career, Participant D had maintained his links with industry and his ability to attract funding for research with industrial applications. Although he had moved more and more into teaching as he stayed on at the university (before moving back towards a research-focused role at the time of the pilot study), he believed that his teaching was continually informed by his research activities and vice versa. He had progressed to the level of Professor (with stints as Head of School) relatively quickly, based on promotion for his ability to attract large grants from industry for research projects in his technical field. As such, he was able to draw on and use *capital* from outside of the higher education node of the *field* in the form of funding for research from industry. It also shows, however, that the Higher Education node was willing to recognize and value highly this form of *capital*, given the rate at which this participant was promoted.

Despite the high levels of *capital* this participant was seen to transact, and the strength of his position as someone capable of producing highly funded and valued research, his ranking list for goals showed a relatively high degree of disagreement compared to his other two lists. When asked about this, he was not entirely clear about the reasons for this, but did state ¨maybe [each goal is] highly important but I'll get there by focusing on interest areas¨ (Pilot Participant D Interview 2). This statement itself exhibits a high degree of confidence in his ability to control the outcomes of his choices, as he felt that his interest areas would naturally lead to important outcomes. This in itself does not explain the levels of disagreement between interest and importance for this list, but the participant did also state during interviews that he was at a stage in his career of reviewing his own goals and goal setting activities, and that the interview in itself was a chance to reexamine his priorities in this respect. He stated he had been rethinking his short and long term goals, and was at the point of having to choose between continuing a role which included teaching, or moving in to a head of school role which would not include teaching. Incidentally, this participant was the only one who discussed goal setting as a distinct activity within his role, and explicitly included this in his free list of tasks in the form ¨time management/planning against short, medium and long term goals.¨ It is possible that this kind of focus on planning and time management is a strategy that can increase participants´ level of choice in their positions. The degree of advancement and levels of *capital* for this participant at least suggest that this was a profitable activity for him individually.

The levels of *capital* for research that this participant was able to accrue indicate a position in which the participant himself could exercise a very high degree of control over his choices and strategies. This circumstance was the result of his ability to both bring in *capital* from the engineering industry node of the *field*, but also have it recognized in the reward structures of the Higher Education domain. This is likely because the form of *capital* he was able to access and use, by utilizing experience and networks from industry, resulted in a high level of (publishable) research outputs, which in turn attract prestige to the university itself. In this respect the position of Participant D, despite drawing on *capital* from outside of the Higher Education node, can be considered a conservative one, and one which is not likely to challenge the status quo, unlike that of Participant B which, should it gain traction, would challenge the dominant forms of *capital* surrounding research activities.

6.3 - Field analysis

Based on the data above which suggest the degree of choice of each participant, along with their strategies and amount of access to different types of *capital*, the following map of theorized possible positions in the *field* is proposed (Figure 21, below). This map shows theorized positions (in boxes) along with the relative locations of the pilot participants (shown in lettered circles) along the lines of strategy that were identified. The left hand side indicates a high research focus and a low teaching focus, and the right hand side the inverse. Higher on the map indicates positions associated with high levels of *capital*, lower on the map indicating lower levels of associated *capital*. Towards the centre of the map are positions that are considered more quantitative in approach, such as in the approach to research focusing on rate of publication, and the approach to teaching focusing on efficiency and quantity of teaching activities in the time available. Towards each end of the map are positions that take a more qualitative approach, be it for either a teaching or research related focus.

The positions and strategies shown in yellow, orange and red, indicate what is theorized as a standard and conservative trajectory in the engineering education *field.* This group of positions and strategies is one in which the status quo of structures affecting the distribution and recognition of the dominant forms of *capital* is not challenged by participants. Rather, participants on this trajectory are seen to match their efforts to pursuing this trajectory. Both Participants C and D fall on this line of trajectory, although were seen to be at different stages of progression along it.

Participant C was seen to occupy a position somewhere between that of the ¨teaching performance position¨ in which a minimum quantity and efficiency in teaching is expected of participants, and that of the ¨research publication position¨ in which participants have used a strategy of getting research ¨runs on the board¨ as a means of attracting recognition and reward. Participant C explained that his longer term strategy would be to work on the quality of his research activities and outputs in order to seek a position in which the quality of his research work is recognized, particularly from the engineering industry node of the *field* through use of research findings in industrial applications. This is the position and strategy seen for Participant D, who had reached that stage through intensive research activity involving high levels of funding for industrially relevant research projects.

Significantly, each of these conservative and dominant strategies and positions deemphasizes a focus on teaching, especially compared to research activities, and as the participant follows the trajectory towards collecting more *capital*, a focus on teaching is further deemphasized. Data from the pilot phase in fact suggest that taking a teaching focus coincides with a low level of *capital* for a given participant. This was true for both Participants A and B who were in teaching focused positions by appointment and choice respectively. For Participant B, although she seemed to be using a strategy of developing better graduates for professional practice in industry, and was depending on *capital* from the engineering industry node to do so, there was no clear position for her to move into by doing so. It was not clear that the form of *capital* this strategy depended on would be recognized, or would enable her to improve in position. As such it is questionable that a position with a higher degree of *capital* would result from this strategy.

Participant C, in her specific curriculum development role demonstrated no clear strategy or trajectory with which to change position, and it may be that positions such as hers become pockets or dead-ends within the *field*, with few opportunities for advancement unless the dominance of research related *capital* was to wane over time, and the relative value of other forms of *capital* was to increase.

In summary of the pilot phase, a range of forms of *capital* and relative value of *capital* was observed. As theorized, *capital* related to research activities (especially the publication of research, winning of grants and recognition of research from engineering industry) was seen to dominate and have a structuring effect on the *field*. Teaching was seen to form a type of *capital*, insofar as a minimal level of teaching was recognized for quantity and efficiency, such as was the case for Participant C. It was not clear from the pilot that any *capital* existed for quality in teaching, such as that which was exhibited by the focus of Participant B, however this is explored further in Case Study A, the findings of which suggest that some localized support is relevant to this strategy (hence this participant is positioned higher in terms of associated *capital* than participants A and C, and relative to the theorized position in the blue box.

Finally, a form of *capital* relating to curricular and student support activities was evident for Participant A, although her level of choice, desire to ¨challenge the system¨ and difficulty prioritizing among tasks and goals in her role suggest that this *capital*, although recognized within the *field* (especially in that it comes with a specific job title in the case of this participant) carries little value, and is not associated with any clear strategy for advancement.

The only node of the *field* that appeared to influence forms of *capital*, other than the Higher Education node itself, was engineering industry. This influence was seen to occur at the periphery of the *field* and only for two participants. The first, Participant B, was seen to draw on industry´s value for the quality and characteristics of graduates in supporting her emphasis on quality in teaching. However, this was also seen to be a unique position in the *field* and not one available to most participants. The second, Participant D, was positioned in the upper echelons of the *field*, with high levels of *capital* and a traditionally secure position which was based on attracting prestige to the institution based on research outputs. Once again, this position is not easily accessible to most participants, or at least not until some way into their career.

This theorized map of the field informed subsequent data collection phases of the research. In particular, in the case study phase, the positions on this theorized map of the *field* provided one dimension of the units of analysis to be investigated in each case. For example, Participant B and her specific position and strategies were investigated in Case Study A, with a particular focus on the effect of a teaching-focused and relatively independent *habitus* on the teaching practices that are seen. Case Study B focused on a participant at a different site, who could be considered to occupy a position somewhere between the theorized positions of ¨teaching performance¨ and ¨research publication.¨ This case study focused on the ways in which the context of the site in the *field* could be seen to affect the *habitus* and subsequent teaching practices of a participant in this position. Finally, Case Study C took a focus on a participant in the ¨teaching performance¨ position, but with a teaching quality and educational research focus.

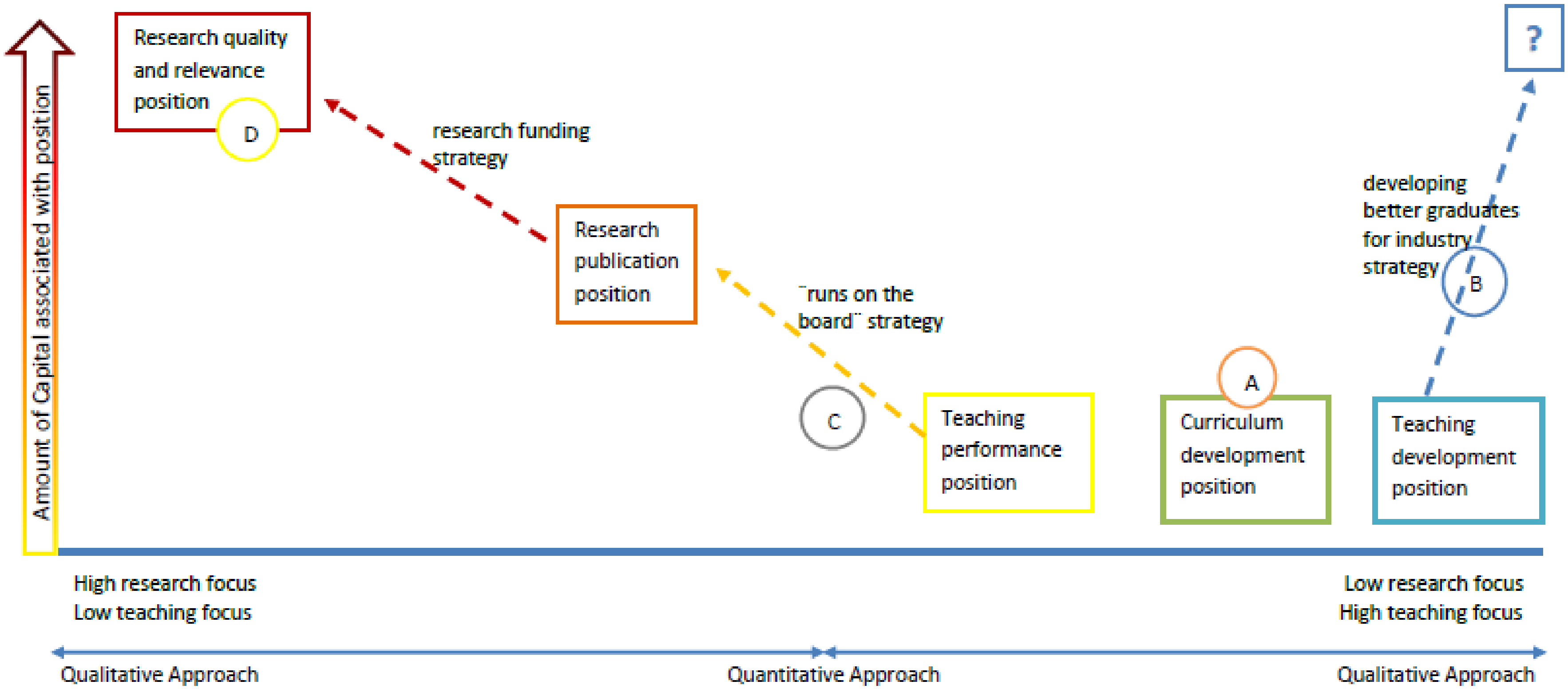


Figure 21 – Proposed positions and strategies in the *field* based on pilot data and analysis

7.0 – A questionnaire of engineering academics: establishing patterns in perceptions of capital for a wider group

7.1 - Overview of the Questionnaire Data

Following the pilot stage of data collection, an online questionnaire was conducted in order to test the ways in which the findings from the pilot stage were relevant to a broader group of engineering academics. This stage initially sought to explore:

How are the categories of 'ways of playing the game' identified in the pilot relevant to a broader group of engineering teachers?

During analysis it was found that although there were trends in the data which support the theorised forms of *capital* that emerged during the pilot stage of the research, without the opportunity to interview participants in detail about their role, it would be difficult to draw conclusions about specific strategies that survey respondents were using in participating in the *field*, particularly over time. As such, the conclusions here are mainly confined to discussing forms of *capital* which were most often recognised and valued across this wider population. These were identified by examining the patterns in interest relative to importance for each of the items on the ranking lists produced during the pilot phase of the research. This subsequently allowed for the identification of the most relevant dimensions of contrast for the subsequent case study stage of the research, discussed at the end of this chapter.

The participants for the questionnaire were recruited with the assistance of the Australasian Association of Engineering Education, by sending a communique to its members to invite participation. As such, an invitation for participation was only sent to those engineering academics who have a current or previous interest or involvement with this association, and presumably with engineering education research to some degree. Despite this, responses during the survey indicate that the participants held a range of research interests, as will be seen below.

In collecting and analysing data from the questionnaire, a number of limitations of the instrument were identified. First, in total only 80 participants responded to the email, meaning that the data set is not sufficiently large to give a representative sample of engineering academics across Australia, in statistical terms. However, given that the aim of the questionnaire was to test theoretical propositions about the nature and structure of the *field* this is not considered to be problematic. It should be noted that any conclusions drawn from this data are not claimed to be statistically generalizable, only theoretically generalizable. A number of arguments are presented below for how the range of participants can be seen to encompass a broad set of possible characteristics for academics in engineering across different types of institutions, positions and interest areas.

Second, only 40 participants completed the questionnaire in full, with most non-completers dropping out of the survey during the ranking tasks. Although when it was tested with dummy participants, the survey took around 15 minutes to complete, a number of participants reported that it took much longer than that for them to work through. A number of participants also made comments indicating that they were in disagreement with the validity of the ranking task, for example because in their view the distinctions between their priorities for items on the list were minimal. Without the opportunity to explain in person to participants that the aim of the ranking exercise was to elicit decisions about their priorities in their role, and that results would be analysed conceptually rather than statistically, it was not possible to ameliorate such perceptions. As a result of these factors, it was concluded that this type of ranking instrument does not lend itself well to online modes of data collection. Despite this, the data from the questionnaire yield complete data sets from 40 participants. These data show clear trends, in keeping with the findings of the pilot study, which are reported on below.

As is common with the design of questionnaires and surveys, a number of questions included in the instrument were later determined to be irrelevant or not sufficiently meaningful to the study. As such, only the questions which yielded meaningful data are reported on herein. Detailed data from these questions are included in Appendix F. The remaining (unreported) data have been stored and are available on request.

7.2 - Data about respondents

Analysis of the data showed that a majority of participants in the survey had been working as an engineering academic eleven years or more (72.7%), and that 35.7% had been working in the field for 20 years or more. 12.3% of respondents had worked in the field for 3-5 years and none had worked for less than that. The group of respondents as a whole is therefore considered to be both familiar with and experienced in the *field* about which they were asked to comment.

For question three, 15 respondents (21.1%) reported never having spent time in industry prior to entering academia. The remainder of respondents in this question showed a spread of responses from 1-2 years through to 20+ years, indicating a diversity of level of experience with the industry node of the engineering education *field*. Participants were also asked if they have any ongoing links with industry in their current position, in order to indicate the ways in which industry may influence their current role, and their views and practices in that role. Of the participants who responded to this question (70), ten reported having no ongoing links with industry. The remainder of respondents provided open ended comments about the nature of their ongoing links, and these responses were coded thematically, with many respondents giving comments that were coded under more than one theme. These themes included the use of guest lecturers from industry in class, ongoing research partnerships with industry, ongoing work as a consultant to industry, sharing of research supervision with industry and industry providing real life projects for and current advice on coursework. Other dominant themes in the responses were academics facilitating students to visit with industry for example for site visits, internships and for graduate placements, and finally, maintaining industry contacts or participating on boards or industry advisory bodies.

28 (40%) of respondents reported using guest lecturers in class, however it is questionable how significant this form of contact with industry is for shaping the views of the academic, because this activity may have no effect on anything else the academic does in their role. Consultancy on the other hand (which 27 respondents reported) is expected to be significant in maintaining academics´ currency with the industry node of the *field*, because it requires them to work (at least partially)

within the structures of this node in their role as a consultant. This would allow them to keep track of the events and developments of their disciplinary area in industry, which may in turn affect how they approach their practice (particularly for teaching purposes) in the academy. It is significant that 60 (85.7%) of respondents reported maintaining one or more links with industry, suggesting that engineering academics in general see this as a valid and important aspect of their role in the *field*. This supports data from the pilot stage which suggests that the engineering industry node has some structuring effect on the *field* as a whole.

Participants in the survey were also asked to comment on why they chose to enter academia as an engineering academic. Their responses were coded thematically, as per Figure 22, below. Fourteen of 74 respondents gave a reply that indicates reasons concerned with a focus on teaching in the academic role (for example that they enjoy teaching or wanted to contribute to developing future engineers). Twelve respondents indicated that they valued the opportunity to work on both teaching and research. Twenty-three reported intrinsic or personal reasons, such as that they wished to pursue a PhD or that ¨it was the right thing at the right time for me.¨ Sixteen respondents gave comments that indicate they were attracted to specific conditions of the academic role, such as its flexibility (especially for hours worked), its perceived security and the opportunities it can provide (such as the opportunity to pursue their own research interests). This range of responses from participants gives an indication of a diverse range of reasons for participation in the *field*.

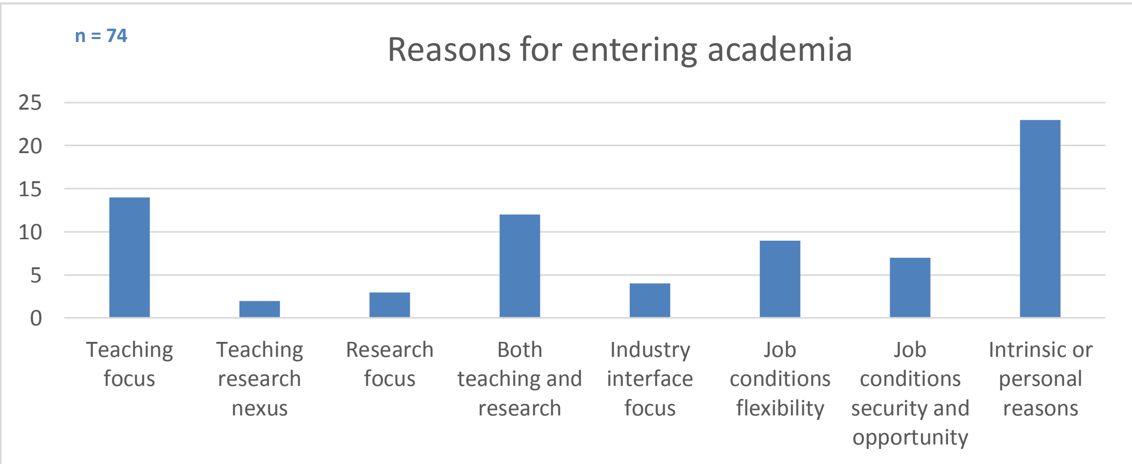


Figure 22 - Survey participants´ reasons for entering academia

Despite this diverse range of reasons for participation, distinct trends in perceived interest and importance emerged from the later ranking data.

Participants´ responses also indicated a diversity in the nature of their current position in their faculty or school (Figure 23). Of 69 respondents to this question, 20 reported being in a primarily teaching focused role, with some research duties. Fourteen reported being in primarily administrative or service focused roles, with some research or teaching duties. Six reported being in a research focussed role with some teaching duties, eight reported equal weighting for teaching and research, and eight reported a normal academic load balancing teaching, research and admin. This spread of responses also indicates a diversity of type of role represented in the group of respondents as a whole. However, as with reasons for entering the field, this diversity in role type did not prevent clear patterns from emerging in the ranking data.

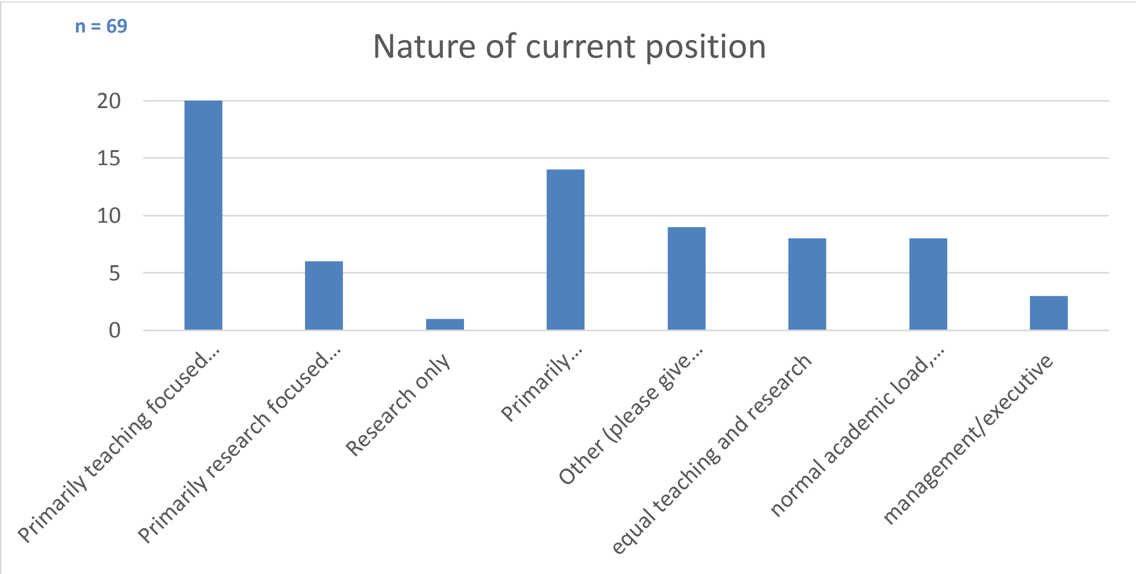


Figure 23 - Nature of current position of survey participants

Finally, participants were also asked to report on the type of institution to which they belonged (Figure 24). As with type of position, their responses showed a clear spread across all types of institution. This was of interest because it is possible that different types of institutions may give differing emphasis to different aspects of the academic role (particularly the relative values for teaching and research) and that *capital* at different sites may therefore work differently. Because the participants in the survey represent a spread of institutions, it is expected that their responses taken together have the capacity to account for this issue.

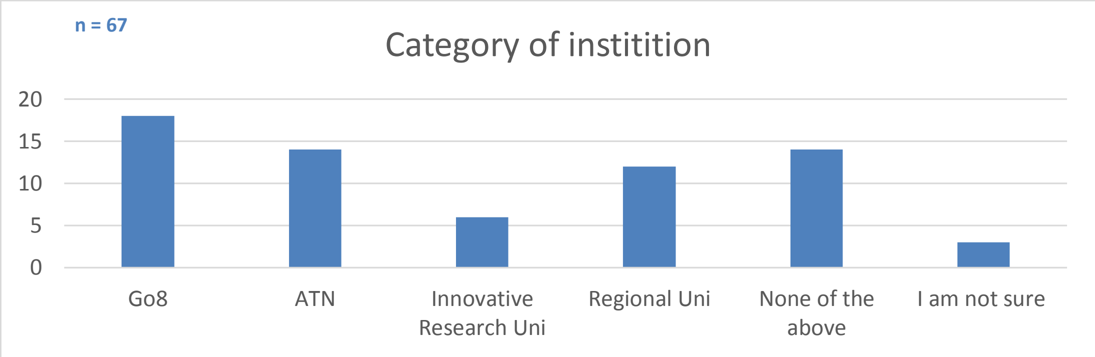


Figure 24 - Type of institution of survey participants

7.3 - Perceptions of the engineering academic role

A variety of questions in the survey addressed the participants´ views of the academic role in their faculty generally, as well as specific information about their own position and interests. In commenting on what they believed their faculty or school felt was the most important aspect of staff performance, 18 of 67 respondents selected the quality of research, and 16 the quantity of research. 10 selected the quality of teaching, and 18 selected that all of these things (including service) are somewhat equal. This demonstrates a trend supporting the strength of *capital* concerning research in the *field*, as around 66% of respondents believed this was the most important aspect of their performance.

Three respondents selected ¨another aspect of performance¨ and gave comments detailing their views. Of these three responses, one indicated ¨funded research¨ was most important. The second stated they ¨weren´t sure¨ and that professional development was not taken seriously at their site. Finally, the third respondent replied that staff were expected to ¨not think and do what management wants without them telling us what they want.¨ Collectively, these responses represent a negative and uncertain view of how academics are expected to address their own performance. Another three similar comments were provided under question 13 (see Appendix B, Q13) which also show a negativity towards the emphasis or direction imposed on academics and their tasks. These views indicate a concurrent uncertainty over the forms of *capital* available to academics, and the means by which they can attract and use such *capital* in order to improve their own position.

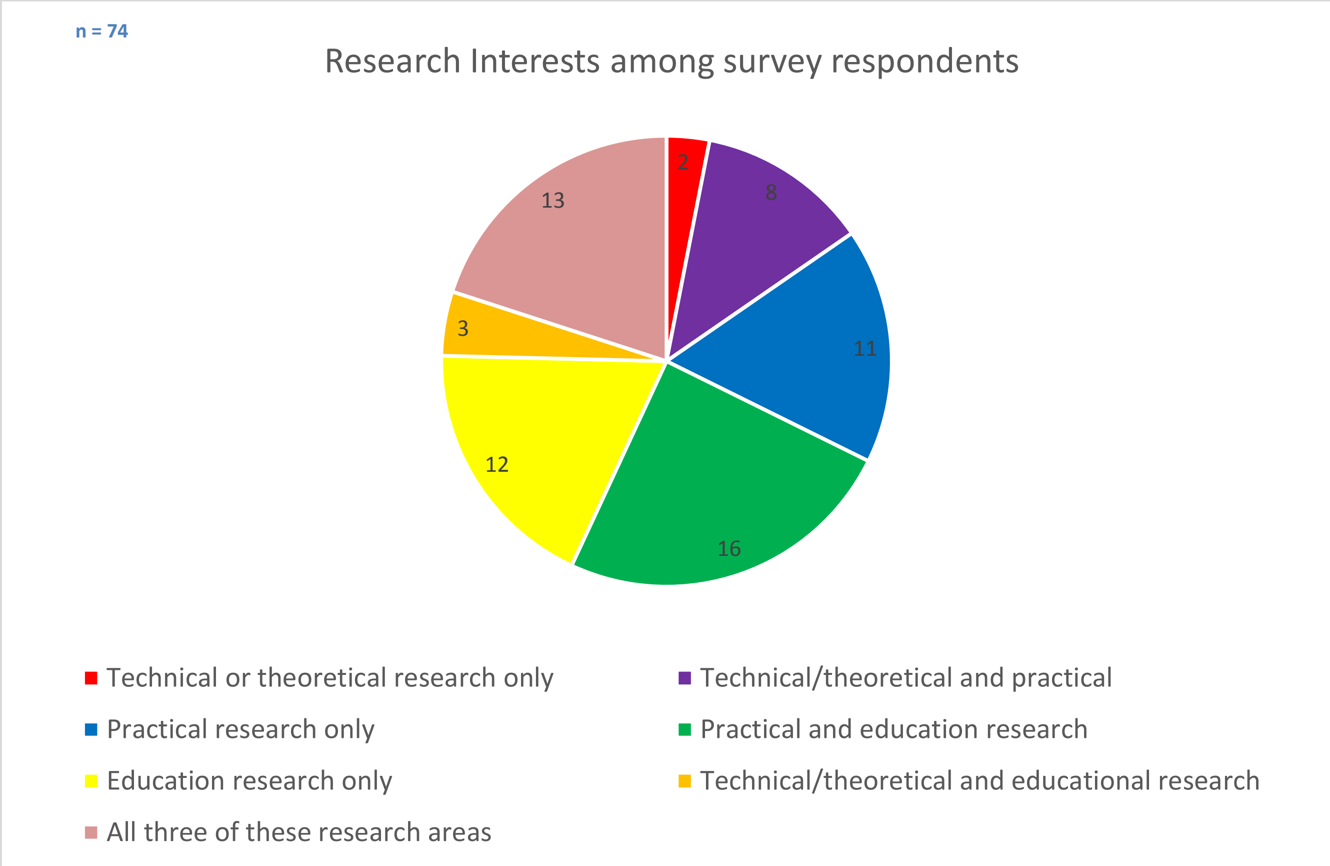


Figure 25 - Research interests among survey participants

When asked to indicate their own type and level of research interest, responding participants (67 in total) also showed a clear spread over research areas of interest and degree of interest in research. Theoretical research on its own was the least represented area of research (only two respondents reported only being interested in theoretical research). However, a further 24 participants reported being interested in theoretical research in combination with some other research area. Twelve and 11 participants reported being interested in educational research only and practical research only (respectively), with 16 being interested in both. Thirteen participants were interested in all three research areas. These distributions of research interest are represented in Figure 25.

Participants were also asked to select their amount of interest in research, and their responses once again show a clear spread across categories. These responses are represented in the bar chart below (Figure 26). This spread of type and level of interest in research captures the range of possible positions of engineering academics on the issue of research, which supports the theoretical generalisability of the later trends shown in the ranking data.

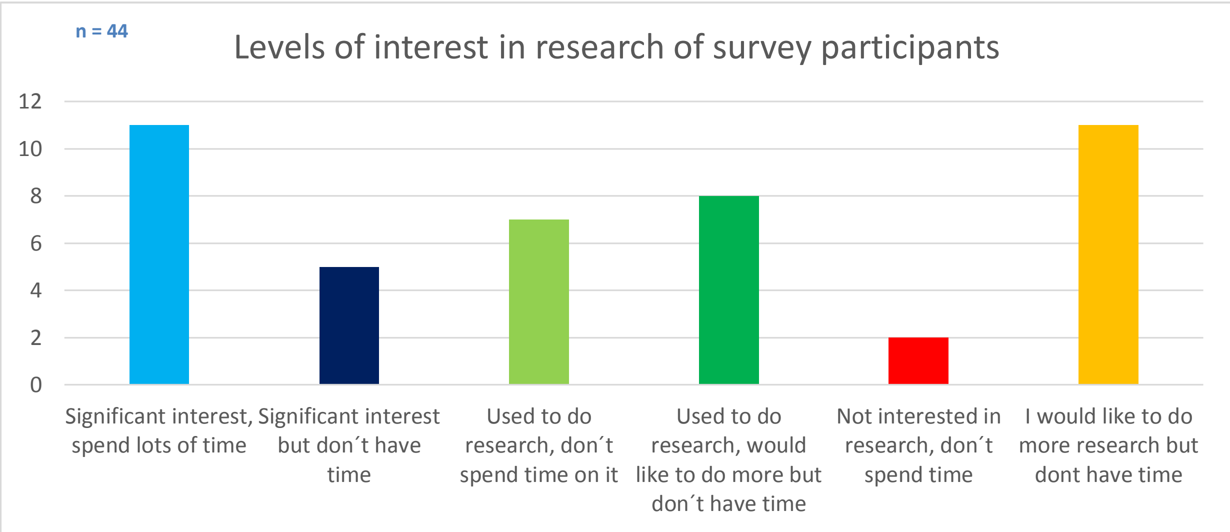


Figure 26 - Levels of research interest among survey participants

In addition to commenting on their research interests, participants gave responses indicating the amount and type of teaching they undertake in their current role. 62 participants responded to this question. In answering how many courses they teach in an average semester, the range of responses was between zero and six, with the average number being 1.89. The same participants reported a fairly even spread of the types of courses in which they teach. Fifty respondents in total reported teaching in theoretical or technical courses, 40 in practical courses and 30 in project based courses. Most respondents reporting teaching in more than one category. Once again, this spread indicates a diversity of representation of the range of possibilities for type and amount of teaching that the wider body of academics are likely to do.

In reporting the teaching mode in which their courses take place, most participants (60.3%) said they taught in on-campus courses only. Twenty-five percent reported teaching in courses that use both on-campus and online modes and only 6.9% reported teaching only in online courses. As will be seen in later discussion for Case Study 3 (Chapter 10), it is expected to be relevant to academics´ views of the nature teaching practice in their role whether or not they teach online or face-to-face.

Having contact with face-to-face students may be associated with a greater range of pedagogic practices, and subsequently stronger views of the nature and value of teaching within the academic role (see Chapter 10 for further discussion). As such it is helpful to the strength of the findings of the survey that only six percent of respondents have no contact with face-to-face students.

7.4 - Experience and training in teaching

Finally, before completing the ranking exercises, participants were asked to report on their levels of experience and training in teaching. 62 respondents in total answered these questions.

In reporting the number of years teaching experience they had before entering academia, 59.6% of participants stated they only had one year of experience. Unfortunately, an error the survey instrument omitted including a category for zero years´ experience and so it is possible that some of these responses would fall in this category as well. 19.4% of participants reported having 3-5 years´ experience, and only 20% reported having more than 6 years of teaching experience prior to entering academia.

Of the 62 participants responding to this question, 24 (38.7%) stated that they hold a formal qualification for teaching, and 38 (61.3%) still did not hold any formal qualification. Of the 24 who did hold a qualification, 16 respondents reported that their qualification was a Graduate Certificate or Postgraduate Certificate in Higher Education. 8 others reported some other qualification, and these included Diplomas or Bachelor in Education, or some other form of formally recognised teaching experience.

Taken together, these data about participants´ levels of experience and training in teaching support the findings from the case study about the lesser value that is placed on teaching in the Higher Education setting. Consequently, forms of *capital* surrounding teaching are weak compared to other types of *capital* that are available, particularly those concerned with research. This is also supported by the trends for interest relative to importance shown in the ranking exercise data, discussed next.

7.5 - Data from the ranking exercise

A total of 40 complete data sets for the ranking exercise were available from the survey data, thereby giving 400 data points for each of the three ranking lists (1200 data points in total). As with the pilot stage of data collection, the purpose of asking survey participants to rank each item on each list was to elicit decisions from them about their priorities in their role in terms of both interest and importance for a list of ten items. By comparing interest relative to importance for the items on each list, it is possible to discern trends in what participants see as more important (extrinsically) than interesting (intrinsically) in their role, as well as what they see as more interesting than important. In this way, as with the pilot participants, it was possible to explore the degree of choice that a wider group of participants exercise in their roles, as well as identifying particular aspects of their roles in which they would like to act in particular ways (interest scores), compared to how they feel they are compelled to act by the *field* itself (importance scores). By examining distributions of scores for each of the items on the lists, it is possible to compare the relative levels of interest and importance across items, and thus build a picture of participants´ perceptions of the available *capital* in the *field*. The methods for this analysis is explained in detail below.

7.5.1 - Data for Tasks

The ranking list for Tasks was as follows:

- Preparing and revising lectures/teaching activities
- Lecturing/tutorials
- Writing proposals for grants
- Writing papers for publication
- Reviewing and improving existing courses
- Designing and developing new courses
- Conducting research (e.g.: research design, data gathering, analysis):
- Service to the faculty/school (e.g.: committees, administrative duties, etc.):
- Eliciting and evaluating feedback from students
- Training tutors or teaching staff

When the 400 available data points for Tasks are shown on a scatter plot, by plotting scores out of ten for interest versus importance for item and each respondent, the results are as per Figure 27:

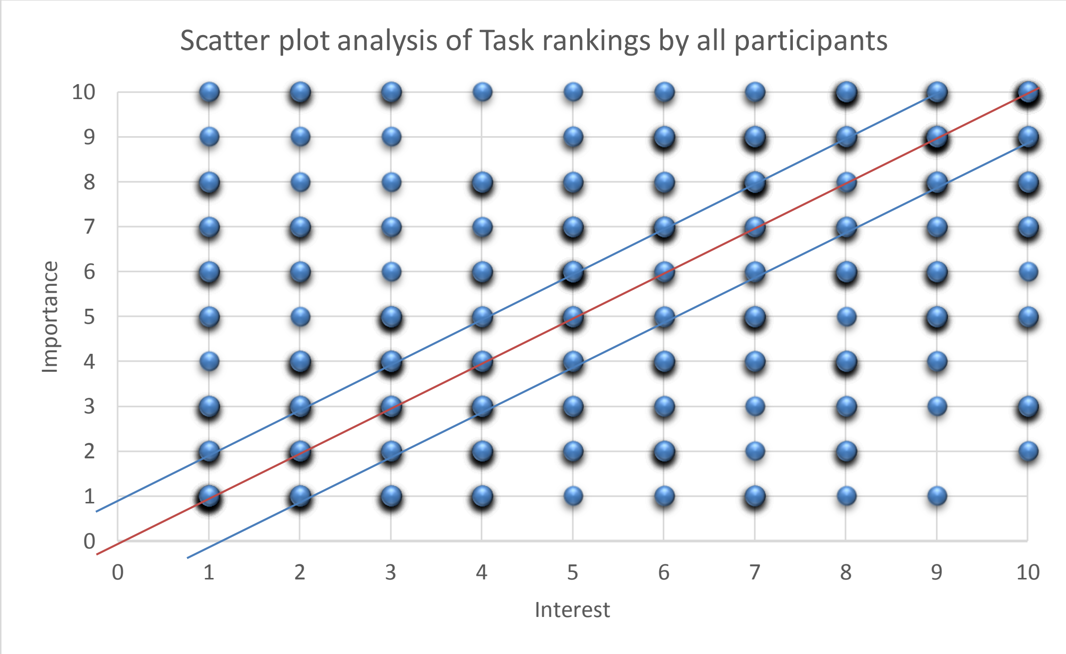


Figure 27 - Scatter plot analysis of Task rankings by all participants

Whilst in one sense, this representation of the data is limited, because it cannot show the distribution of every single data point, this chart does show the sheer diversity of responses for the group of participants, as almost every point on the graph is occupied by at least one data point. This diversity reflects the differing interests of the group of respondents but also suggests an overall low degree of choice over the tasks associated with their roles. If the group of participants´ choices were diverse but with a high degree of control of choice, the data points would be distributed much closer to but still along the length of the diagonal line of agreement. This data can be broken down further to show a number of underlying trends, which this scatter plot on its own does not show.

The number of scores lying either on the diagonal line of agreement or within one point of it gives a baseline figure for the level of agreement between interest and importance for Tasks as a whole. This figure can then be compared to the scores for individual items on the list, in order to discover trends in how different items are perceived differently for interest relative to importance. In total for Tasks, 64 data points (16%) fell on the line of agreement, and 92 (20.25%) within one point for Tasks as a whole. This is a total of 36.25% of data points with agreement between interest and importance. From this score it is now possible to make a measured comparison among specific items on the list.

A number of analyses were performed for each of the ten specific tasks on the list. As with Tasks overall, the degree of agreement (number of data points on or within one point of the line of agreement) was measured in the same way for each specific item on the list. Four items on the list showed significantly less agreement, meaning there was significantly more disparity between interest and importance for those particular tasks, as shown in red in the right hand column of Table 23 below.

Data for each of the Task items were also analysed for distributions of data points showing an item to be more interesting than important, or more important than interesting. This was achieved by subtracting importance scores from interest scores, for each participant in each Task item. Where importance was greater than interest, this would yield a negative value (and the concomitant data point would fall above the line of agreement on a scatter plot). By then adding all of the positive scores to the negative scores for each Task item, we arrive at a numerical score for disagreement, and an item could be shown as either more interesting than important or more important than interesting. Positive values show that an item on the list was perceived as more interesting than important by the group of participants as a whole, and a negative value the reverse. This process yielded relative values for the list of Tasks as follows:

Table 23 - Disagreement and agreement scores for each Task

Tasks	More Interesting than important	More important than interesting	Overall % agreement score
Preparing and revising lectures/teaching activities	22		42,5%
Lecturing/tutorials	11		55,0%
Writing proposals for grants		-103	22,5%
Writing papers for publication		-36	57,5%

Reviewing and improving existing courses	23		40,0%
Designing and developing new courses	85		17,5%
Conducting research	42		27,5%
Service to the faculty/school		-55	20,0%
Eliciting and evaluating feedback from students	5 (neutral)		30,0%
Training tutors or teaching staff	6 (neutral)		52,5%

For the scores in the middle two columns, the closer to zero the score is, the higher the level of overall agreement between interest and importance. The further from zero the score is, the higher the level of disagreement between interest and importance for that task item overall. If the number is positive, it means that for most participants this item was more interesting than important, and for negative scores the reverse is true. Differences among items on the list in terms of relative importance and interest are shown in Figure 28 below. There are a number of task items that are of particular interest on this list.

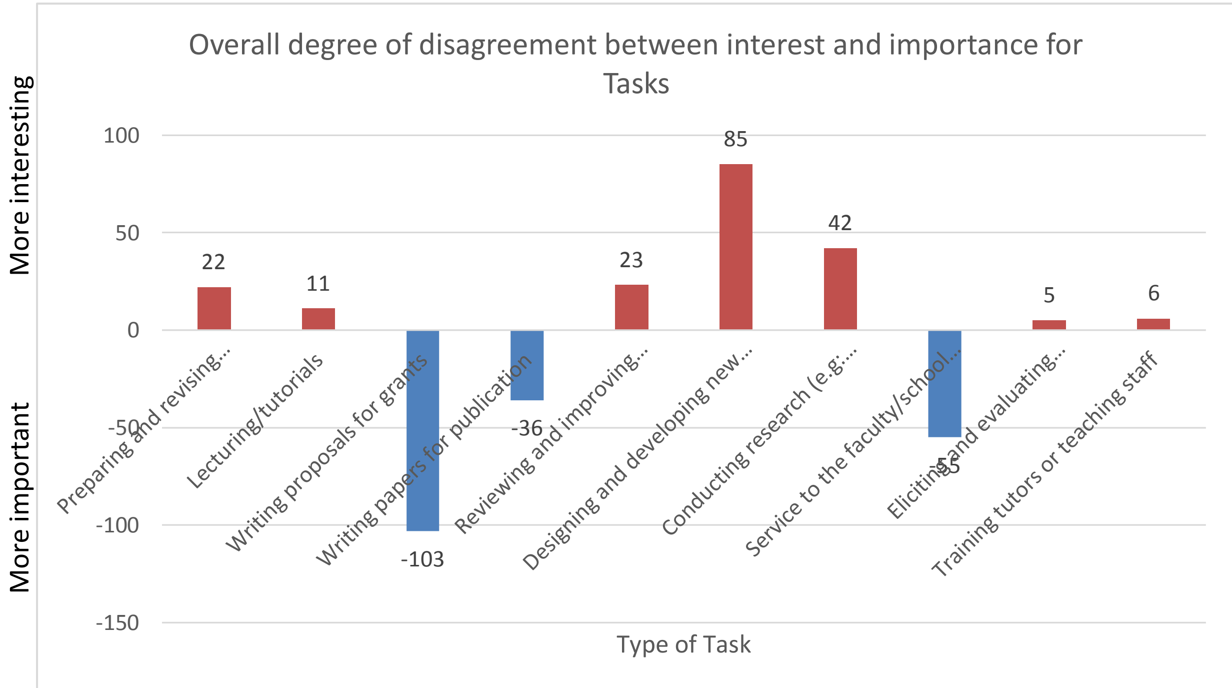


Figure 28 - Overall disagreement between interest and importance for Tasks

The highest score (-103) is for writing proposals for grants, and shows that for the group of participants this is significantly more important than interesting to them. In other words, they feel they are expected to do it to do well in their role, but that it has little intrinsic value in terms of interest. Conversely, actually conducting research (with a score of 42) was significantly interesting to them but not seen as important to doing well in their role. This distribution of scores is easily seen in examining the individual scatter plots for these tasks (shown below). More data points fall above the line for writing proposals for grants (more important than interesting) and fall below the line for conducting research.

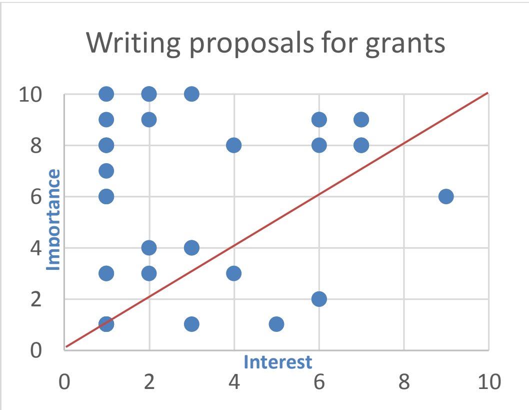


Figure 29 - Interest versus importance for Writing Proposals for Grants

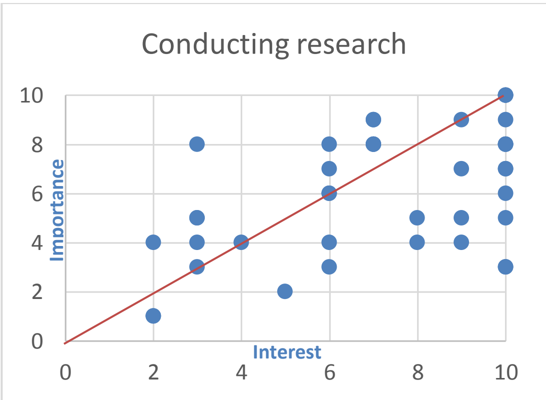


Figure 30 - Interest versus importance for Conducting Research

This finding supports evidence from the pilot stage concerning the nature of *capital* surrounding activities to do with research. Although the outputs from research activity (especially winning funding and publications) are valued highly in the *field*, and thereby constitute a strong form of *capital*, actually performing research is valued much less. On the surface this is seemingly illogical, because conducting research is necessary to produce research outputs. However, given that research activity itself does not attract prestige to institutions, but the outputs of research do, this may be a reason for why *capital* for research is distributed in this way. The implications of this are that academics are not supported by forms of *capital* for research *during the research process.* Rather, research *capital* is only available to them at the outset *if they win funding*, or at the end if they are successful in having the results of their research published.

The second highest disagreement score (85) in the list of tasks was for designing and developing new courses, indicating that survey participants were significantly more interested in this task than saw it as important for doing well in their role. Similarly, preparing and revising lectures and reviewing and improving existing courses were more interesting than important. As above, this supports the findings from the pilot that the strength of *capital* surrounding activities related to teaching is significantly less than for research related tasks.

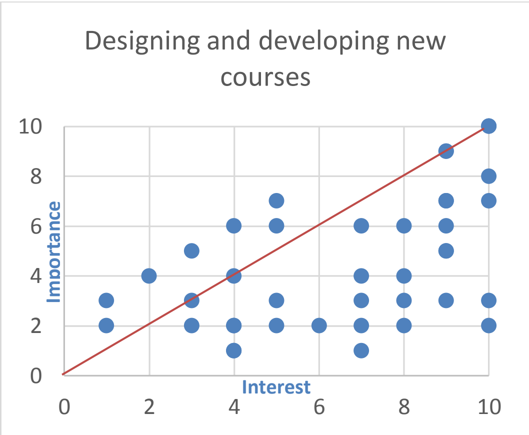


Figure 31 - Interest versus importance for Designing and Developing New Courses

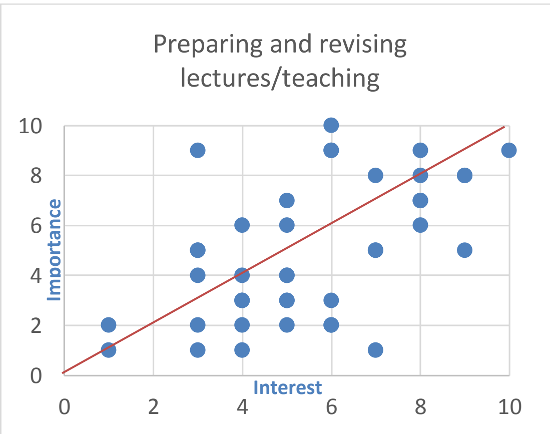


Figure 32 - Interest versus importance for Preparing and Revising Lectures/Teaching

7.5.2 - Data for Goals

The ranking list for Goals was as follows:

- Ensuring my own relevance and currency within the discipline
- Achieving promotion
- Improving my rate of publication
- Educating the next generation of engineers
- Improving student feedback on my teaching
- Developing a good research record and reputation
- Improving the learning outcomes of students
- Increasing the amount of funding I have for my research
- Enabling young staff to learn how to do research

The scatter plot for Goals shows a highly diverse distribution of data points, once again demonstrating diversity among participants and a low overall degree of control over choice of Goals. The agreement scores for Goals, however, were higher than for Tasks, with 109 data points falling on the diagonal line of agreement, and 78 falling within one point, a total of 46.8%.

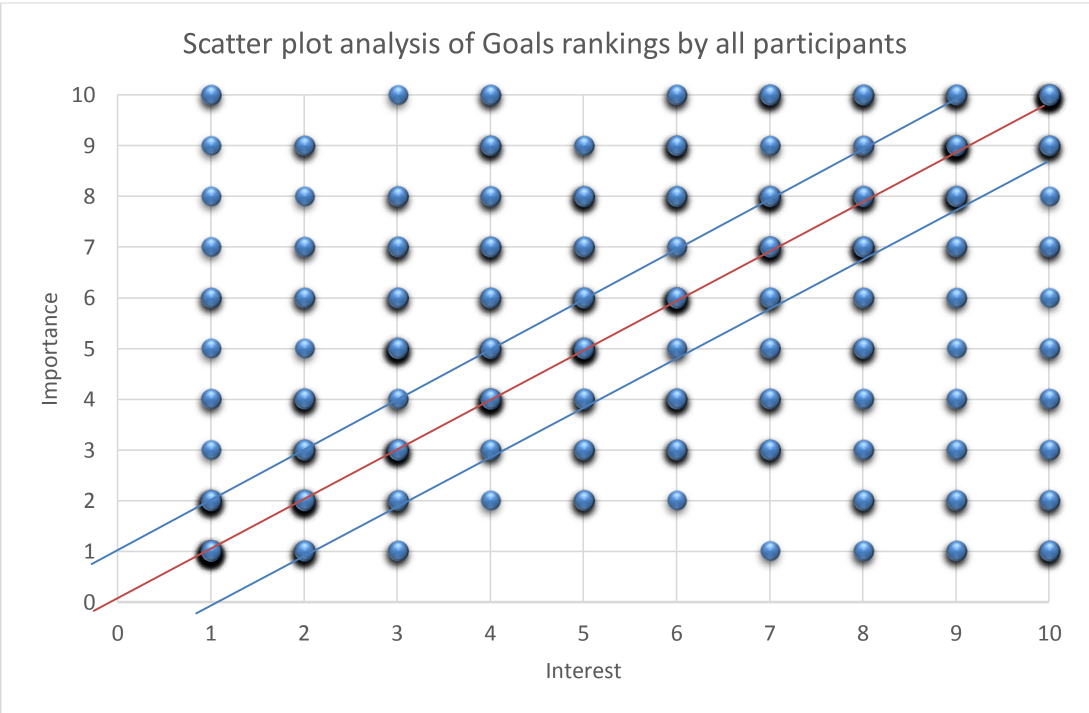


Figure 33 - Scatter plot analysis of Goals rankings by all participants

As with Tasks, in comparing which items were more interesting than important, and more important than interesting, a number of significant trends emerge (Figure 34, below). Of significantly greater interest than importance were the following goals:

- Educating the next generation of engineers (72)
- Ensuring my own relevance and currency within the discipline (53)
- Improving the learning outcomes of students (40)
- Doing a better job of teaching (31)

These items also had lower percentages of data points on the line of agreement.

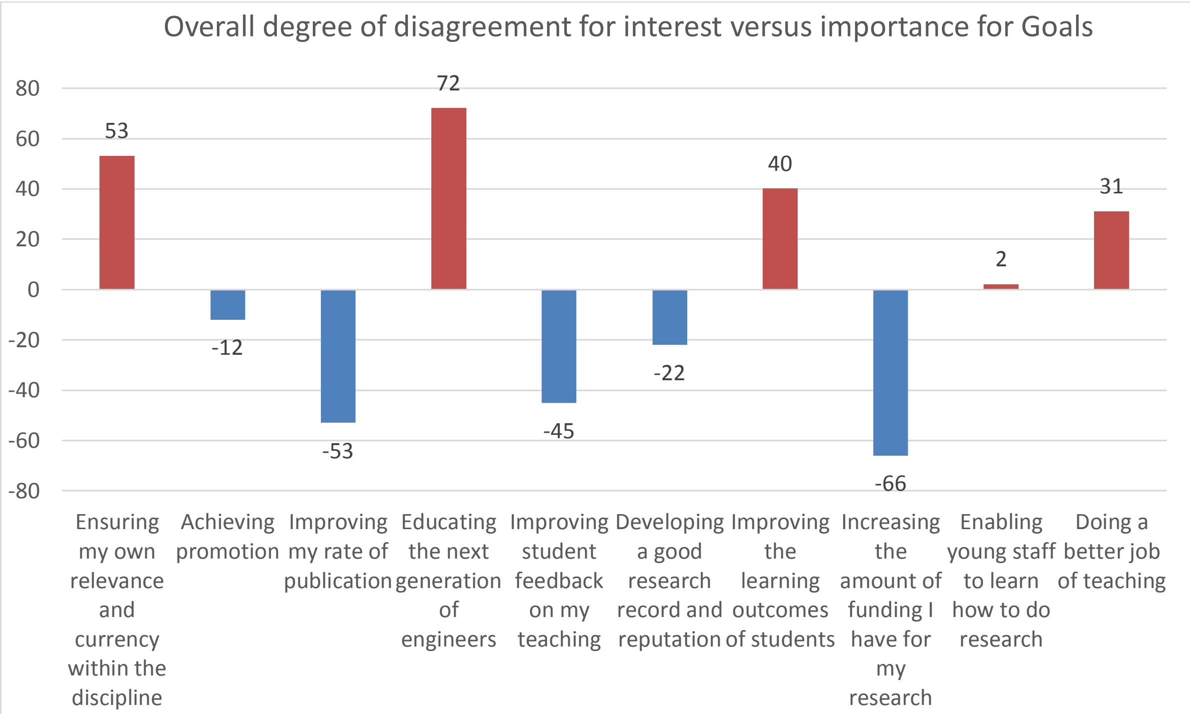


Figure 34 - Overall degree of disagreement for interest versus importance for Goals

Although these goals relate directly to the core business of teaching students, especially in ways that adequately prepare them for work in industry, the lack of perceived importance associated with these goals suggests a low level of *capital* available for pursuing them. Conversely, the goals of ¨improving my rate of publication¨ and ¨increasing the amount of funding I have for my research¨ were seen as significantly more important that interesting, once again supporting the findings about the strength of *capital* associated with these activities. Also more important than interesting to participants was the goal of improving student feedback on my teaching. It is reasonable to conclude that participants interpreted this to mean the formal teaching evaluations that academics must conduct for each course and submit as a part of their performance reviews. There is plenty of research available that concludes that such evaluations do not successfully measure teaching effectiveness (Hemer, 2013, Chalmers, 2011), and that instead they reflect the popularity of lecturers and courses, a fact that most academics are well aware of. This accounts for the participants´ lack of interest in this goal, as well as its relative importance.

7.5.3 - Data for Indicators of Success

The ranking list for Indicators of Success was as follows:

- Having research published
- Winning citations/ awards
- Achieving promotion
- Being asked to collaborate on research projects or publications
- Having my teaching innovations or pedagogies taken up elsewhere
- Seeing the outcomes/findings of technical research being used for industrial applications
- High levels of attendance at lectures/ teaching sessions
- Positive feedback from students on my teaching
- Being able to use research activities to inform teaching activities and vice versa
- Getting recognition by professional engineering societies

Once again, scatter plot analysis of the distribution of data points for Indicators of Success (Figure 35 below) shows a highly diverse set of responses for the list overall and a low overall degree of choice. In examining the distribution of data points on or within one point of the line of agreement, a total of 47.5% (190 data points in total) were in agreement. For individual items on the list, achieving promotion scored the highest degree of agreement (62.5%). This is a logical finding given that promotion is the most tangible and overt form of recognition of success. The strength of this degree of agreement, however, may have skewed the strength of overall agreement for this list of Indicators of Success as a whole. A number of items on the list scored significantly lower for level of agreement, these being:

- Positive feedback from my students on my teaching (30%)
- Being able to use research activities to inform my teaching and vice versa (37.5%)

Despite the low level of agreement for positive feedback from my students on my teaching, this item scored almost neutral for disagreement (-3). This is because 23 participants saw this item as more interesting than important, and 17 saw it as more important than interesting, but the distribution of these scores fell mostly away from the diagonal line of agreement.

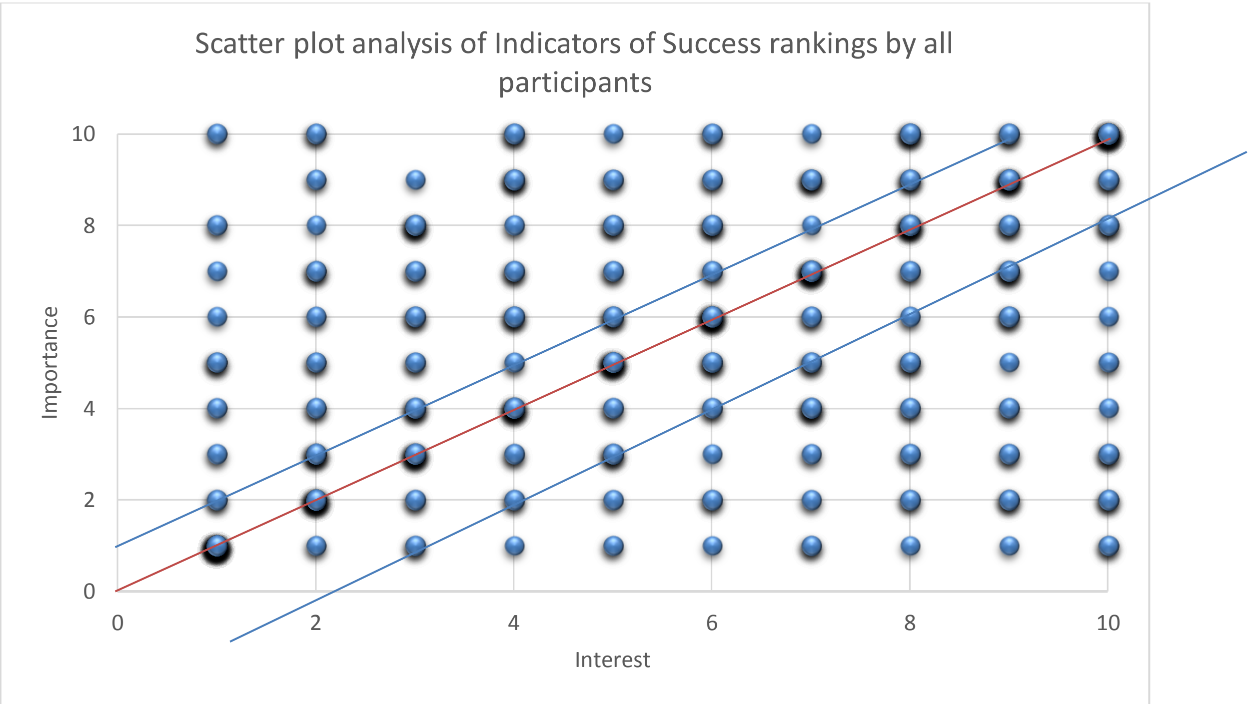


Figure 35 - Scatter plot analysis of Indicators of Success rankings by all participants

The item of ¨Being able to use my research to inform my teaching and vice versa¨ scored highly for disagreement (44), and was seen as significantly more interesting than important by participants. This is despite the common defence of the research-teaching nexus in the academic role; that currency and expertise in research for a given disciplinary area naturally informs teaching in that disciplinary area (Prince, Felder & Brent, 2007). The strength of the disagreement for this item suggests that although academics are interested in developing this nexus, it is not in fact valued in the *field* or recognised within available forms of *capital*. Also scoring as significantly more interesting than important was ¨having my teaching innovations or pedagogies taken up elsewhere.¨ This is another indication that the forms of *capital* surrounding teaching well or in innovative ways does not carry much strength in the *field*.

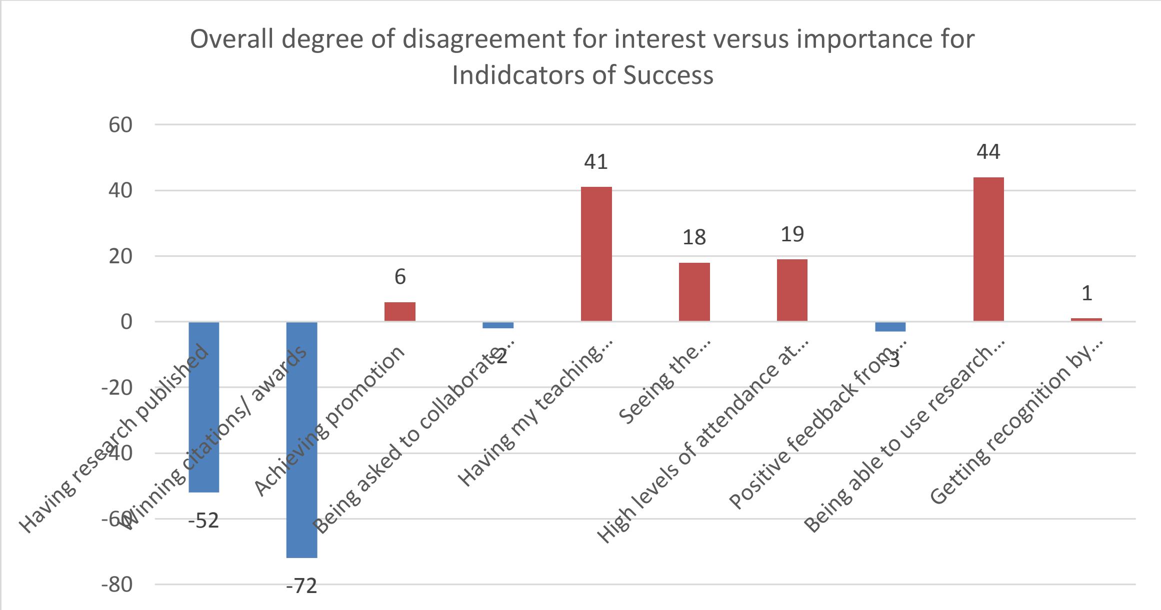


Figure 36 - Overall degree of disagreement for interest versus importance for Indicators of Success

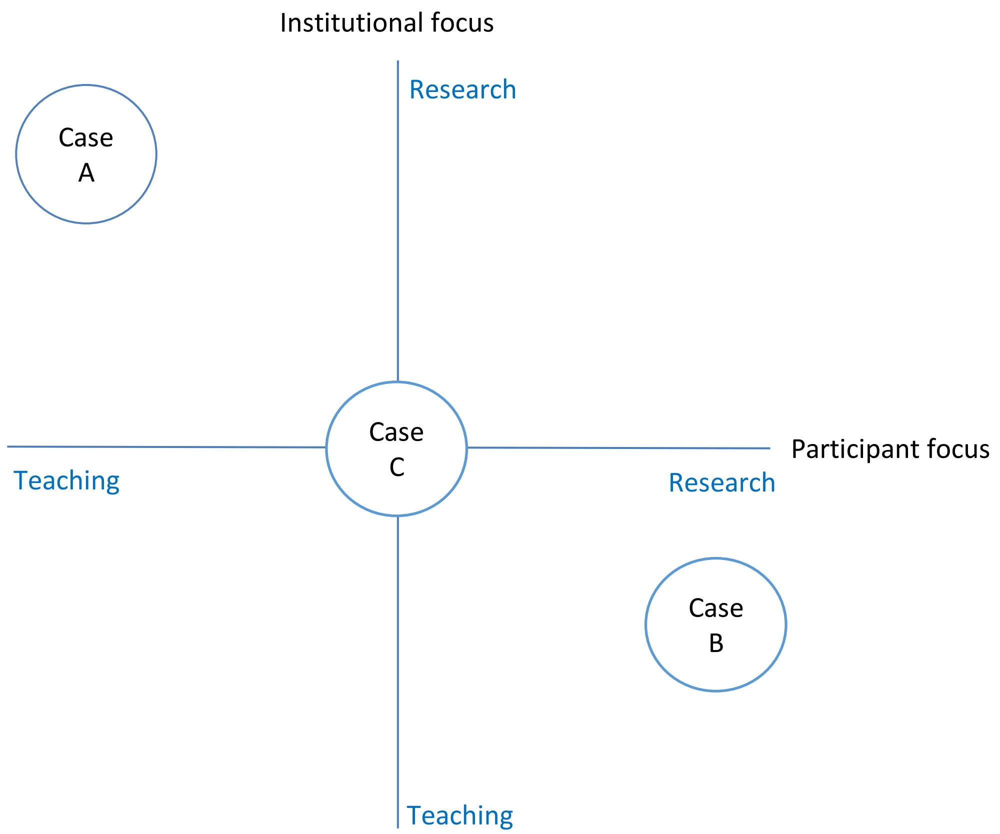
Conversely, the items of ¨having research published¨ and ¨winning citations or awards,¨ both associated with the outputs of research, and bringing direct prestige to individual academics and their institutions, were perceived as significantly more important than interesting (with scores of -52 and -72 respectively), again supporting the strength of *capital* for these activities.

7.6 - Summary and preparation for the case studies

The overall trends in data that compare relative interest and importance for aspects of the academic role strongly support the findings of the case study with respect to the forms of *capital* available for use in the *field*, and the specific activities associated with that *capital*. While *capital* for research appears to be the strongest form of *capital*, it is through the output of research that this *capital* is accrued, rather than through the activities that lead to research outputs, such as actually conducting research (design, data collection, analysis, etc.). Whilst the survey data showed that some *capital* is available for teaching through positive student feedback on courses (in the form of teaching evaluations), this *capital* carries less strength than that associated with research, and may not be associated with the quality of teaching. Furthermore, activities concerned with improving teaching and learning (such as reviewing and improving existing courses, improving learning outcomes, doing a better job of teaching and maintaining own disciplinary currency) appear to not attract much *capital*. Time spent on these activities is therefore likely to detract from time spent accruing research related *capital*. These patterns concerning the *capital* of the *field* not only support the findings about *capital* from the pilot stage of research, but they also suggest that the most dominant strategies available to academics to improve their position in the *field* are the ¨runs on the board¨ strategy and the ¨research funding strategy,¨ as shown in Figure 21, Chapter Six.

As a result of this data, the case study phase of research took a focus on particular units of analysis. For Case Study A, Participant B from the pilot phase was selected in order to explore the possibilities for teaching practice when the participant has a high degree of interest in teaching, and can exercise a high degree of choice within the *field*. This participant was situated in a research intensive university. For Case Study B, a participant was chosen with a particular interest in the theoretical aspects of the engineering discipline, but in an institutional context in which non-traditional modes of teaching and learning (such as those associated with student-centred instructional models, and practice-oriented instruction) were being promoted within institutional policies about teaching and learning. Finally, Case Study C a participant was chosen who had a known interest in engineering education research, in order to examine if this research interest would go along with an epistemological shift either pedagogically or with respect to the nature of the engineering discipline. This participant was situated in a regional university which claims a high number of employment opportunities for students upon graduation, and in which around 70% of students are enrolled for online course offerings.

The theorised dimensions of contrast between these cases, and between the participants themselves and the institutions that they belong to is shown below in Figure 37. In this visualisation, the axes display a spectrum of focus from research to teaching, the idea being that the greater the focus on one, the lesser the focus on the other, with subsequent patterns of capital coming into use accordingly. By



comparing institutional focus and participant focus, as well as research and teaching focus, the case studies generated further site-specific findings on the nature and distribution of *capital*, the effect of *habitus* of individual academics on the nature of practices that were seen, as well as the effect of both *field* and *habitus* on the PCK and overall teaching practices of participants.

8.0 - Case Study A - ¨Here´s a good engineering habit¨

For the first case study a participant was chosen for whom teaching was the central focus of her activity as an engineering academic. In particular, her observed practices demonstrated a consciously reflective approach to the development of her teaching in order to optimise learning outcomes for her students. When the PCK construct was applied to analyse her teaching practices, a picture of a highly developed and integrated body of Pedagogical Content Knowledge emerged. Within this body of PCK, each component knowledge area of the proposed construct was present, interconnected and mutually reinforcing. The processes of reflection on and integration of these knowledge components were also constitutive of the structure and nature of her PCK.

Because of this participant´s approach to working with the *capital* of the *field* she was uniquely placed to pursue her teaching interests and the capacity to develop her PCK. This was seen despite the fact that she was not interested in accumulating the main form of *capital* that was widely available at the site in the *field*; that is, research *capital* through technical and theoretical research activities. She was also seen to possess an epistemology of teaching and learning for her discipline that was at odds with the one that was widely shared at her site in the *field*.

In part, these circumstances were seen because of the degree of risk she was willing to accept in operating in her role in unconventional ways. However, she was also seen to leverage *capital* surrounding *what it means to be an engineer,* in order to develop a unique position for herself within the *field*. Within this position, and with some localised support from her direct supervisor, her combination of experience in industry (and the ability to authentically bring this experience to bear on the development of professional skills and habits of mind in her students), and her rigorous approach to teaching development, became strategies for consolidating her place in the *field*, and for pursuing her own agenda of interests. Crucially, it was the effect of her *habitus* for working in the *field* that made possible the set of practices (and the body of PCK behind them) that were observed.

The following chapter gives a description of the events of the week of the case, including detailed excerpts from observation of her teaching sessions that give a picture of her teaching practices, and excerpts from interviews which demonstrate her attitudes and beliefs concerning teaching and her wider role as an engineering academic. Her apparent Pedagogical Content Knowledge is analysed for its contents and composition. A description and analysis of the site in the *field* in terms of Bourdieu´s notions of *field* and *capital* is then given. Finally, the pertinent characteristics of her specific *habitus* that allow for this configuration of PCK to occur at this site in the *field* are presented.

8.1 - Background of the case

The participant for Case Study A worked at a research intensive, ¨Group of Eight¨ university, the same site as for the pilot study. The case study took place in 2014, whereas the pilot occurred in 2013. Some data from the pilot is included in the discussion of this case, as it was not practicable to separate the points discussed and views expressed in initial interviews from those of case study, especially as the participant´s habitus, including her beliefs, opinions and activities, were largely unchanged from one year to the next. The interviews conducted during the case constituted a continuation of the conversation that began during the pilot interviews. The pilot data is therefore relevant to understanding the data of the case study. This is not seen as a confound because both the pilot and the case study interviews captured data about the participant´s own perspective in and on the field, which were not seen to change between the time of the pilot and that of the case.

At the time of participation, the participant had achieved tenure and had been working at the university since 2001. She had been promoted to Senior Lecturer in 2012. The participant also had significant experience working in industry since 1987 as a structural engineer specialising in concrete, and continued to work privately in a consultancy capacity. She continued to hold positions on a number of industry boards. She completed her technical PhD in 1995. At the time of the case study she was employed in a nominally 80% fractional appointment, but with what she described as a ¨double teaching load¨ (Pilot Participant B Interview 2).

This participant was selected for the case study based on her high degree of interest in teaching, reported through the pilot stage of the research. She was known to me through my collegiate networks, however, I had never worked with her directly before interviewing her in the pilot stage of this research. The details of her teaching practices were not known to me prior to the case commencing, and I had formed no specific expectations about what practices would be seen during the week of the case. The case study took place part way through Semester 1 in which she was teaching the first year Statics course (a notoriously challenging course for students, often with high failure rates at some institutions) and a fourth year capstone design course. She was also supervising fourth year project students and PhD students.

The institution for this case has a considerable reputation based on its research output, and as such is considered as a research-intensive institution, with academic staff generally expected to undertake ongoing research activities. Despite this, during the case study the participant expressed little interest in the research aspect of her role, choosing instead to undertake increased contact hours with students in order to be able deliver her courses more effectively and to directly improve her students´ learning. The participant explicitly stated that her main interest in her job is in teaching; specifically, to improve her students´ learning outcomes. She stated explicitly ¨I want to one day teach a course where no one failed, that´s my goal every year¨ (Pilot Participant B Interview 1).

As with all of the case studies, Participant A was followed for a week during the teaching semester. During this time, she was observed in all teaching related activities and as many faculty activities as possible (where researcher attendance was permitted), including meetings with a research group and with other staff. Interviews were also conducted with the participant and documents were collected relating to teaching activities (such as assessment documents and teaching resources). A total of 13 teaching sessions were observed during the week, in which observation notes were taken, as well as a number of photographs and audio recordings. Audio recordings were taken for the purpose of capturing the tone, style and pace of lecture activities. Observed teaching sessions included lectures, tutorial sessions, student consultations and supervision meetings.

A large volume of data was produced for this participant, in particular because during interviews she had a lot to say regarding the topics of discussion. Similarly, observations of the numerous teaching sessions revealed much that was relevant to the PCK construct, as will be seen in the discussion of the data below. The data that are presented in detailed excerpts below are used for the purpose of ¨pattern explanation.¨ (Sturman, 1997, p. 62). Here, pattern explanation refers to ethnographic explanation of ¨patterns of human thought and behaviour¨ that are present within a given culture (Fetterman, 1998, p. 1). Wherever possible, contrary data are also presented to give a fuller picture of the nature of the case. However, most often it was found that the participant´s beliefs and attitudes proved to be stable and consistent. By the end of the week of the case, saturation of the data was being achieved, in the sense that the same phenomena were repeated, with no new phenomena being discovered.

8.2 - Description of the week of the case

Table 24 (following) lays out the activities that the participant took part in during the week of the case. The green fields indicate the observed teaching sessions which the participant ran. The one light green field shows the lecture that was run by a guest lecturer for the participant, who also happened to be the participant´s direct supervisor and Head of School. This session was intensely Socratic in style and accorded well with the participant´s own approach to teaching the course in question, as it was focussed on encouraging students to apply judgment to ill-defined design problems. Although this session was not run by the participant herself, it was highly relevant to her overall approach to the course in question and she was in attendance for this lecture, in part to see how her students responded to the guest.

The yellow fields of the above table indicate times in which unstructured discussion took place between the participant and the researcher, or observation of her interaction with other academics. The orange fields show sessions which the participant attended but the researcher was not permitted to observe. Finally, grey fields indicate the times for which there were no activities that were observable. In addition times shown in this table, semi-structured interviews took place between the participant and the researcher in the weeks before and after the week of the case, as per the protocols that are provided in Appendix C.

As can be seen from the table, the participant used lecture sessions, supported by interactive tutorial sessions, for both of the courses that were observed. Despite the use of lectures, the approach to teaching seen in these sessions was not purely theoretical, didactic or transmission focused. Each of the lecture sessions included considerable time spent on questioning of students (for which students were required to give answers before the activities would proceed), group discussion activities in which the students were the ones talking, physical demonstrations and examples from professional practice in industry. Similarly, tutorials were structured to emphasise interaction among students and staff, and were based on loosely structured activities that students needed to work on themselves with support from the teacher/s.

The schedule includes six tutorial sessions for Statics, each of which the participant ran herself in groups of 100 students. She had chosen to run these sessions personally in each week of the semester, instead of allowing them to be taken by tutoring staff, because she wanted to ensure they were run the way that she felt was necessary to help her students learn the subject matter successfully. The fact that the participant had elected to take these six hours of tutorials each week dramatically increased her contact time with the students.

Table 22 also shows a significant amount of time dedicated to activities that count towards the ¨service¨ aspect of her workload allocation. For example, she served on a number of faculty committees concerned with course and program design, and said she was able to do so based on her overall knowledge of the curriculum for the structural engineering discipline. She also took part in a teaching and learning development committee, and was involved with a research group who were working on a research project with an educational focus. In discussing the service aspect of her role, she said that she was able to tailor her service activities according to her own interest in teaching. In this way she was able to get ¨credit¨ from the faculty for activities that were concerned with teaching, and to make the service related tasks that she was obliged to do personally interesting and relevant to her focus in her role.

Table 24 - Timetable of activities for Case Study A

<table>
<tr><th></th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>7.30-8am</td><td>Discussion with participant while walking to lecture</td><td>Participant discussion with HoS who is guest lecturer on the way to the lecture</td><td></td><td>Discussion with participant before lecture</td><td></td></tr>
<tr><td>8-9am</td><td>First year Statics lecture

Modelling ¨second moment of area¨ theory using ruler and keys</td><td>4th Year Design Lecture

Topic of Fire Safety by Head of School (4th year capstone design course) - Socratic lecture style observed</td><td>Discussion with participant while walking to lecture</td><td>First year Statics lecture

Junior academic who will be teaching Statics next semester observes the session</td><td>Office time for participant (catching up on emails, and to be used as needed)</td></tr>
<tr><td>9-10am</td><td>Supervision meeting with beginning PhD student</td><td rowspan="3">4th Year Capstone design workshop session

10 minute debrief with tutors following the session on student progress, teaching issues to be resolved</td><td>First year Statics lecture

¨Angel of the North¨ example</td><td>Discussion with junior academic following lecture</td><td>Repeat contact session (tutorial) for first year Statics</td></tr>
<tr><td>10-11am</td><td rowspan="5">Office time for participant (catching up on emails, and to be used as needed)

Participant advised that some of this time was spent preparing for tutorial sessions later in the week for Statics (organising physical models to be used for estimating locations of centroids)</td><td rowspan="2">Consultation time with first year Statics students</td><td>Faculty meeting (not observable)</td><td>Repeat contact session (tutorial) for first year Statics</td></tr>
<tr><td>11am-12pm</td><td></td><td>Repeat contact session (tutorial) for first year Statics</td></tr>
<tr><td>12-1pm</td><td>Teaching and Learning Committee meeting (not observable)</td><td>Supervision meetings with thesis students</td><td>Contact session (tutorial) for first year Statics

Using physical shapes to estimate location of the centroid</td><td>Meeting with another academic for 4th year capstone design course - discussion of design brief for assessment purposes</td></tr>
<tr><td>1-2pm</td><td></td><td></td><td>Repeat contact session (tutorial) for first year Statics</td><td rowspan="2">Office time for participant (catching up on emails, and to be used as needed)</td></tr>
<tr><td>2-3pm</td><td>Meeting with research group about an educational research project</td><td>Teaching and Learning Development Program meeting</td><td>Repeat contact session (tutorial) for first year Statics</td></tr>
<tr><td>3-4pm</td><td colspan="5">Participant off campus after 3 each day (due to 80% appointment)</td></tr>
</table>

8.3 - The nature and composition of the participant´s PCK

For this participant, her PCK was found to be a complex and compound construct, with multiple component knowledge areas interacting with each other at all times. To aid in the discussion here, the table below presents a summary and descriptions of the aspects of PCK that will be discussed. The definitions presented in this table are derived from the codebook used for analysis of the data.

Table 25 - Aspects of Participant A´s PCK with descriptions

Node	Sub-node	Description
	PCK	
B1 - 0rientations to teaching and learning (including but not limited to):		The participant´s beliefs about the purposes, goals and methods for teaching in the discipline
	Socratic approach	Posing questions to students and encouraging students to ask questions about the learning
K1 - Using knowledge of students´ understanding in the discipline (including but not limited to):		Knowledge about students´ characteristics, what they know and likely areas of difficulty
	K1 a) Sense of belonging	Understanding when and how students identify with belonging to the discipline
	K1 b) Characteristics of a cohort or group of students	Understanding of the characteristics of a cohort or group of students that are relevant to how they should be taught
	K1 c) Known areas of difficulty for students	Specific conceptual difficulties that the teacher is aware that students encounter
	K1 d) Understanding and prediction of student misconceptions	The specific misconceptions that the teacher is aware that students have about a topic or concept
	K1 e) Specific understandings of a topic	Understanding of how students should understand a topic in a particular way that allows them to progress with the subject matter or avoid confusion
K2 - Using knowledge of discipline curriculum		Knowledge about the horizontal and vertical curricula for a subject, including the teacher´s understanding of the importance of topics relative to the curriculum as a whole, enabling teachers to identify core concepts, modify activities, and eliminate aspects judged to be peripheral to the targeted conceptual understandings

	Understanding of specific learning objectives and skills to be acquired by students	The participant can explicitly identify specific learning objectives and skills that students need to acquire in order to have learned well.
K3 - Using knowledge of instructional strategies and representations (including but not limited to):		Subject specific and topic specific strategies that are consistent with the goals of teaching for this teacher
	K3 a) Modelling expert thinking and working processes with verbal reasoning	Explaining or verbalising thinking and working processes in order to demonstrate how an expert would approach a task that is relevant to what is being learned
	K3 b) Choosing to not provide direct answers or explicit instructions to students	Encouraging students to discover processes and outcomes for themselves by avoiding giving explicit instructions or specific answers to direct questions
	K3 c) Explaining links among ideas	Explicitly highlighting how concepts or procedures link to one another or form part of a whole
	K3 d) Previewing future learning	Explaining what will be covered in future learning events and how it links to what is being learned now
	K3 e) Giving real life explanations of concepts)	Participants give real life explanation that relate the concepts being learned to professional practice in industry, allowing the students to better understand bot the concept being learned and the nature of professional practice
K4 - Using knowledge of assessment of disciplinary learning		Knowledge of the dimensions of disciplinary learning that it is important to assess, and knowledge of methods by which it can be assessed, including knowledge of specific instruments, approaches or assessment activities
K5 - Using knowledge about teaching for practice in the discipline		Knowledge of how to teach about the nature of practice in industry, and the skills required in professional practice, including knowing how to establish links to and demonstrate relevance of teaching topics to future professional practice
P1 - Reflection on action (including):		Knowledge elaborated and enacted through ¨reflection on action¨, undertaken after teaching practice is completed and concerning the need for expansion or

		modification of their planning or repertoires for teaching a particular topic
	Discussion or consideration of teaching development or change	Additions to, reorganisation or modification to existing teaching practices and knowledge about teaching practices for specific topics or concepts or for teaching generally
P2 - Integration of component PCK knowledge areas (as above)		Integrating multiple components of PCK and enacting them within a given teaching context

8.3.1 Orientations to teaching in the discipline

B1 - The participant´s beliefs about the purposes, goals and methods for teaching in the discipline

The participant´s approach to teaching was clearly predicated on a constructivist epistemology of teaching and learning, in that she saw the role of the teacher as to help students to arrive at an appropriate and workable understanding of the relevant topics and concepts by developing the skills and processes appropriate for the discipline, as will be seen in the following discussion of her PCK. She based her teaching practice on a focus on and extensive knowledge of students´ conceptions and misconceptions of topics and concepts, developed through practice and reflection on practice. She was frequently able to discuss the exact nature of student understanding in reference to a specific concept to be learned or a specific learning objective for engineering, but also talked about the amount of time and sacrifice in other areas of her role that was required to be able to develop her teaching in this way.

A further dimension of her orientation to teaching was that that her style was consistently Socratic in nature. She was more often seen to be asking the students questions and supporting them in answering them than providing answers in the form of content. Even when tasked with delivering lectures for the Statics class, her style remained Socratic and was peppered with links to future professional practice, as wells as links to previously learned material or future learning. She was also able to focus on and demonstrate the skills and processes relevant to practice during these lecture sessions. It was this approach that helped her to avoid reverting to a focus on the ¨right answer¨ or on purely theoretical content for her courses, an approach which she identified as a key barrier to helping students to learn that making mistakes and learning from them was more useful and relevant to engineering practice than rote learning. However, she said that it took a conscious effort not to revert to teaching her topics in the way that she herself was taught. In her view, using Socratic techniques helped to prompt students to use and build on their existing knowledge and understandings, to interrogate those understandings for appropriateness and accuracy, and to learn to see themselves as a key resource for finding and applying information to engineering processes.

The constructivist epistemology of learning and of teaching engineering that this participant both discussed and demonstrated formed a foundation to which other aspects of her PCK knowledge are interconnected. For example, it was this set of beliefs values and attitudes that made it possible for her to focus so clearly on her students and their conceptions of the subject matter, as well as on the ways in which component PCK knowledge areas interact to continually improve teaching.

Her focus on developing student understanding and her goal of providing the best possible opportunities to all students resulted in her spending six hours per week delivering interactive and hands-on contact sessions to relatively small groups of 100. The purpose of doing these sessions in this way was to get students to work more actively on example problems, including discussing them with both herself and their peers. In talking with her about her decision to do the sessions in this way, she said that the cohort that does Statics in second semester has their tutorials in the lecture theatre and the tutors just work through problems on the visualizer and the students are passive. She said that they do more example problems and work faster, but she is convinced that this is less effective than her own method because the students are not working through it themselves whilst interacting with others. In her view students need to actively rehearse the process of doing calculations and this rehearsal needs the support provided by having to communicate about it, both by listening and watching others, and discussing and demonstrating what to do.

This view of learning is one that fits well with the principles of cognitive constructivist and social constructivist learning (Killen, 2007). The decision to take this approach to her teaching practice demonstrated that she had thought through the implication of her underlying epistemology of teaching and learning to the point that it affected her actions, both in terms of her specific teaching practices, and her decision to prioritise aspects of her role the way that she did. Without such a thoroughly developed perspective on the nature of teaching and learning, she would not have been able to see the possibilities for developing her practice, or indeed for strategizing for position in the *field* with a focus on teaching the way she has done. As such, her orientation to teaching and learning in her discipline cannot be considered as separate or distinct from her *habitus* in the *field*. A useful approach may be to think of her orientation to teaching as the rationale that forms the link between her epistemology and her actual teaching practices.

8.3.2 Using knowledge of student understanding in the discipline

K1 - Knowledge about students´ characteristics, what they know and likely areas of difficulty

The participant´s knowledge of her students, both in terms of their specific understandings of topics and concepts, and their general characteristics and perspectives, was apparent throughout the case study. This element of her PCK knowledge was ubiquitous enough that it consistently occurred hand-in-hand with examples of PCK knowledge which will be discussed later under different headings for the components of PCK that follow. Many of the examples of the knowledge components of PCK given herein are taken from sections of data that simultaneously show a number of different knowledge categories of the PCK construct. This is recognised as essential to the nature of PCK for this participant and therefore discussing one example under the heading of one category is not intended to convey that this section of the data shows only one category. Instead, the most appropriate examples from the data for each category will be given, but further examples may be seen again in later discussion under different headings.

For Participant A, knowledge concerning her students was observable in a number of ways. These include knowing about areas of difficulty and specific misconceptions of topics and concepts, the specific understandings of students that students tend to have for a particular topic or concept, understanding students´ sense of belonging as both students of the discipline and future engineers, and general characteristics of student groups and cohorts and the perspectives on learning which affect how they go about learning.

8.3.2.1 Sense of belonging and characteristics of cohorts

K1 a) & b) Understanding when and how students identify with belonging to the discipline and understanding of the characteristics of a cohort or group of students that are relevant to how they should be taught

Fundamental to this participant´s knowledge of her students was the idea that students should be helped to develop a sense of belonging to the discipline of engineering, and to the role of being an engineering student, particularly in large classes. She saw this as central to how students could engage with the learning in a way that would foster success. For this participant, academics simply interacting with students and seeing their capabilities was one method that could help students to achieve this:

> I think the students really benefit from having an academic in classes, and having an academic who is actually engaged and doing things with them, I think that is really positive…I think that [gives students] a sense of belonging. I think they come from high school, and it is very easy for them to be completely lost in the sense that they are completely anonymous. And even though you have no hope of actually remembering even 100 names, you would hope that by the end of a couple of weeks you would probably have spoken to every student at some level. And there have been studies in the States that show that students who make contact with…academic staff are more likely to do well…When people look back and reflect on their time at university it is

> often very much about the people that they interacted with. With these really large classes, there is just no interaction, it is so impersonal and I just think it is important for the students to actually feel somehow connected to engineering in some context. (Case Study A Interview 2)

The participant believes academics have a responsibility to interact with their students to help them to identify with the discipline, despite working with large class sizes. It is also important for them to work towards understanding the material to be learned in terms of how the students themselves encounter it:

> I think back to when I was first here, I probably had unrealistic expectations. I probably didn´t appreciate the diversity of skills in the cohort, the level that they come in with, and I think that is a real problem for academics…you are an academic for a reason, it is because you are academically inclined, and you sometimes can – you have to work really hard to actually put yourself in a position to think like someone who is struggling to understand a concept. (Case Study A Interview 2)

This attitude of responsibility to the students means that an understanding of students (rather than an understanding of the content to be taught) forms the basis on which specific teaching practices should take place, so that teaching can be matched to the needs of someone who is, for example, struggling to understand a concept. It is the teacher´s responsibility to make the material and concepts accessible to them, and not solely the students´ responsibility to make the best of what information they are given. This viewpoint illustrates what the participant has in mind with her goal of service to ¨the future generation of professional engineers¨ (discussed further in section 9.4).

The participant often discussed the characteristics of her students both in terms of the present generation of students, and for specific groups or cohorts. For her, these characteristics were continually informing how teaching should occur. In discussing why the teaching of engineering should not fall only to guest ¨experts¨ from industry, she says:

> Practicing engineers have unrealistic expectations of what undergraduate students are actually capable of. They forget what skills level you can expect from a 20 year old sitting in their Semester 1 fourth year class. (Pilot Participant B Interview 1)

Part of the job of an engineering academic, therefore is to know how to meet the ability level of the cohort whilst still presenting challenging, realistic and relevant learning. For this participant, part of achieving this balance, indeed part of the teacher´s role, is to develop a workable understanding of their students and how they learn. The participant was able to demonstrate in a number of ways how she had done this. For example, she was able to distinguish between the commonly seen learning behaviours of different genders and different cultures for specific teaching sessions. In the following example, she discusses how this kind of knowledge should be fed in to instructional decision making, such as how to run activities in a contact session:

> In a laboratory class what often happens is you have an international group and the girls end up just doing the calculations, and the boys do [the rest]… [I like tutors to be able to] look at those obvious things of looking at someone who is not engaged with their group and can you actually have strategies of getting them to engage with their group, because, again, first year success really depends on students´ abilities to actually make friendship groups and form study groups and all those sorts of things. So even in the contact sessions that I run that are sort of like tutorials, there is a reason we do them in round tables - we actually make them do things like solve a problem as a group, so they have to pair up and come up with a solution and then as a table come up with a solution, and then we look at different solution methods. So I like tutors to be aware of those sorts of issues as they can show up in a laboratory. (Pilot Participant B Interview 1)

Here we can also see how her knowledge of the factors affecting student success intersects with her knowledge of instructional methods. In other words, her choice of teaching methods here relates to how she knows she can help her students to succeed.

The participant could also identify the ways in which students commonly engaged in *inappropriate* learning practices or attitudes, and the ways in which academics could act to ameliorate this. For example, the most common view of success among students focussed on the attainment of grades, rather than skills for future professional practice:

> I would love the first two years of engineering to be pass fail. Stuff the grades, get rid of the grades, make it about getting the basic skills that you need to go on and do third and fourth year and let third and fourth year be graded. That´s never going to happen, but they are so driven by marks, and say ¨I have only got 63% and I think it should be 65%.¨ It is not about learning, for a large chunk of the cohort it has stopped being about learning. It is about getting that bit of paper at the end that says I have got a Bachelor of Engineering. (Pilot Participant B Interview 1)

In a similar vein, it was participant´s view that students often wanted to take shortcuts to producing a product, rather than thinking about working through the process of learning. The participant gives the following example:

> The students want to do everything on computers…but I have just given the fourth years a rip because we have just started to do the second phase [of their project] and they are getting on to do some more analysis and actual design which they are more comfortable with, and they will all plonk themselves down in front of computers and they are setting up these models, and I said but where is your plan, how are you actually… ¨oh I am doing this.¨ And I said, no, no, you sit down with a piece of paper and you draw how you think you are going to model that structure, you put in what you think the section properties are, and what the material properties are…and if you haven´t done that before you sit down you will get that wrong, because you need to actually do that thinking. That planning is really important…Because they will come

> and they will throw you a computer print out and say my answers look wrong [and I will say] yeah, show me how you modelled it and they will throw me another page, and I say no, show me the diagram of how you modelled it…but they won´t come with that, they will come with computer printouts. (Case Study A Interview 2)

Also:

> They don´t like drawing by hand because they want it to be pretty and accurate, but hand drawing helps them to think it through [and so this is what I make them do]. (Case Study A Observation Notes)

Despite these drawbacks to the students´ general approach to learning, the participant´s attitude to her students was still overwhelmingly positive, for example saying that despite the fact that maths tends to ¨fry their brains¨ (unlike for previous generations), ¨they deserve to be supported in what they find difficult,¨ and was confident that they would be ¨good at something else instead¨ (Case Study A Interview 1). She also consistently sought to help them find their way to resolving their learning difficulties and conceptual challenges, and saw her role as that of needing to support them in doing so.

8.3.2.2 Known areas of difficulty for students, specific conceptions and misconceptions

K1 c), d) & e) Specific conceptual difficulties that the teacher is aware that students encounter, and specific misconceptions that the teacher is aware that students have about a topic or concept

This focus on students enabled the participant to develop more specific forms of teaching knowledge about how students understand and respond to specific topics and concepts and to approach her teaching accordingly. For instance, in reference to Statics she states that:

> You learn which bits they struggle with, and so I know that they are really weak in maths, I know that integration fries their brain…it is not a

> tangible thing [and so they struggle with it], but after we have done the beam design and we use what we have just done, it will start to make a bit more sense to them. (Case Study A Interview 1)

Because of her awareness of this difficulty, she is able to modify her approach to such topics and even how she discusses them with her students. During a Statics lecture she was observed to say to the students:

> Right now this seems like a mathematical oddity, I know that, but this is very much leading into beams and how we design beams...It will be a bit like those first few weeks when everything was new and it didn´t yet make sense where we were going with it. (Case Study A Observation Notes)

In speaking like this, she communicates to students that she has made an effort to understand their thinking and what it is like to be a learner at this stage. She also modifies the specific tasks that she asks the students to do, once she recognises where they need more support:

> The concept of a moment is the thing that they struggle with the most and actually that is an issue because that concept is through everything you do in Statics, so this year I taught moments differently. (Case Study A Interview 1)

And:

> Based on what I was seeing in the classes in the last few weeks, I really need to get them – they were struggling with this concept of what a centroid was and once you have done it physically it makes sense, so I thought that I really need to make up models and [get them to consider the notion of a balance point in reference to a physical object]. (Case Study A Interview 1)

In this example, the participant had observed a specific misconception that students were having; that is, that centroids could fall in negative space for a shape. Consequently, she had devised a teaching activity using physical models to address this. She also had planned how she would use a similar question on a formal assessment later in the course to see how well this activity had helped students to modify their understandings of the concept. This is one example of how knowledge of student understandings fed into her knowledge of specific instructional methods, which then fed into her knowledge of appropriate assessment methods for the discipline, in turn feeding her processes of reflection on and integration of knowledge for PCK. This will be discussing in greater detail under the heading of Integration (9.3.8) below.

In a further example, in discussing her specific approach to teaching a topic with another academic, she stated that she was happy to change one particular aspect of how she explains a particular process for Statics, but for another aspect she was not willing to change because doing so would cause the students confusion and cause them to make errors later on. She then gave the other academic her reasoning for why she presents the material the way that she does for this specific concept, because she knows how students will understand it and work with it, including their specific misconceptions and how to avoid them. This was a conversation that was observed ¨on the fly,¨ so it was not possible to capture more details of the exchange than this. However, this example does show how the participant´s knowledge of her students´ understandings directly underpins her rationale for why she teaches in the ways that she does for specific topics and concepts.

A number of other observations gave evidence of the specific nature of this knowledge of student understandings or misconceptions of concepts. In discussing with another staff member the wording of an assessment question, she was observed to state ¨I always put the wording of unknowns in the positive direction, otherwise they get confused.¨ Later in the same conversation she mentions ¨students always think this is always x or y, when really it is the distance to the centroid¨ (Case Study A Observation Notes). She then went on to give an example of how she believes her approach helps students to develop professional intuition. Here, even theoretical concepts are linked with professional habits for this participant, and she is mindful that they are taught in a way that can develop students´ understandings accordingly.

In a conversation about students using YouTube videos to figure out the working processes for Statics related concepts, the participant commented that students often do this if they want to see a different way of working through the problems, in which case the videos are really useful. I asked her if this can tend to trip them up, because they are seeing it done in different ways. She replied that for some students yes, for some no, because ¨If they understand the concepts it doesn´t matter, but if they are just following a formula it does¨ (Case Study A Observation Notes). It is clear from this that she is aware not only what kinds of problems students run into, but the reasons why it happens.

In an observation of a Statics contact session, the participant also commented to me that she was noticing some students working ahead on calculations that they haven´t been asked to do. She says this is a good thing because it shows that they are testing themselves. She also comments that when they get quieter (like they were at that moment) is when you know that ¨they know how to do it. They just get on with the calculations.¨ In her classes at least, ¨they talk to each other when they get stuck¨ (Case Study A Observation Notes).

In summary, the participant´s understanding of the students´ conceptions and misconceptions, especially for Statics, is thorough. This is made possible because she understands not just the content of her teaching, but how students themselves will understand and conceptualise that content, and, as a result, how it can best be taught.

8.3.3 Knowledge of discipline curriculum

K2 - Knowledge about the vertical curricula for a subject, including the teacher´s understanding of the importance of topics relative to the curriculum as a whole, enabling teachers to identify core concepts, modify activities, and eliminate aspects judged to be peripheral to the targeted conceptual understandings

Intricately related to the participant´s knowledge of her students was her knowledge of the curriculum of structural engineering. When discussing the nature of her subject matter, she tended to give explanations in which her knowledge of the discipline curriculum was explained in reference to how the students need to respond to it:

> First year really is the first time that they have to think of their Maths and Science. One of the reasons it is hard is because Statics or Applied Mechanics needs or uses skills from Maths and skills from Physics and sort of mixes them all up together and they get to do Applied Mechanics. So it is probably the first time the students have had to stop what I call compartmentalisation of their knowledge. They actually have to be able to grab the bits and pieces that they need without me sort of saying ¨and now integrate by parts¨… There is just an expectation that they have those as a base skill and they know when they need to go and grab them. (Pilot Participant B Interview 1).

Her understanding of the curriculum was apparent in three ways. She demonstrated knowledge of vertical curriculum, in terms of how different courses fitted together at the different year levels, to make up the program as a whole. She was also fluent at discussing how different concepts fitted together to make up learning as a whole within each of her courses. Second, she frequently discussed how her knowledge from industry affected what she believed needed to be taught in the classroom. Finally, she could express quite explicitly, the specific learning objectives that students needed to achieve at any stage of the curriculum.

8.3.3.1 Vertical knowledge of the curriculum

In discussing how the curriculum was structured vertically, she demonstrated a comprehensive awareness of each stage of the engineering program.

> The other two courses that I teach are civil only, so that´s when students have broken into their disciplines and they are now identifying as a civil engineering student. So the second year reinforced concrete subject is for those students the first time that they have done what they consider to be real engineering. So the first year is about giving them, you know, they do [a teamwork based project course] which is about giving them

> some professional skills and communication skills and teamwork, they also do a lot of maths and what I call Engineering Science. So core Engineering Science. They come into first semester second year and it is still a lot of engineering science so they do Structural Mechanics, they don´t do any engineering design. And they get to second semester and they get to my course, and my course is the first course that is heading towards a design course. So it is the first time that they get introduced to things like the building code, and legal requirements, so it requires that they have skills from statics and skills from structural mechanics, so it has a couple of prerequisite subjects but then it is really introducing them to a professional design experience, so again that´s a challenging course for them because they haven´t done that before. (Pilot Participant B Interview 1)

She could also clearly express the cumulative nature of learning in the program, and how specific problems at an earlier stage could affect students throughout the program. For example:

> The big thing about first year Statics is when you look at it through the cylinder of curriculum, it impacts on - I worked it out one time - on something like 60% of our follow up courses. So by the time it weaves its linkage through the curriculum it is so absolutely fundamental that you need a good understanding and a poor understanding early on actually has quite long term problems. (Pilot Participant B Interview 1)

It is interesting to hear the participant using the phrase ¨weaves its linkage through the curriculum¨ (Pilot Participant B Interview 1), as for the other cases in this research, the participants did not demonstrate awareness of the curriculum as a whole, at least in such a coherent sense as for the present case study.

This participant was equally able to demonstrate her awareness of linkages between concepts within courses or topics, such as in the below quote for a Statics lecture:

> This is all tools, we are getting to the point that we can calculate the second moment of area – but we have to get across this theory before we can get there. (Case Study A Observation Notes)

The participant was combining her knowledge of curriculum in this instance with the instructional technique of previewing future learning (part of her knowledge of instructional methods, as per 9.3.4.4), to help students to deal with the concept at hand. In another instance during Statics, the participant used the sculpture the ¨Angel of the North¨ as an example from ¨real engineering¨ to show how the concepts being learned at the time would apply in the students´ future professional practice. This example is discussed in detail in considering the Integration process of her PCK (9.3.8), but crucial to this use of this example was how her knowledge of curriculum influenced *when to introduce* this example. During this example, the participant referred to the links between the future concepts to be learned in the course, the concept currently being worked on, and the concepts already learned in earlier weeks. All of this was done in reference to the processes used for design on an actual engineering project and acted to tie each of the relevant concepts together in her explanation. Here, her knowledge of how concepts and topics fit together within the Statics course helped her to use this example to greater effect in the course.

8.3.3.2 Industry perspective on the curriculum

Another aspect of this participant´s curriculum knowledge, was the view that professional practice in industry was the foundation for what the curriculum should contain. It was through relevance to and applicability in industry that the contents of the curriculum became important and relevant to students´ overall learning. This viewpoint is seen in how she presents topics in certain ways, as well as the learning objectives that she can specifically identify as important to student learning. In a discussion with another academic about teaching Statics in a particular way, the following interaction was observed. It is presented here from observational notes of the conversation:

The participant is talking to a junior academic about why she adheres to conventions of teaching topics in particular ways; because these conventions are adhered to in industry for discipline-specific reasons. She gives an example where software engineers came in to redo a computer system for a civil engineering firm, not realising that certain conventions were in place because they affect how civil engineers go about their work. They changed these processes within a design software package because they thought the design conventions were not important. ¨There are reasons why we do things the way we do them.¨ She talks about how different conventions relate to how different types of engineers work and says ¨that´s why I don´t employ mechanical engineering students as tutors¨ (because they have different ways of working and this causes problems that they are not aware of because they don´t understand the discipline specific reasons for the conventions). (Case Study A Observation Notes)

In another example of a discussion about a specific topic that was being worked on in Statics, the rationale for the importance of the topic within the curriculum was expressed in terms of its fundamental use in industry. In fact, this concept was seen as so fundamental to engineering practice that it needed to become an automatic recall of knowledge for students:

Participant - This topic is some serious maths you have got to learn how to do – I described it to someone as a bit like learning your times tables, you have got to be able to, you just have to know how to do it and it is very difficult to make it interesting and exciting.

Interviewer – Is there a certain amount of drill that is just necessary?

Participant – this bit is drill, yeah…Our industry people expect that kids can just do this and that is something that they as a generation tend to struggle with. The notion that there is some stuff you just have to know how to do and you have to be able to pull it out of your brain as and when required, like two fours are eight, you have to be able to do it like

> that. You ask my husband who is a traffic engineer, who hasn´t done structures in thirty years, and you say to him what is the second moment of area of a rectangle and would say ¨b h cubed on twelve.¨ So, there is some stuff that you just have to know. (Case Study A Interview 2)

Industry perspectives were also seen to influence how she allowed her students to work, for example, requiring them to use ¨hand-analysis¨ to develop reasoning, rather than relying on AutoCAD:

> When you work for me in industry, I never let you near an AutoCAD. And this is what industry are telling me, when they tell us about what is good about our graduates, they tell us this, and when they tell us what is bad about our graduates they tell us that you don´t hand sketch enough, that you jump on the computer too often, so this is why we are not allowing AutoCAD, this is why we are making you do hand analysis first before you jump on the computer, so this is why we have actually set these hurdles for you to jump through, because industry has actually told us, you need to do this. So that does actually - it doesn´t always satisfy all of them, but it does go a long way to them saying ok maybe she does know what she is talking about...But also it means they know they are not going to be able to argue me into changing my mind. No, I have got a really good reason for why I have done it and it is kind of non- negotiable. (Pilot Participant B Interview 2)

Here, it was the rationale provided by practice in industry that meant the participant viewed learning to hand sketch as a vital part of the curriculum.

8.3.3.3 Specific learning objectives

The participant was observed to identify a suite of specific learning objectives that arose out of her conception of the curriculum of engineering. Not only did she consistently demonstrate that she knew what she wanted the students to be able to do as a result of their learning, but she also demonstrated that she knew how to elicit it through specific approaches to teaching. The following examples give evidence of this.

In discussing the progress of a teaching session of capstone design that I was observing, the participant commented that the students were asking questions in the class that they should have been dealing with in week 2. She said that put this down to not enough work done on working the process of design in the earlier stages rather than a lack of conceptual understanding on their behalf. She commented that ¨they need to learn to act as professionals rather than as students.¨ In clarifying this statement she commented that a key skill is in dealing with ambiguity in the design process by ¨asking questions, reflecting, hypothesising, reflecting again, asking more questions,¨ as they saw the guest lecturer exemplify in the morning lecture on fire safety. Here she describes specific abilities that the student needs to be able to demonstrate, as well as an overall iterative process that is crucial to effective design for engineering. In the same class a student asked her if extra documents can be submitted. The participant replied no, ¨because the task is to filter out or sort out what is key and what is not¨ (Case Study A Observation Notes).

The participant was also observed to share with students examples of particular learning objectives being put to use for practice. For instance, she tells them that she and former staff member had been disagreeing over design of a beam. After half an hour´s discussion they couldn´t reach an agreement. She went on to explain to the students that this was because that particular beam was outside the scope of the building code, so ¨you have to use engineering judgment and we just didn´t agree.¨ In summing up she said to the students ¨this is where ambiguity can enter the design process.¨ Commenting to me about this example, she said that the learning for the students is in ¨dealing with that ambiguity and that openness, and they need to justify and make a judgment and make a decision and back it up and be prepared to say well I think that x is right and articulate why you think x is right.¨ (Case Study A Observation Notes).

Many of the participant´s stated learning objectives related closely to the skills involved in professional practice for structural engineering; crucially here, her principles for practice in industry (in the following example ethical responsibility of an engineer) are directly linked to the specific engineering processes that allow professionals to enact these principles in their practice. This example also shows how she links the principle of professional practice that she is seeking to engender in students, to the specific learning objective being pursued, as well as linking this to how she approaches the teaching task:

> The one that I have is this notion of ethical responsibility of an engineer and what that means in a design office. Really simple things, like developing self-checking skills. Students sort of see that as oh boring, but my approach - and it is actually within my course profiles - is that as an engineer, that is actually part of your responsibility to develop those skills and so that informs a lot of what I do, particularly how I teach a couple of topics in Statics, I actually talk to them about the need to understand those topics from a big picture level because it then gives them this ability to gross error check. (Pilot Participant B Interview 1)

She is also clear about some of the responsibilities of students as future professional engineers to their employer and their clients, such as the ability to select and use information judiciously:

> It is part of being a professional engineer… that your employer and your client employs you to filter out the dross. They expect that you are technically competent and that you can filter out the garbage and only deal with the stuff that is important. I said so you actually need to develop that skill somewhere along the line and here is an example of where you need to filter out rubbish, and I pointed out rubbish that some of the students had put up last year, so it is going to be interesting to see whether or not I get better quality stuff in terms of sustainability and ethics this time, than I got…Those resources aren´t completely applicable, there were parts that were… so it will be really interesting to

> see if people just take that resource holus bolus and just chuck it in, or whether they are actually critical and pull out the good bits which is what they are supposed to be doing. (Case Study A Interview 1)

The specific learning objectives she pursues also echo her orientation to teaching engineering as a whole, for example in this instance of discussion with a student about engineering not being about finding the ¨right answer¨ to every problem:

> [A student said to me] ¨I don´t know how you are going to mark it when you don´t even know what the right answer is.¨ And I said ¨I don´t need to know what the right answer is. We don´t need to know what the right answer is, you know, we are looking at if you are able to justify your decision, if that is based in good judgment and good engineering options, I said there is no [right] answer.¨ (Pilot Participant B Interview 1)

8.3.4 Knowledge of Instructional Strategies and Representations

K3 - Subject specific and topic specific strategies that are consistent with the goals of teaching for this teacher

The participant´s use of knowledge of instructional strategies and representations was one of the most obvious aspects of her PCK, and one that constantly drew on information from the other knowledge areas for its composition. It is perhaps not surprising that this aspect of her PCK was so readily apparent, as it is the aspect of PCK that is most easily visible in the activities that take place during teaching sessions. However, it was the nature of this aspect of her PCK knowledge that is so characteristic for this participant.

A number of specific instructional techniques were observed to be used by this participant during the case study, even during lecture sessions. These techniques are seen as significant for her PCK because they relate to and embody other aspects of her PCK and her overall orientations to teaching in the discipline. For example, her focus on both asking questions of her students, and prompting her students to ask questions themselves, reveals the Socratic and constructivist nature of her orientation to teaching in the discipline. Similarly her use and timing of real world examples for the topics and concepts being taught reveals the presence and importance of her knowledge of teaching-for-practice in the discipline.

The specific techniques she used include explaining links among ideas or concepts, referring to past or future learning of concepts, choosing not to provide answers to questions or explicit instructions in certain situations, giving real life examples of explanations of concepts and modelling expert thinking and working processes with reasoning. This section will also discuss the participant´s use of free body diagrams as a teaching tool for the discipline, as it was her particular use of these that demonstrates her approach to theoretical or content knowledge instruction for structural engineering, and provides a useful point of comparison to Case Study B, later.

8.3.4.1 The use of Free Body Diagrams as a teaching tool for the discipline

Despite the fact that the participant was tasked with teaching in a content heavy, theoretical course such as Statics, and that she did so by giving two lecture sessions a week (on top of tutorial classes), the way that she used free body diagrams (FDBs) as an instructional tool reveals an approach that was much more student-centred than it first appeared, and with a focus on modelling of expert thinking and reasoning. Although any Statics class would be seen to use FBDs in support of calculation, it was the way that the participant used them which was so characteristic of her approach.

When performing the calculations for example problems for the Statics class, the FDB was a focal point for the students to work from in *focusing on process rather than theory*. This is where the use of the FBD differed from that of other instructors, because the way that she used the FDB was to make explicit the working process and the reasoning for it, and as a tool to rehearse the process of calculation that she wanted the students to be able to both understand and replicate for themselves with other problems. Importantly, the way the diagrams informed *how* to do the calculations, and the way that the calculations related to the diagrams was always made explicit, meaning that the diagrams could be used *to better effect* to support the process of calculation for the students.

Whilst demonstrating the calculations for an example problem, the participant would physically refer to and alter the free body diagram (FDB) as she worked through the calculation process. For example, she would highlight in colour the section of the diagram that she was currently considering, and show the mathematical notations for that section alongside the diagram, whilst talking through how she was doing the calculation for that section. At the end of doing the calculation for that section, she would again refer the students back to the diagram so that the link between the calculation and the physical object was explicit. An example of a highlighted FBD during working is shown in the image below (Figure 38).

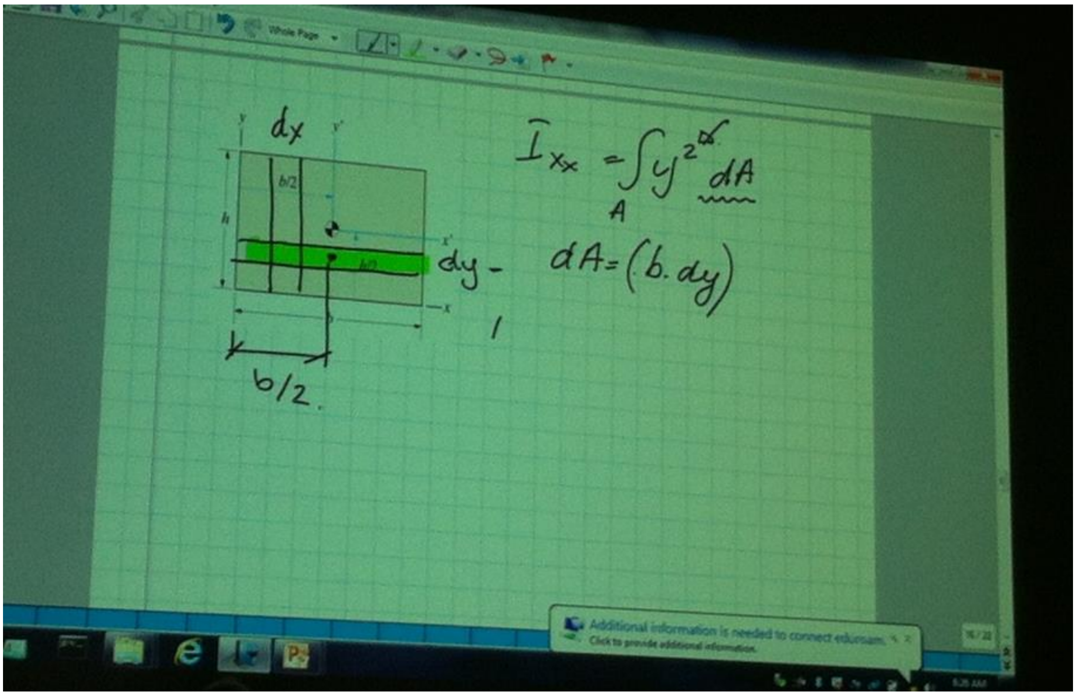


Figure 38 – Diagram being used part way through the process of calculation, using highlighting on the FBD to focus on part of the shape

She would also verbalise her thinking during this process with such phrases as ¨now I know I need to look back at my diagram again, to see which force I need to account for next,¨ and ¨put your hand at the cut and look what you can see to the right.¨ (Case Study A Observation Notes). In explaining her working processes verbally she was able to give the students important tips to help them remember how to work through the process independently. The following examples captured during example problems show some of the ways that she did this:

> Look at the left hand FBD, write out the three FBDS [for that shape]; horizontal, vertical, equilibrium, and take moments of that cut. That is a key point for how to do this.
>
> Hopefully the first thing you did was put some axes down, because you always need a reference point
>
> The reason you take moments about the cut is because if you get the axial forces or shear forces wrong, it doesn´t actually affect the result for moments, so that is a good engineering habit.
>
> It doesn´t matter which FBD I use, you must get the same answer – otherwise something has gone wrong and you won´t get equilibrium
>
> Let´s deal with the forces first, I have this force… (highlighting on the FBD while she is talking about it)
>
> So we want to break this diagram down into composite shapes…I am going to step you through the process graphically and then we will do it in numbers
>
> It sometimes helps to record what you are calling each area. (Case Study A Observation Notes)

The participant was also explicit about certain decisions that students would have to make when working with FBDs and gave them some considerations for how to make them. For example, in demonstrating for students the different ways they could break down a FBD into its component shapes she was heard to comment ¨it doesn´t matter which way you do it, you will get the same answer.¨ In another example, she was writing out calculations and explaining how and why they were set up that way against the free body diagram as a reference (Case Study A Observation Notes).

When I asked the participant about the free body diagram is used in her discipline of structural engineering, she explained:

> They are probably the most fundamental starting point for anything in structures. So you use your free body diagram to define the everything acting on a structure and then that is how you design that structure – forces, applied loads, reactions, and it is from something as simple as a retaining wall in your backyard through to a reinforced concrete dam…It defines everything that is acting on the structure and it has got to be in equilibrium, so if you leave anything off that FBD your answer will be wrong. (Case Study A Interview 2)

In terms of how using free body diagrams affects the work of a structural engineer, she explained:

> It is ingrained in what you do…if I want that dam to not slide down the hill and kill people, I have to be able to resist all those forces…[Your FBD] does actually help you to think about what information you need, what information do you have, what information don´t you have, what is going to be critical in terms of that structure failing. (Case Study A Interview 2)

I also asked the participant how she therefore uses free body diagrams when teaching:

> The way I think I approach it is I actually take them through what I am including as I draw that…In class today…we will be doing internal bending moments in beams and the free body diagram actually becomes a generic one, it is valid for a distance along the length of a structure, so I actually do that one [in hard copy on the visualiser instead of on the laptop]. Normally I use the laptop, but this one I always do on the visualiser, because now we are doing beams so we want to plot how it changes along here (showing an example diagram), so I actually want to be able to do this (drawing on diagram and

> demonstrating her explanation), ¨let´s take this cut and this is our free body diagram and we have got to include everything that is - and that cut, if you look at how it is valid from, when does it change, it changes from the minute that load¨...so that´s how we sort of build up what was on this free body diagram, we were sort of going back and saying what can you see, if you can see it you need to include it in terms of the forces on it...it is so basically fundamental, and engineers draw them all the time without actually saying it. I mean, I do, so I say it to the class that I am going to draw the free body diagram, but by the time they get to third year and fourth year they should be doing that without me going draw a free body diagram. It should be ingrained in them. (Case Study A Interview 2)

In this respect, the use of the FBD as a teaching tool reveals that the participant conceives of her subject matter not as a set of content or theory to be exactly reproduced by the students, but as a set of processes involving decision making to arrive at an appropriate and workable outcome for practice. The FBD itself is a process rather than a static object because she needs to show her students how she develops it. Whilst she does aim for her students to be able to replicate the processes she uses, she does so by focusing on them understanding FBDs as expressions of these processes; of the decisions to be made and the reasoning behind them, *rather than solely as the artefact of a set of static mathematical formulae to be learned and reproduced by rote*.

Supporting this view is the fact that that her overall approach to the subject matter involves including the students as much as possible in working the process, and by encouraging them to undertake independent practice with support. For instance, during calculations for example problems in class, she would often ask the students to prompt her in the next steps of the process. During face-to-face tutorial sessions in which she encouraged the students to interact with each other and her, the students would try working on problems themselves with support from tutors, before they worked through the process (using highlighters to emphasis steps and decisions in reference to FBDs) as a whole class, as shown Figure 39 below.

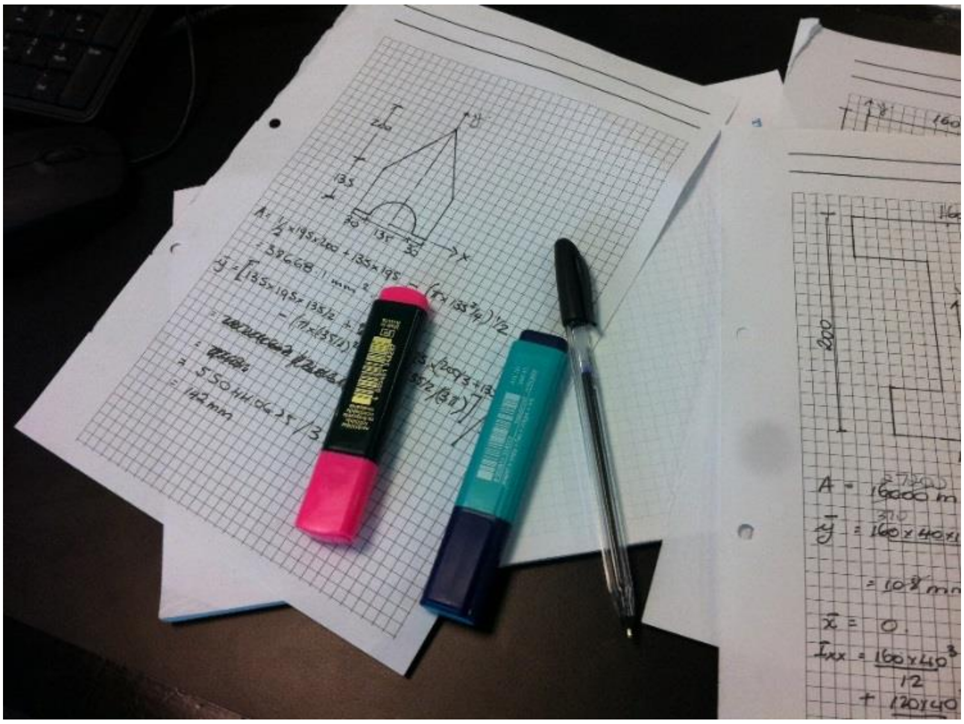


Figure 39 – A worksheet from a tutorial session, showing the labelled FBD and highlighters for working through the calculation

Similarly, when a student approached her for help with doing calculations during her consultation time, the emphasis was on rehearsal of the process and decision making. This interaction taken from observation notes, is a microcosm of her approach to teaching Statics concepts:

> A first year statics student has asked for help to go over a particular concept. The student starts by saying exactly what she is having problems with. She knows where her conceptual difficulty is. She is visibly anxious about her difficulties with the concept. The participant talks about strategies to approach the problem...¨You do this, then you start to thinking...¨
>
> ¨You are far better off doing more cuts that are easier.¨
>
> ¨When you go through the process of seeing where you are going to cut, can you show me what you are going to do...¨ The student explains aloud how she works through an example problem. Participant asks

student if she is physically covering the sections of the FBD as she works through.

¨You have to make a judgment and that is difficult.¨ Points out that ¨you learn by practicing.¨

Student asks which example problems are best to work on. Participant gives advice on where to look and says to start simple.

The student is saying once she works out what cuts to make it is simple. Participant says to her she is not in as much trouble as she thinks she is. ¨It takes practice to go from novice to expert. It is like learning to drive; there is a reason why they say it takes 100 hours.¨ Student comments how on the exam there isn´t time for trial and error. Participant says ¨that is why practice is so important, it gives you the confidence to see what to do and what not to do.¨

They discuss exam strategy, perusal, choosing what to leave aside, reviewing the whole exam and seeing where the marks can be won within an exam question. Participant advises student to practice under exam pressure because that is the real test of whether you understand the concepts or not.

¨It is ok to take cuts that don´t work. Use that to identify why it is not working. You will know it already. At least you know that something is wrong, it is when you don´t know that something is wrong that you have problems.¨

Discussing conceptions of problems against learning strategies - what makes sense after a centroid has been worked out: ¨you can look at it and it makes sense.¨

Student - ¨When I can´t see things it is hard to work out what I am doing.¨ (Case Study A Observation Notes)

In this example, the interaction with the student in a one on one setting involves the participant focusing on the student´s process of working, and supporting that process with an emphasis on practice. Even the learning strategies for the student are explicitly considered, despite the theoretical nature of the content.

8.3.4.2 Modelling expert thinking and working processes with reasoning

K3 a) - Explaining or verbalising thinking and working processes in order to demonstrate how an expert would approach a task that is relevant to what is being learned

The approach to instruction described above also demonstrates another key aspect of the participant´s instructional strategy; that is, to model expert thinking and reasoning, and to explicitly discuss the role and habits of professional engineers with the students. This was seen to be done in a conceptual way, for example, making explicit the processes and decisions involved in calculating second moment of area, but it was also seen in reference to professional skills and thinking, for example in the fourth year capstone design course, in which the emphasis, even in assessment, was on ¨what is professional¨ rather than how a design would be graded.

When explaining working processes for Statics the participant was frequently observed to make comments such as ¨here´s a rookie error¨ or ¨this is a good engineering habit¨ (Case Study A Observation Notes). This reinforces the relevance of a topic or concept being learned to future professional practice, but is also an inclusive habit that lets students in on what it is like to be an engineer. This in combination with explicit discussion of the entire working or thinking process for calculating the second moment of area for a real shape, as depicted by a free body diagram, acts to demonstrate for students how it is that engineers work and think. Crucially, it also encourages students to focus on *how something is being learned* rather than purely on what is being learned, which discourages the passive or rote acquisition of content knowledge and emphasizes the skills development that it is consistent with the participant´s orientation to teaching in the discipline.

At times this approach to instruction was as simple as peppering explanations with phrases such as ¨all good engineers will have an estimation before they do the calculation,¨ or ¨engineers always go by the written dimensions¨ and ¨most engineers will have a sense of what the answer will be before they calculate it¨ (Case Study A Observation Notes) At other times, the participant was seen to prompt students to develop their own professional judgment or skills. For example, when a student asked her if an aspect of their design would work or not, rather than giving a direct answer, she replied ¨you will have to make that assessment yourself,¨ and then went on to give them a set of considerations that were relevant to their decision, for example, head heights for the carpark ceiling (Case Study A Observation Notes). Whenever possible, the participant tried to confirm the students´ thinking processes in reference to engineering skills, rather than telling them that the solution they had was correct. A detailed example of this approach from the Statics class will be discussed in the Angel of the North example under Integration, later in the chapter.

In a final example for this approach, the participant talks about how she realized that her fourth year design students ¨did not know how to read an engineering drawing.¨

> A lot of them had never seen one before so in my second year class I got a friend who runs a consulting firm to give me some copies, nothing fancy, just of a boring reinforced concrete building, and so I took a couple of sets down and in groups of ten I just sat down with the students and went through this is what an engineering drawing looks like when you draw it up, this is what you can expect to see, this is how you lay it out, these are the plans this is how you interpret them. And it was great because on those drawings were beams slabs and columns which was exactly what they were learning to design. So even though

> there was no assessment related to that [activity] they loved it, they thought it was great. (Pilot Participant B Interview 1)

By modelling an aspect of professional practice in this way, the participant was able to reestablish the relevance of the students´ current learning to their future professional life, the reward for which was an increase in student engagement. As the participant stated ¨it was interesting because the students really engaged with it…with stuff that wasn´t even assessable¨ (Pilot Participant B Interview 1).

8.3.4.3 Choosing not to provide answers or explicit instructions

K3 b) - Encouraging students to discover processes and outcomes for themselves by avoiding giving explicit instructions or specific answers to direct questions

Related to this approach of modelling appropriate working processes and reasoning, was the participant´s decision to not always answer student questions or give them explicit instructions for how to work on something. This was especially apparent during the design course, where the emphasis was decision making based on judgment and justification, as discussed earlier. The participant was happy to support the student by explaining some of the professional or design considerations that should be taken into account when making a decision about the question that they posed, but was not prepared to tell them if their solution was right or wrong.

She also deliberately made the assessment for this course open to allow for this, and was open with the students about the reasons for this. In one exchange that was observed, a student approached her to ask a question about how to meet a particular criterion for their design of their carpark. He said that their group could not think of what to say about the sustainability or ethics of their design. The participant replied that there may not be anything in their project that is of relevance to that criterion, but that she had left it in to leave room for this aspect of professional practice. She also said that she had left the marking rubric simpler this year in order not to be too prescriptive about the design process or outcomes. She said to the student that she knows they want more detail than this ¨but in industry it is not like that, you might get one paragraph to build a whole tender out of¨ (Case Study A Observation Notes). This non-prescriptive approach is clearly designed to prompt students to deal with the ambiguity inherent in this aspect of the discipline, and to help them to avoid a focus on the ¨right answer.¨ Whilst this is a logical approach for a design course as opposed to a theoretical course, such an approach was also seen in use for Statics, for instance in the earlier example in which the participant deals with a student´s difficulties during a consultation.

8.3.4.4 Explaining links among ideas and previewing future learning

K3 c) & d) - Explicitly highlighting how concepts or procedures link to one another or form part of a whole, explaining what will be covered in future learning events and how it links to what is being learned now

Despite embracing ambiguity and a lack of prescriptiveness for the design aspects of the curriculum, the participant was always careful to support students in managing concepts, and this was often done by redirecting their attention to process considerations that could support their judgment and justification. As well as the fourth year course, it was also done in the Statics course by continual reference to the links among concepts. The participant used references to both past and future learning in order to highlight to students how concepts fitted together in the curriculum and to remind them of their relevance. For example, in introducing a new topic in Statics, the participant talked about the calculations that will need to be used in designing a structure, and how parallel axis theorem (to be learned later on in the semester) will allow them to do that. She also referred back to a concept that was just learned in the previous topic, and how it leads in to new theory, before going on to explain how to do it. In another example of an explanation of a concept, she said

> That is a property we are going to use when we start looking at parallel axis theorem. The parallel axis theorem says that…and it is really powerful, it is how we are going to calculate…This is all leading up to being able to… (Case Study A Observation Notes)

In some other examples, the participant explained the need to calculate the property IXX in millimetres in terms of ¨what it allows you to do later on.¨ Similarly:

> We are doing this because we will be able to use the second moment of area to design a little structure (later on in the course). (Case Study A Observation Notes)

In another instance, she said to the class towards the end of a lecture on centroids: ¨the thing I forgot to mention is why centroids are so important.¨ The participant goes on to explain how centroids establish the neutral axis and this ¨will help with more and more concepts as we go.¨ Later in the week, the participant referred back to the processes used in the truss section of the course. ¨We are now going to do the same for beams, but with more unknown forces¨ (Case Study A Observation Notes). This continual linking among the concepts in the course signals to the students something about the nature of the concepts by *how* they link together, thereby helping students to build appropriate and workable conceptions of the subject matter. It also demonstrates how the various concepts are interlinked and cumulative in nature, which reinforces the need to continually consolidate existing learning through ¨practice, practice, practice,¨ before moving on to subsequent topics. This could be argued to demystify the subject matter somewhat for the students, as it makes it more clear to them how they can learn to better cope with the cumulative difficulty of the concepts.

8.3.4.5 Giving real life examples or explanations of concepts

K3 e) - Participant gives real life explanation that relate the concepts being learned to professional practice in industry, allowing the students to better understand bot the concept being learned and the nature of professional practice

Another important feature of the participant´s instructional strategies was her use of real life examples and explanations. These occurred in two ways: in reference to real physical objects and in reference to real instances of professional practice. At times, both were referred to together.

In Statics, which is a notoriously difficult course for first year engineers, the participant used real examples of physical objects to help students build their intuition with concepts. For example,

> Before the first tutorial class, before I had even done the concept in lectures, we did the concept of a moment in the hands-on class. So, I brought in 18 muesli bar boxes and chopsticks and they made little three dimensional axes out of chopsticks and blu-tac, and they put their muesli bar boxes on the table and they had to actually think if I push it this way it is rotating that way…so I actually physically [work through the concept] I don´t know if that has helped them, but we will find out as we go... (Case Study A Interview 1)

By working from observation of a physical object, the participant was seeking to establish an empirical basis on which student understandings of concepts could be gradually built. Similarly, in one example from a lecture, working on example problems was interrupted to consider a physical object. In the following example, the students needed to build a conception of how the physical object compared to an abstraction in the form of a free body diagram:

> The participant includes in the lecture what she calls an interlude. She holds up a plastic ruler with keys hanging from it. Changing the orientation of the ruler so that it bends differently, she asks the students ¨what did you see? Draw me the free body diagram for that structure, and I want you to explain to me why what you see is different.¨ Students are given time to work on the activity. A while later the participant calls their attention back to the ruler and asks ¨what sort of structure is that at the moment?¨ One student answers cantilever. She replies ¨what sort of structure is my hand?¨ The participant is giving students the chance to answer but then prompts them with different questions or wording of the question to get more or better responses. ¨What is the free body diagram for that structure? What sort of load is at the end of that structure? Is it a uniformly distributed load?¨ A

> student answers no. Participant continues ¨no, it is a point load.¨ The participant goes on to draw the free body diagram on the visualizer.
> (Case Study A Observation Notes)

In this instance, the purpose of using the physical example was to support students´ processes of abstraction in considering the concept at hand. The basic premise here is that students will have both a better understanding of the physical world and a better understanding of the concept itself, when they can make a stronger link between the real object and how it is represented in the abstract. The participant was explicit about when and why she used physical objects to support students´ conceptions of abstract concepts:

> It is difficult [for students to grasp some of the more abstract concepts] because they want to know where do you use it, but to be able to know where you use it we have to do all this other stuff – so you actually have to keep saying to them I know, trust me. That is why I sort of bounced the ruler around, you know, that was why some were starting to get it, some were starting to say this is the way the area is distributed, and it`s like yeah, that is exactly what it is. And then when I go through the beam design and then at the end we actually design a skateboard and I actually bring a skateboard in and it is a really simple structure and they can actually do the calculations in class and I actually bring a copy of the European design code [so that they can see] you don´t just go and design a skateboard, you actually have certain criteria that you have to meet, so let´s have a think about what those criteria might be. So that brings it nicely together. And they actually have to use the properties we have been learning to calculate. (Case Study A Interview 1)

In a final example for this type of instructional strategy, the participant was seen to develop an entire activity for a tutorial session in response to the fact that she identified that students were struggling with the concept of centroids. She had physical objects made up for which the students needed to first estimate and then calculate the location of the centroid. The task was to balance a shape on a finger in order to find the approximate location of the centroid and then to see if they could get a result from calculation that would match. As with the other examples, the aim was to build students´ intuition with the concept, because comparing estimation and calculation allowed the students to see the physical logic behind the concept. For example, when they discovered that they were unable to balance a shape on their finger because the centroid fell in negative space, their workable understanding of the concept would be improved. Supporting this use of physical examples, the participant also spent time in class to comment that ¨engineers always rely on estimation¨ because it is a means by which they can self-check their work, an important engineering skill (Case Study A Observation Notes). Once again, this reference to professional practice acts to reinforce the relevance of concepts being learned, as well as *how they are being learned*, to future practice for the students themselves. A further example of this will be seen in discussion of Integration for this participant.

These examples present some of the most pertinent data for this participant about her particular instructional strategies. Many more similar examples could be provided, however it is clear from this discussion that the selection of particular strategies was the result of a logical process for this participant of developing her teaching practice. Specifically, she used information from other knowledge areas such as her knowledge of students´ understandings, her knowledge of discipline curriculum in terms of specific topics and concepts, and her knowledge of teaching-for-practice, to develop increasingly responsive and effective learning activities. As will be seen later (9.3.7), the process of reflection on action, had an important role to play in enabling her to do this, as this was the process that supplied information feed into this knowledge category.

8.3.5 Knowledge of Assessment of Disciplinary Learning

K4 -Knowledge of the dimensions of disciplinary learning that it is important to assess, and knowledge of methods by which it can be assessed, including knowledge of specific instruments, approaches or assessment activities

Knowledge about assessment of disciplinary learning had an important role to play in the participant´s overall PCK in two distinct ways. First, it included information about how to most appropriately assess student learning; that is, the best ways to get information about *how* and *how well* they had understood the topics and concepts (as opposed to what grades students had earned). Second, as a result of assessment processes, the participant was able to extract information from this knowledge category that could inform future teaching, as well as informing other knowledge categories, such as knowledge of student understanding, and knowledge of instructional strategies.

In respect of what she knows about how to assess learning for her discipline, the participant was clear about how the information she got from assessment could be used to gauge what her students had understood about the subject matter. For example, in reference to how student use free body diagrams in assessments for Statics:

> When I look at my marking they get allocated marks [for FBDs] two ways. One, directly, because I say your free body diagram is your interpretation of the structure, and if you have misinterpreted what I have meant, I don´t know. So if you have got a diagram and I can see that you have misinterpreted I can work out whether it is that you had no idea what you are talking about, or I can go oh yeah, I understand why you looked at it the way you did - there are levels of getting that stuff wrong, one is that you had absolutely no idea, one is yeah ok, I understand, I know why you have made that mistake, so there are different levels of [understanding and misunderstanding]...and you get ones where you think you have got no idea. So there are marks

> specifically allocated to the free body diagrams, when I mark a problem, and they know that, and then I say to them but it is a double whammy, because if you don´t do a free body diagram, one you don´t get the couple of marks...and then if you make a mistake I have got no idea how you made that mistake, so now I can´t give you any part marks because it´s rubbish, what you have given me is rubbish, and I have got no reference point to see why you got it wrong. But if you have got a diagram I can look at it and [see where in the process you made the mistake] but the rest of this is right, and I know why those bits are missing. Ok, I can make a more balanced or a fairer grading, but if you have got no diagram you lose the marks for the FBD, and if you got it wrong, it is just wrong, I don´t know if it was because you had no idea, or if you got it wrong because you left off a simple force. Every year there will be a student who will think they are better than that and they will just put two lines of working. (Case Study A Interview 2)

From this example it is clear that the participant knows both what to expect from student answers to assessment, and how to read student answers for how and how much they have understood the relevant topic or concept. As a result, she is able to design assessments accordingly, even when the assessment instrument itself is not optimal for giving a genuine assessment of learning. For example, in discussing the multiple choice sections of exams, the participant acknowledged that these are not an ideal way to assess the students, but with such large class sizes and little time in her role allocated for marking, she has little choice but to assess with this method. However, she can design the multiple choice exam to give her more information than expected. By allocating full marks for the correct answer, and part marks for two of the wrong answers that result from common misconceptions or partial errors made by students, the students have the chance to get more marks than they otherwise would, and the participant has more information about just where they went wrong in answering the question. Because she knows the typical mistakes that students make in their calculations, she can see the relationship between the answer the student has selected and the nature of the mistake they have made. If it is a minor mistake, it is deserving of partial marks for the working out that they were able to do successfully.

Furthermore, understanding how common mistakes appear on exams allows the participant to provide the student with more feedback on the assessment than she would otherwise be able to:

> With my written exams I keep what I call an error code book, and so typically I know the five common errors that they make on any of my exams, and so I will actually just...[give a comment like] perfectly correct, nothing of any substance...and incorrectly calculated lever arm, or forgot to do this...you know there will be actual errors that people tend to make and they get an email that says dear [student name], your final grade was a 6, here is a summary of how you went on your exam...so that is something I have spent a lot of time doing after the exam and the students really appreciate that because the top ones can see that they did actually just make a few minor mistakes, and the ones who actually failed atrociously...because they will be going why did I fail...(Pilot Participant B Interview 1)

This approach also allows the participant to collect information for her own reflection processes, which can then be used to inform future teaching practice. In one example of this, she cites an instance where student responses on an exam were so ¨all over the place¨ that she couldn´t see where they were going wrong with the topic being assessed. As a result, she used this example problem during the class in which students were using physical models to support estimation before doing calculations. In discussing this choice, she explained that for this question on the exam only 60% of students got it right, whereas 90% should have because it is a foundational concept for the subject. By doing the exercise in class, she wanted to see if she could figure out where they were going wrong with the concept, and to see if working on it in class would have an effect on the students´ grasp of the concept. When the students sit for the next exam she will make a similar question, specifically one that is symmetrical, because a lack of symmetry adds to student confusion of the concept, even though it doesn´t have an effect on the process they should use. The participant comments that it becomes apparent in exam results that this type of shape ¨seems like it is obvious when it is not¨ (Case Study A Observation Notes). Thus, she was using information from assessment to feed into her reflective processes, which could then feed into her knowledge of student understanding and, in turn, reinforce her knowledge of assessment in the discipline. This is an example of the integration process that will be discussed in greater detail later (8.3.8).

8.3.6 Knowledge of Teaching for Practice in the Discipline

K5 - Knowledge of how to teach about the nature of practice in industry, and the skills required in professional practice, including knowing how to establish links to and demonstrate relevance of teaching topics to future professional practice

Discussion so far of the participant´s PCK has shown the ubiquity of instances in which professional practice in industry was pertinent to her teaching practices. There were many examples throughout the case of her discussing the relevance of learning to practice in industry, and vice versa. Her instructional strategies embodied a process of modelling professional skills and processes, and enabled students to better identify with being an engineer. Similarly, most of the explicitly discussed learning objectives were directly related to skills for practice. In this sense, her teaching encompassed the Mode 2, experiential knowledge emphasized by Hills and Tedford (2003) and by the EA Stage One Competencies (EA, n.d.) Furthermore, developing the skills relevant for professional practice was a fundamental focus for this participant in carrying out her role as an academic through her teaching activities. Therefore, teaching-for-practice in the discipline became a fundamental feature of this participant´s *habitus*, so much so that she was reluctant to identify more as a teacher than as an engineer, even though teaching is what she spent most of her time doing.

As will be seen in discussing her *habitus* (8.5), the participant´s background in working in industry, as well as her many years of experience in teaching in the discipline had given her a view of teaching engineering that involved combining expertise from each of these roles. In her view, skill in engineering practice and skill in teaching engineering needed to be carefully balanced during teaching if students were to be properly prepared to enter the engineering workforce upon graduation. Experience in industry was also seen as lending authenticity to teaching about topics and concepts. In discussing her overall approach to her teaching practice, it is clear that a focus on teaching-for-practice was the basis of her overall approach:

> When I teach Statics – I think about how it was taught to me and how I teach, and I sort of flip it over – the first thing I do before I introduce a new topic is I show the real world examples of what we are going to be talking about. So if I want to talk about designing trusses, I don't start with the theory and then at the end show them the pictures. I show them here is a roof truss and you slept under a roof that was held up by a roof truss, and take them from the simple that they can relate to, to the much more complex. And then you can talk to them about things that you have done as a design engineer, and jobs that you have done, so that they can actually – there is a certain amount of respect you can get from students because you – it´s that whole tangible nature, you know, you can drive through the [name of tunnel] and that´s my tunnel, I designed that. (Pilot Participant B Interview 1)

In agreement with the students, the participant also clearly believes in the link between authentic engineering experience and authentic teaching, and explains how this informs her teaching practice:

> I actually tell them the story of when I had a structure collapse, and I got a phone call at six o´clock one Saturday morning saying your retaining wall has just collapsed on site , you need to get down here, and I felt just complete and utter panic, because I had been at the retaining wall the day before with some undergraduate students doing field work and I

> think oh my god I´ve got it wrong, oh my god, I´ve made a mistake… and I thought no, no, no, I did all these things, I checked it. And it hadn´t been me, the bloody contractor had parked a massive bit of equipment on top of the retaining wall which they are not supposed to do, and that collapsed it, so it wasn´t me at all. But I say [to the students] you never want that feeling, never, ever, ever…so that is something that does actually inform teaching – most academics would not have had that phone call, most academics won´t have had that responsibility. (Pilot Participant B Interview 1)

The participant is also clear about her belief that it is the fact that she possesses experience from industry that allows her to teach the way that she does, for example, enabling her to make links between learning and practice in a way that gives context to what students are doing:

> I am actually really upfront with them, I actually tell them in the very first lecture this is who I am...you can actually say these are the things I have done, this is who I have worked for, these are the jobs I have been doing, so I am actually quite explicit...and then because you have done it, when you talk about things, you can say when I was working in industry this scenario happened - so I had that with the civil design students this year and I actually made them keep a log book. They hated it but I said no, no, this is what you do as a professional engineer, and I said I have got 15 years´ worth of log books sitting at home and I have seen my husband six years down the track say hang on, I did that problem when I was working on xyz for firm abc, and I have seen him spend half a day going through and finding his work log book that had all this really important stuff that saved him a week of work. And I have had to pull out log books when people have queried decisions that we made - I was able to pull it out and say no, there´s the log book, these are the decisions that were made, this was the discussion, this is why we did x, there´s the proof. So, you are actually able to weave in scenarios about why are we ask you to check your work [for example]...we are

> getting you to do this, and this is why we are getting you to do this.
> (Pilot Participant B Interview 2)

Thus, teaching-for-practice is both a beginning and an end point for teaching engineering for this participant, in that it forms the basis on which she builds her teaching practice, as well as providing the Mode 2-related outcomes of teaching that she wants to see her students develop for use in industry. Her view encompasses an ontological, rather than just an epistemological dimension, in that she seeks to address through her teaching engineering ´ways of being´ not just engineering ´ways of doing.´

Overall, the participant´s approach to teaching-for practice accords with Shreeve´s (2010, p. 694) category of ¨balancing,¨ which describes a relationship between teaching and practice in which ¨there is a symmetrical relationship…with a fluid exchange between both.¨ According to Shreeve, compared to categories of this relationship in which there is a one way of flow of information, with a focus on transmission of knowledge, this approach to the relationship between practice and teaching is much more productive for learning because:

> [within this category] there is a much greater insight into the contexts of practice, the meaning or the ontological dimension, of understanding process, emotion and social context. The [teacher] enables the world of practice to be accessed and experienced, either as replicated for the student through learning activities, or as a vicarious experience where practice is described, where [teachers] bring in elements of their practice into teaching. (Shreeve, 2010, p. 700)

Despite the fact that this relationship between teaching and practice can ¨imply tension between the ideal participatory activities that practitioners would like and the constraints an institutional context might impose¨ (Shreeve, 2010, p. 699), as will be seen in the *field* characteristics for this site in the *field* (8.4), it can also lead to ¨a greater awareness of the ways to experience teaching…and can lead to conceptual change as a teacher¨ (Shreeve, 2010, p. 700). As will be seen next, this participant´s focus on processes of reflection on teaching suggest that for her this has indeed been the case, as it is in her processes of reflection that we can see teaching development and change taking place.

8.3.7 Reflection on Action

P1 - Knowledge elaborated and enacted through ¨reflection on action¨, undertaken after teaching practice is completed and concerning the need for expansion or modification of their planning or repertoires for teaching a particular topic

As has already been seen, an emphasis on reflective processes was an important part of the participant´s teaching practice. For her, reflection took place intuitively in responding to how students were learning, but it was also built in to planned feedback and evaluation activities performed routinely (over and above standard generic course evaluation activities). Combined, these reflective activities allowed the participant to continually review and renew her practice: from a micro level of how to ask the students questions in a specific session, to the macro level of ongoing course redesign. In discussing how her teaching had changed over time, the participant was clear about the differences that the changes had made:

> When I first began teaching, content was king…If I think back to what I was like when I was first here, I would have stock standard explanations of concept one, and that was my explanation. I think over the years I have probably tried to think of more variety, and I am probably more prepared to go out on a limb and try something on a whim if I think the class is not understanding something, so I think...and I think probably when I first started I just talked and talked and talked at students, and it was all about content, not understanding. So that has changed a lot. Now it is more about - I look back now at what I cover in first year Statics, things like worked examples, I do less worked examples but spend more time talking about them or doing them two ways, or stopping and repeating stuff, and going back and saying...so I cover less, but I cover with more depth and more prepared to go back and look at things as we need to… I would rather do one worked example well and

> look at it from a couple of different perspectives, and do it thoroughly and do it aggressively and do it in a well-structured way so that it develops, it tells a story and they get a better understanding... [If you look back at what I did originally] I just went so fast, and it is pretty hideous. (Case Study A Interview 2)

Over time, with this shifting emphasis from transmission to student comprehension, the participant´s classes became much more interactive, allowing her to be more responsive to student needs, and to adapt her teaching activities accordingly:

> I gradually took some worked examples out [of lectures], and I made my tutorial classes much more interactive, so the examples that I don´t do in class now I actually do in the tutorial classes - I get the students to do them…So I get them to work in groups and [for example] what they are going to be doing this week is that the topic that we did last week which was on how to calculate the centroids of shapes…and I actually have some cardboard cut-outs of shapes and they will actually balance them on their finger and try to work out where the centroid is and then do the calculation, so they will actually get that physical sense with the calculation, so I have taken examples out of the lecture and put them into an active class. That is probably the biggest change [in my approach to teaching]. (Case Study A Interview 1)

For this participant, information to feed into the reflective processes that led to change came from a number of sources. First, she made as much use as possible of routine teaching evaluations in which the students provide her with comments and feedback on teaching:

> The most effective teaching nominations that the faculty gets the high achieving students to do, I actually find them quite useful because they actually often in their comments point to particular things that you have done in a course that were instrumental. So they are a little bit more specific [than regular evaluations]. Some of the teaching feedback [is also useful to me]- not the number, I don´t give a stuff about the

> number anymore,…I did mine the other week but I said [to the students] ¨guys what is important for me is what you write in the short answer. If you are going to give this course a five out of five tell me why. If you are going to give it a one out of five, tell me why. Because giving me a one is useless if you don´t tell me why you thought it was terrible.¨ Trying to elicit that sort of feedback from students [is a really important source of feedback]. (Pilot Participant B Interview 1)

The participant also engaged in extra evaluation activities as part of an educational research project, which provided insight about the value of interactive sessions and about how teaching activities for specific topics needed to be modified to better address student difficulties with topics:

> I got my postdoc...to do some work, ask some questions of my first years and one of the things that came out was just how important those contact activity sessions were, and they were talking about how they hope that they do them in other years, and I hadn´t been. And they´re not exactly the same, so I have sort have taken that theme and changed them a little bit…Last year we did a meta-learning exercise, a learning inventory exercise and then they did a reflection on it… what came out of this reflection was that in week seven they just didn´t understand moments...so this year, based on that feedback, I introduced moments completely differently. I introduced it in the small groups, outside lectures, with a physical thing. So it is going to be interesting to see when they do the reflection exercise which will happen next week, whether or not if that has had any impact. It is hard to tell, I don´t know, but it is what they struggle with most. It will be interesting to see if it has had any impact at all, I just don´t know. (Case Study A Interview 1)

Importantly, this example shows that for this participant, evaluation, reflection and instructional redesign were all part of an ongoing, planned process. For this participant the process of reflection was never over, and in this and other ways she was committed to ongoing reflection and subsequent improvement of her teaching. For example, she also engaged in regular course renewal:

> I´m not one of those people that just churns out the same lecture every year, so every year I will look at - and some years there is not a lot of change - but like this year I redid almost everything in almost all my courses, I was just sort of bored, basically...Every year I try to look at my course, like what could I have done better, what could I have done differently, so that course renewal...So like this year in my reinforced concrete class, I completely changed the way I ran my tutorials, so I made them much more active, got them into a good learning space, got the group sizes down and got my tutorial attendance up to about 150 to 180 out of about 270 kids every week…things like that course renewal I think you have to, every year, you have to sit back when the course is done and dusted and you are less emotional about the semester, and say what worked, what didn´t work and think about what you want to do next time. (Pilot Participant B Interview 1)

Another opportunity for reflection on teaching and student learning that was seen during the week of the case was created by the participant herself in scheduling time to meet with the tutors for her fourth year design course. The participant told me that this time was set aside after the workshop sessions each week so that the teaching staff could ¨get on the same page¨ about common issues and misconceptions that students have and how to deal with them. In the meeting that was observed during the week of the case, the participant started by asking the other teaching staff how they thought the students´ conceptual understanding compared to the previous year. The tutors also raised the question of a specific design issue that the students were having with the assessment task, and how they should best respond to this. Such meetings constituted an important opportunity for the participant to access alternative perceptions of how the students were engaging with topics and concepts, as well as to gather information about the classes and instruction in those classes. The chance to discuss with other teaching staff is also an ideal way to facilitate the reflective process, because by sharing ideas and perspectives with other practitioners, the participant is required to explain the rationale for her approach to teaching and course design, and to consider how other staff can help her to implement the desired effects of this approach.

Other than these formal mechanisms for gathering information for reflection, there was a much more intuitive process of responding to students that was observed during the week of the case study. For example, the participant often commented about how she had noticed students responding to particular topics or concepts, where they were seen to be having difficulty, and the nature of their conceptions and misconceptions about the material. She also had the opportunity to revise her delivery of learning activities immediately, because of the six contact sessions for Statics that were repeated one after the other over two days. During these contact sessions in the week of the case study, the participant was observed to make slight but significant alterations to how she discussed and explained the activities with students in response to how effective they had been in the class before. This went beyond the choice of words she selected to present the activity and rather was a purposeful and iterative improvement of the exact presentation of a task. The most pertinent example of this was do with a shape for which the centroid fell in negative space. The students had been working with other shapes, balancing them on their fingers in order to aid estimation of the location of the centroid. For the shape with the centroid in negative space, this was obviously not possible, but the participant wanted to make this point as strongly as possible, to help the students to understand and remember this key conceptual issue.

For the first of the classes, she simply asked the students when the time came to balance the shape on their finger and they discovered that they couldn´t. This was not an unsuccessful technique, but in the next few sessions the participant tried to emphasise the point further by offering students a fifty dollar bet if they could balance the shape or not. This attracted slightly more interest from the students, but in the final two sessions the participant took this yet further and brought out a fifty dollar note and said ¨this belongs to anyone that can balance this shape on their finger:

> Participant: Who thinks this can be done?
>
> (One student tries)
>
> Participant: You can´t? Why can´t you?
>
> Student: because the centroid is out here (pointing to negative space)
>
> Participant: Exactly! The lesson we are going to take from this is…(Case Study A Observation Notes)

In this final revision of this particular instructional strategy, the students were observed to be much more attentive and interested in the outcome, as a result of actually seeing the money for the bet. Furthermore, delivering the activity in this way (as opposed to how it was delivered in the first class) creates a stronger link between the event in the classroom (which is particularly memorable for students) and the importance of the concept that it relates to. Through her questioning, the students were asked to come up with a conceptual explanation for a physical phenomenon that they had just witnessed. As a result, students are likely to be much more able to understand how the concept applies to the task of calculating a centroid for certain types of shapes, because the implications of the physical task of not being able to balance the shape were explicit during this final iteration of the activity.

In this example, the participant´s ability to engage in teaching development on the go to improve the success of a particular activity meant that she was able to optimise how it was delivered almost immediately. The ability to do this was no doubt underpinned by a deep-seated commitment to continual improvement of teaching, even at this level of detail. This commitment was explained by the participant herself in these words:

> It is an intentional choice [to teach in a way that was different to how you were taught]. And it is often a conscious effort to think oh I am not going to do it that way, I need to be doing this, I need to be doing this, because it is so easy to fall back into the habits that you are comfortable with…But there is always stuff you can learn about your teaching you

> just have to actually ask the question of the students. (Pilot Participant B Interview 1)

Thus, the importance of reflection to her teaching practice is clear. It was through such processes of reflection that her PCK was seen to be developed and developing. This reflection allowed her to continually interrogate her practices in order to arrive at an approach to practice that best reflected her foundational orientations to teaching in the discipline, and her *habitus* as a whole for teaching in the *field*.

8.3.8 Integration

P2- Integrating multiple components of PCK and enacting them within a given teaching context

So far, all of the aspects of this participant´s PCK, from her orientation to teaching, her component knowledge used for teaching, to her reflective process on teaching all combined in a way that was mutually reinforcing. This combination of the knowledge and processes making up PCK constitutes the final element of her practice that was apparent in the nature of her PCK; that is, integration.

In their original discussion of the concept of integration, Park and Oliver (2008) describe it as:

> The [components of PCK influencing] one another in an ongoing and contextually bound way. In order for effective teaching to occur, teachers integrate the components and enact them within a given context. The integration of the components is accomplished through the complementary and ongoing readjustment by both reflection-in-action and reflection-on-action. This implies that as a teacher develops PCK through reflection, the coherence among the components is strengthened. This strengthening reinforces their integration, which in turn facilitates the growth in PCK and further changes in practice (Park and Oliver, 2008, p. 280)

Because integration comes about through the combination of other aspects of PCK, it is observable in the data when multiple aspects of PCK are seen to occur together in an interconnected way. Many examples of this have already been seen throughout the discussion so far. In another clear example from her practice, the participant was seen to be using a number of PCK components together to deliver a highly effective learning activity for students in the Statics class. In this example, observed during a lecture session, the class had just finished working on the calculations for a particular shape. From this shape, the participant then introduced a real world example in the form of the ¨Angel of the North¨ sculpture, as a means of considering both the physical and professional implications of the concept that was just learned. This example was also linked to instances of future learning that the students will encounter. As can be seen in the images below, simply moving from the abstract form of the shape in the slide on the left, to the picture of the real sculpture was enough to signal to students that there are real world implications of the concept just they just learned. However, in the discussion that followed, the strength of this message was reinforced and given depth of meaning through the integration of multiple components of PCK.

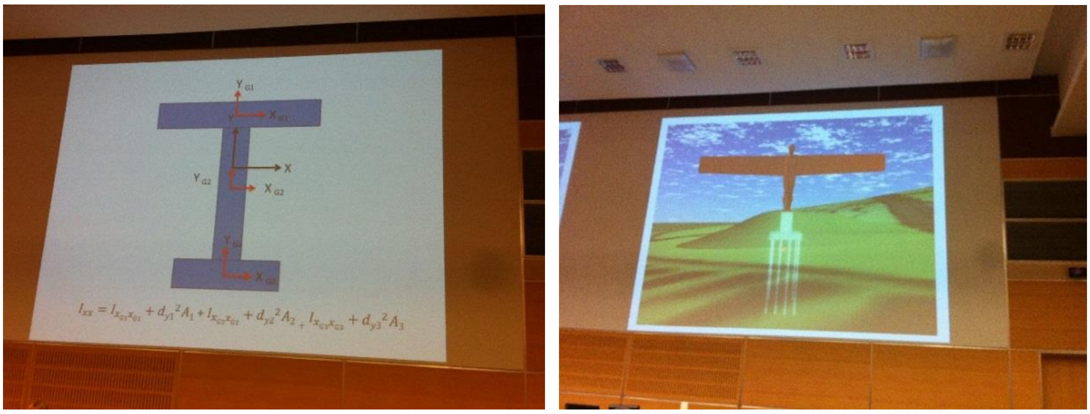


Figure 40 -Images showing the abstract shape just learned and its real world equivalent, presented immediate afterwards

The observation notes from this event are presented in Table 24 below, alongside the elements of PCK that they demonstrate. In order to improve how this is presented, a short code is provided to stand in for the aspect of PCK that is represented, as follows

- B1 – Orientations to teaching
- K1 – Knowledge of student understanding in the discipline
- K2 – Knowledge of discipline curriculum
- K3 – Knowledge of instruction strategies and representations
- K4 – Knowledge of assessment of disciplinary learning
- K5 – Knowledge of teaching for practice in the discipline

Table 26 - Integration of PCK elements shown in ¨Angel of the North¨ example

Data from observational notes on Statics lecture	Aspect of PCK
¨Now we will be moving towards some simple design to give you some context.¨	Previewing future learning (K3)
Uses Angel of the North (see picture) as an example structure to consider. Participant tells students that she used to work for the company that built the sculpture. Gives some context of the site, height, weight, wing span (bigger than a 767). Points out that engineers on the project probably wouldn´t have expected to work on a project for a sculptor. Shows pictures of it being assembled.	Real world example with industry context (K3) Teaching for practice (K5) Real world example with industry context (K3) Teaching for practice (K5)
Asks students ¨*What type of structure is this? How does it stand up*? *What are the design loads*?¨ Points out that it doesn´t fall under any codes. Participant gives students examples of types of structures they have seen. Students discuss questions in groups as well as how they think they will build it.	Socratic orientation to learning (B1) Not providing answers to questions (K3) Linking with previous learning (K3) Interactive group discussion of problem/questions (K3)
During group discussion Participant shows pictures of the sculpture being built and assembled, transport, scaffolding, etc. After students have discussed amongst themselves, Participant asks again what type of structure it is. *¨What do we think it is? What does it have to be? You have done all of this...¨* After a few prompts a student says cantilever. Participant asks ¨*what is going to give it it´s fixed connection?*¨ Students don´t answer. Shows slide of the structure underneath the ground. ¨*Essentially this structure down here acts as the moment of*	Real world example with industry context (K3) Teaching for practice (K5) Linking with previous learning (K3) Socratic orientation to learning (B1) Real world example with industry context (K3) Linking with previous learning (K3)

connection.¨ In this example the participant is referring back to theory/concepts already learned.	
¨*Designing this would have required geotechnical engineers, structural engineers to...*¨ ¨*Design loads - what sort of design loads were important for this structure?*¨ Student answers wind.	Real world example with rich contextual information (K3) Teaching for practice (K5)
Participant discusses aspects of the problem of wind - stresses on the ankles of the sculpture. Goes on to discuss more design load issues in terms of the actual structure, including self-weight, thermal issues, lightning, snow load. ¨Critical design load was building it...Construction when it has got only one arm on it - a common problem with load during construction.¨	Real world example with rich contextual information (K3) Teaching for practice (K5) Relevant concepts from Statics (K2) Teaching for practice (K5)
Participant says there was a one in 1000 year storm on the night of construction. ¨This is what engineers get to do, and this is what we will look at the basics of over the next few weeks.	Linking to future learning (K3) Teaching for practice (K5) Knowledge of curriculum (K2)

Park and Oliver highlighted the importance of the kind of process of integration seen here for teachers´ overall bodies of PCK, as follows:

> On one hand, the development of one component of PCK may simultaneously encourage the development of others, and ultimately enhance the overall PCK. On the other hand, PCK for effective teaching is the integration of all aspects of teacher knowledge in highly complex ways. Thus, lack of coherence among the components would be problematic within an individual's developing PCK and increased knowledge of a single component may not be sufficient to stimulate change in practice. (Park and Oliver, 2008, p. 280)

Therefore, because the participant was able to successfully integrate contributing components of PCK, her overall teaching practice was more effective that what it would have been if each component had been applied or developed in isolation.

8.3.9 Overall composition of PCK

The results of analysis of the PCK of this participant can be seen on the following page, with a diagram that represents the configuration and function of her PCK as an overall construct that describes her approach to teaching practice. The following section considers the characteristics of *field* that were apparent for this case, and their implications for the PCK that was seen for this participant.

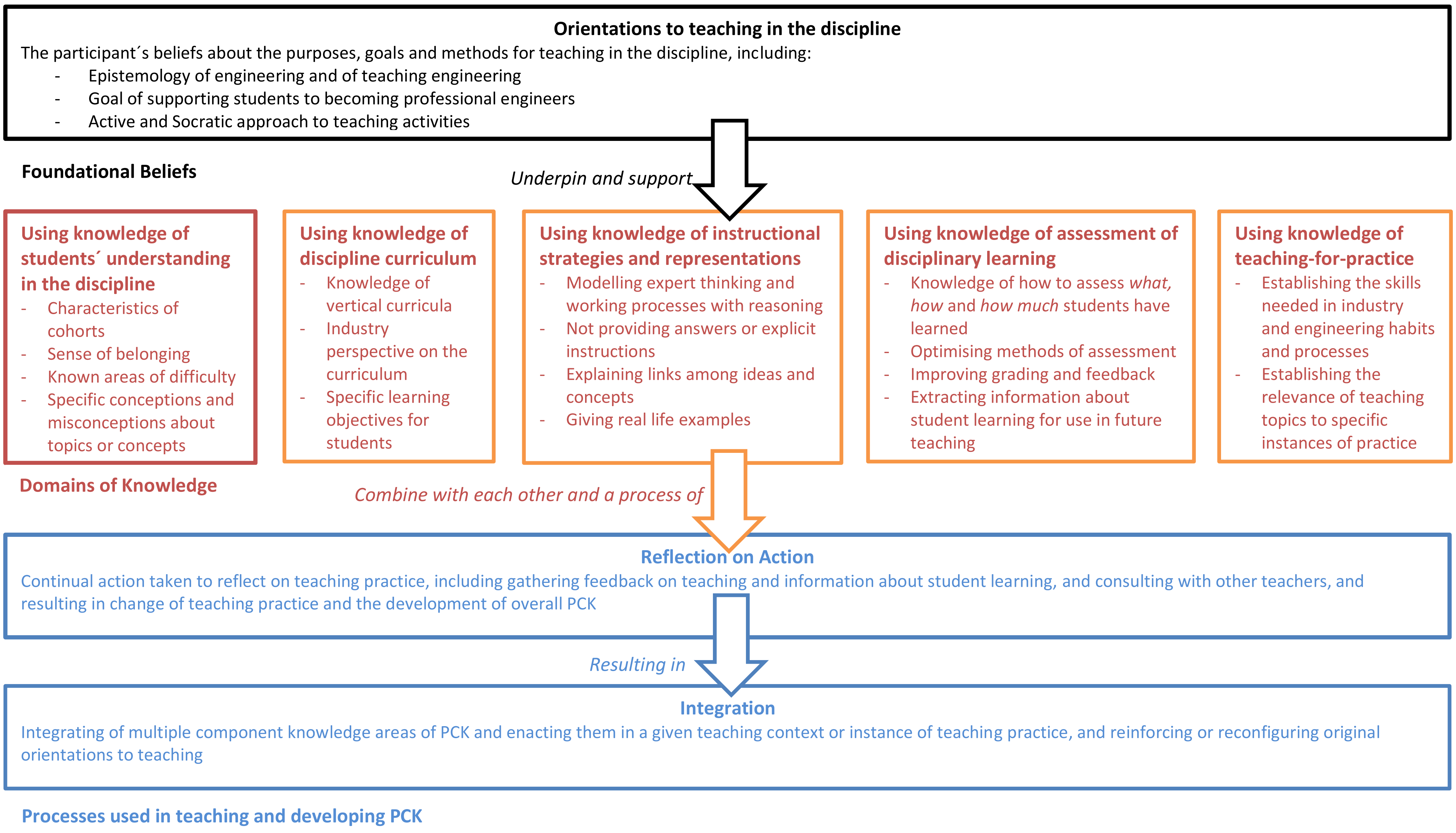


Figure 41 - Configuration of PCK (including beliefs, knowledge and processes) for Participant A

8.4 - Characteristics of the Site in the Field

Webb et al (2002, pp. 21-22) describe *field* as the:

> objective hierarchy which produce[s] and authorise[s] certain discourses and activities [and is] constituted by, or out of, the conflict which is involved when groups or individuals attempt to determine what constitutes capital within that field and how capital is to be distributed.

The following section therefore considers the ways in which the data from the case study contribute to a picture of how *capital* is created and is competed for at this site in the *field*, both by the participant herself, and by the wider group of participants she comes in contact with. In considering what this might look like for a group of academics, it is useful to remember that:

> Anything may count as capital that is afforded, however tacitly, an exchange value in a given field, and that thereby serves as a resource for action and as a ¨good¨ to be sought after and accumulated. The implication of this is that the forms of capital are multiple, each field defines its own species of capital. (Crossley, 2001, p. 87)

Capital can include ¨untouchable but culturally significant attributes such as prestige, status and authority¨ (Harker et al. 1990, p. 1, cited in Webb, et al. 2002, p. 22). A variety of data were found that can lend insight to the nature of *capital* that is available for academics at this site in the *field*, through the accumulation of which participants can strategise for position. These data are discussed below in terms of:

- The generally shared epistemology of teaching and learning engineering that is apparent at the site

This is considered indicative of the nature of the teaching-related *capital* that is available, and how it is competed for, because it indicates the ways in which players at the site in the *field* generally value and engage in teaching related activities, the outcomes of teaching activities, and the ways in which participants are rewarded for them.

- The primary activities for the accumulation of available *capital*: teaching versus research

In particular, those activities that are concerned with research and the production of research outputs, and how these are valued, recognised and rewarded above other forms of *capital*. Here, the *capital* associated with teaching is compared to that of research in order to show the strategies that are most rewarding for players in the *field*.

- Risk taking and conforming

The participant discussed the factors which determine players´ ability to take risks compared to the ways in which they are encouraged to conform to the status quo. This set of circumstances is seen to restrict the range of strategies for position taking that are available to most participants in the *field*.

- Responsibility for workload

The data showed that it was particularly challenging for academics at this site to be able to meet the minimum requirements for performing in their roles whilst simultaneously accumulating *capital* to advance in the *field*. To be able to perform adequately to maintain their position whilst still accumulating *capital* resulted in a restriction on the range of strategies available to them. The available data suggest a number of ways that this can be seen at the site, as well as the ways in which the participant aimed at doing this herself.

- Finding support for positioning by strategizing with alternative *capital*

Despite limitations existing for the strategies that are available to players in the *field*, the participant also discussed some ways in which she has been able to achieve localised support for her position, and to leverage this as an alternative form of *capital*.

Data from the case study were analysed to build a picture of the configuration of relations at the site in the *field* primarily through the participant´s own perspective. The characteristics described below are generally derived from data from interviews in which she gives her opinion. However, these data are highly relevant and useful to giving insight into the *field*, because they show how the participant herself understands the structure and nature of the *field* from the perspective of her own *habitus* and position, and thus help to explain her choices. This is important because it is her own view of the *field* that will prescribe how she sees *the possibilities for practice in acting in that field*. This is ultimately the concern of this case, because it is through establishing such possibilities as they are seen by the participant herself that we will come to understand the regularities in and reasons for her practices. However, the participant´s perspectives on these characteristics are confirmed as often as possible through observational data from the case.

8.4.1 Epistemology of teaching and learning engineering apparent at the site

A variety of data emerged during the case study that were indicative of the epistemology of teaching that is generally shared by members of the site in the *field*. In other words, this data is concerned with the generally shared attitudes about what it means to know about teaching, what kinds of knowledge contribute towards knowing about teaching, and the value of that knowledge and how it can be arrived at and exchanged (Jolly, et al., 2013). This is central to understanding the forms of *capital* that are available for teaching related activities in the *field*, because understanding how epistemologies are shared gives a clear indication of how something is collectively *recognised and valued*, and crucially, *competed for and with.*

First, the participant commented openly on two occasions that academic staff could perform poorly or only to an average level in their teaching, with no consequences for their position. In her words: ¨the university preserves the position of someone who teaches poorly¨ (Case Study A Observation Notes). She says:

> Participant: that is the way that the university works, so, you know, that is one reason why it is really difficult for new staff, young new staff, if they want to get promoted, all they have to do is an adequate job of teaching. As long as they don´t completely stuff it up, they are alright.

> Interviewer: so you are saying that the university doesn´t recognise the difference between adequate teaching and really consciously good, reflective –
>
> Participant: No, it doesn’t, it doesn’t, absolutely not. (Case Study A Interview 1)

In other words, in the participant´s opinion, teaching is secondary to other academic tasks in terms of how it is rewarded. In an institution where the core business is nominally learning, the ¨just adequate¨ view of the value of teaching may seem somewhat illogical. However, in examining more of what she says about the generally shared epistemology of teaching, she gives some explanation.

In discussing the reasons why her colleagues do not generally collaborate over their teaching, the participant commented that this was due (in her opinion) to engineering academics believing that ¨they are the expert in their [technical] field and they shouldn´t have to be accountable to others when they know the most about their topic¨ (Case Study A Observation Notes). In this view of the academic role, disciplinary expertise is seen as *the same thing* as teaching expertise, and teaching successfully requires no other skills or knowledge beyond the mastery of content for a given topic or subject. This is at odds with the participant´s own beliefs about teaching:

> No one ever came and listened to my first lecture…and when I look back I think that´s just so wrong. I could have been completely crap. There was an expectation that I had my PhD, I was a good engineer, I would be fine, I knew my stuff, which is just so wrong, so, so wrong. (Case Study A Interview 2)

She also commented that as the result of refining her teaching over the years she now understands her subject matter differently and better. For her, knowledge and experience with teaching interacts with content knowledge to create something bigger than the sum of its parts. However, she also believes that this is not a position that is commonly shared by her colleagues in the faculty.

Her opinion that the general view of teaching at the site (that it requires no special skill or knowledge beyond mastery of content) is supported by observational data from a research meeting that was observed during the case. The participant attended a meeting about an educational research project designed to explore how encouraging students to undertake metacognition by considering how the SOLO taxonomy of learning objectives (Biggs & Collis, 2014) could help to improve e their learning. The meeting was for an ongoing research group of five academics wishing to pursue educational research topics. On the face of it, this project would seem to be well founded in learning theory, with attention given to educational research literature about metacognition. Despite this, in the meeting that was observed, little focus was given to the principles from available research about metacognition and the uses of the SOLO taxonomy. Furthermore, some of the views about learning that were expressed were directly at odds with much of that literature.

For example, one participant was observed to comment that ¨metacognition has no value [for learning] in its own right.¨ This comment was observed directly after the same person stated that student feedback about the activity was that ¨SOLO had helped them to think.¨ This person also stated that ¨the point is not to change their behaviour, the point is to make them aware of something that they were not aware of before¨ (Case Study A Observation Notes). Both of these statements are at odds with learning theories that say metacognition can allow students to develop and adapt learning strategies that allow them to learn better, in other words, change their learning behaviours (Killen, 2007). These views went unchallenged during this meeting, suggesting that they were either generally shared by the group, or that there was not scope to address them in such a forum. The participant herself did not challenge this view, a fact that will be discussed later in considering her *habitus.*

In discussing how the research project should be progressed in future teaching activities, another participant stated that such an activity ¨does not need to be made more intellectual, keep it simple, go with your instincts in the room¨ (Case Study A Observation Notes). Taken together, these data indicate an epistemology of teaching and learning in which educational knowledge and know-how is not ¨intellectual¨, does not necessarily have inherent value, and does not require that attention be given to available bodies of educational research literature. This is true even within a group that was undertaking an educational research project. These data tend to support the participant´s view of the epistemology of teaching that is apparent at the site.

Despite this general view of the nature and value of teaching, the participant did also comment that there were some isolated opportunities to professionally collaborate over teaching. These were also observed during the week of the case. A junior academic was attending the participant´s first year Statics lectures to see how she taught them, so that he would be more prepared to deliver the course in the following semester. In his words, ¨I want to see how [the participant] teaches so that I can get some consistency.¨ He also commented to me that although he believed her teaching to be highly effective, he was worried that students will struggle later on when they switch to a different teacher with much more advanced concepts that lead on from those of Statics, because other teachers´ ways of working are different and much more ¨complex¨ (Case Study A Observation Notes). Walking back to the office from a lecture, he and the case study participant discussed this. She said they need to have a meeting as a teaching team so that they can get on the same page about this and that there is a good opportunity with this new staff member coming in to be able to do so.

Similar discussions were observed at other times during the week between the participant and the staff that she worked with. However, a key point here was that, with the exception of the above example, these instances of collaboration over teaching were the result of the participant´s own efforts at getting teaching staff to collaborate, rather than an artefact of the *field* itself. In fact, when I asked the participant if there were frequent opportunities to collaborate with other teachers she said no, because other teaching staff do things very differently, and academics in general don´t tend to confer over teaching. As such, the chance to confer over teaching and to share her own epistemology of teaching with others was not a common occurrence for the participant and therefore not a characteristic of the site in the *field*. Rather, when it did occur, this was generally under her own direction, and as a result of aspects of her own *habitus*.

Overall, the picture of the epistemology of teaching engineering that is seen at the site is that the ability to teach is the result of the possession of disciplinary expertise, with no special skill or intellectual knowledge required beyond what the teacher already knows by knowing about their subject matter. As a result, as will be seen below, in competing for *capital* associated with teaching, academics are encouraged to develop teaching *capital* by adding to their disciplinary expertise through research, rather than by undertaking special activities that could be seen to improve teaching practice, or lead to innovation in approaches to teaching.

8.4.2 The primary forms of capital available: teaching versus research

This epistemological perspective on teaching is reflected in the relative value that is placed on teaching and research at the site, according the participant. In discussing rewards for teaching, the participant was blunt:

> There aren´t any, there are no rewards for teaching…ok, I have been slightly facetious there, I think you do get rewarded when you build a rapport with students: I value that, I have a Head of School that values that, but it won´t get me promoted. So the university values it with lip service, not with – no one will ever get promoted because their teaching was outstanding, but you will get promoted because your research was outstanding. Your teaching can be completely shit. (Pilot Participant B Interview 2)

In other words, whilst academics were expected to undertake teaching activities to an expected quantity, in her opinion there was no expectation of minimum quality. In her view, part of the cause of this problem was the difficulty of effectively evaluating teaching performance. While it was relatively easy to measure the outcomes of research in terms of numbers of publications and citations, as well as the quality of publishing journals and the amount of grant money won, ¨how do you measure your impact on a class of 500? The metric they use is, you know, your course evaluations – well I can manipulate the hell out of that course evaluation!¨ (Pilot Participant B Interview 1).

Further, she asserts that it is often the conceptually difficult and ambiguous courses that push the students the most and make them uncomfortable, but that also simulate and are the most relevant to ¨real world¨ engineering work in industry. It is these kinds of courses that students ¨hate¨ and grade poorly in evaluations, according to the participant. Despite this, having spoken with graduates who had completed a course like this five or six years ago, the participant commented that:

> They thought the course was really shit at the time, but now they are working in that sort of environment they are actually saying ¨wow, that was really on the money - gee I did actually learn a lot¨…the impact of those courses is not that semester, it should be measured 12, 18 months or five years down the track. (Pilot Participant B Interview 1)

As such, in her view it is the courses that are the least popular that can be the most valuable for learning, but institutional measures of teaching have no mechanism to capture that. As such, the numeric and symbolic value placed on teaching does not measure what it purports to measure. This view is well supported by available research literature on the subject of the validity of standard teaching evaluation practices (Shevlin, Banyard, Davies & Griffiths, 2000, Greenwald, 1997, Cashin, 1995).

According to the participant, measures of research output are much more straightforward:

> People get labelled outstanding researcher because they publish a heap of papers, they get referenced a lot, but they can be completely useless and have no impact on the real world, but in the research parlance they have been published in a journal and it is a high impact journal so therefore it has got to be good. The metrics of measuring that are so easy. (Pilot Participant B Interview 1)

Once again the epistemological perspective on teaching and learning in the site is relevant here. Because the generally shared belief about teaching expertise is that it is based on an academic´s disciplinary expertise, it is not surprising that *capital* acquired through research activities carries a greater value at this site in the *field*. Where research activities (especially, theoretical, quantitative research) are seen to add to an academic´s theoretical disciplinary knowledge, the outcomes of research can act to directly reinforce an academic´s teaching authority, according to this epistemology. As a result, research *capital* carries a greater value at this site in the *field* than teaching *capital*, in part because it easier for the institution to recognise and measure.

Furthermore, for this particular site in the *field*, the university relies upon and cultivates a particular prestige concerning the amount and quality research that it produces to support its overall reputation as a quality education provider. In a communique to staff from the Vice Chancellor and Deputy VC (Research) about the university´s 2015 ERA (Excellence in Research for Australia) ratings, the following was stated:

> The exceptional quality of research at the [name of uni] has again been reaffirmed in the 2015 ERA assessment…One hundred percent of [name of uni]´s research…has again been ranked at world standard or above…The results confirm that [name of uni] is one of the nation´s three leading research-focussed institutions, offering world-class research-led education across all fields. (University communique, 4 December 2015)

Thus, the quality of research at the institution is rhetorically linked to the quality of education it can provide to its students. In this sense, the university is leveraging ¨research prestige¨ *capital* to support its overall reputation as an educational provider, rather than using arguments about the pedagogical quality of its programs, thereby demonstrating the strength of *capital* for research in the *field*.

8.4.3 Risk taking and conforming

For the participant in this case, this may prove to be problematic as she has chosen to not take a focus on research in her role:

> There is a base level that you are you are absolutely supposed to do, and I probably don´t do it, so there are, you know, there are consequences for that, but I have got a very supportive Head of School who believes that my contribution to the school is worth it. It will be interesting to see though, should I try to argue a case for promotion to the next level, how that pans out. (Pilot Participant B Interview 1).

In her case, investing in her teaching is a risk that the participant was willing to take, partly because of her own interests, and the aspects of her job she enjoys, but also because of her life circumstances outside of the *field*:

> I think I have reached that stage in my life where - I would hate to be a young male academic who was the sole income earner for their family...I´m lucky, I think I have got a little bit more freedom. My husband encourages me just to do whatever it is that I enjoy… so that is kind of liberating...so I have kind of reached that stage where I think that if I don´t enjoy it I am actually not going to do it...whereas I see some of my male colleagues, its promotion at all costs. (Pilot Participant B Interview 2).

Clearly, other actors in the *field* are not in a position to make decisions in the way that this participant does, and according to the participant this is due to a degree of risk associated with not focussing on accumulating research *capital*. Even more so, there is a perception of risk associated with doing something that is perceived as innovative in teaching:

> Participant: if you are going for promotion, there is a certain - certain boxes you have to fit into. And I think I notice it with some people, once they have got to professor, they have actually been much more willing to actually do really innovative things with their teaching, because they had ticked all the boxes and they had got there, and now they were in a postion where if it was a bit of a balls up it was no great drama...It is quite interesting when once people get the freedom, whereas if you talk

to new junior staff who are not yet tenured, they are less adventurous because they are concerned about...

Interviewer - there´s a risk?

Participant: yeah there is, because there is always a risk that if you do something innovative or if you change a course and students [respond with] ¨but it has been this way, it has always been this way,¨ so if you change it and they are uncomfortable with that, you might wear a poor teaching evaluation … So that is a really high risk strategy, and I know that most of our young staff would probably be advised just to go with what you know, don´t tinker too much. Wait until you are through the tenure process and wait until you have have got a period of time between one promotion and the next, and you have actually got a period of time where you can tinker and play. Do it then. Don´t do it a year before you are going for promotion because you will...and its true, if you talk to new staff, that is exactly what they do… (Pilot Participant B Interview 2).

This predominant strategy for competing for *capital* through conforming to expectations about teaching and research accords with Gonzales and Rincones (2011, p. 505) assertion that ¨earning legitimacy in academia…is about fitting in, mimicking, and adopting the kinds of behaviours and forms that have already been deemed as expected and acceptable.¨ In Bourdieuvian terms, earning legitimacy is described as achieving ¨symbolic power¨, which for academia involves earning ¨renown and prestige *as measured by* publication record and funded research¨ (Gonzales & Rincones, 2011, pp. 505-506) (emphasis added). This echoes and supports the findings of the pilot stage of the research in which the ¨runs on the board¨ and ¨research funding¨ strategies emerged as the dominant and conservative trajectory through the *field*.

8.4.4 Responsibility for Workload

Another theme that emerged from data in the case concerning strategizing had to do with the difficulty academics experienced in meeting the workload requirements of their positions, whilst still trying to ´get ahead in the game´. For the participant this problem was particularly apparent, because even on an 80% workload the expectations about the hours she should put in were very high:

> I have got a double teaching load so I teach two courses a semester every semester, so I would normally have 14 or 15 contact hours a week, and I am on a four day a week appointment...That is in front of a class let alone preparation time, so where I spend the vast majority of my time is there…So even though I am an 80%, even when I had a 60% appointment, I have typically had a full time teaching load, so if the normal [workload] split is 40 (teaching), 40 (research), 20 (service), mine is usually about 60, 20, 20. (Pilot Participant A Interview 2)

I observed to the participant that this workload split still added up to 100% and not 80%, and she replied that this was a ¨bone of contention¨ between her and the faculty:

> My school manager did the workload, and you have got to have a new workload model, and she was trying to work out my numbers, and a number of staff members were the same and we knew that they had to be wrong, and then she realised that the university had put caps on the workload that you could be accredited for, for teaching. And she thought oh stuff that, I will take that limit off, and then and there was another cap on service, she said stuff that, took that off. My workload went that way [pointing to ceiling]. That is how the university works. (Case Study A Interview 1)

By placing caps on the amount of work that academics are recognized for in the various aspects of their roles, the responsibility for meeting workload requirements and still be seen to perform highly is shifted to individual participants. In other words, itt is up to individuals to make up the gap themselves between the amount that they are supposed to be working and what the university actually expects them to do in order to advance. The participant commented that this was made more difficult by the lack of indicators of success for performance in the role:

> I wish there were some more. It is really hard. That I think is the worst bit of an academic´s job, because when I was a design engineer I could say there is my tunnel, there is my bridge, there is my building, there is my tangible, and I know it is good, it´s standing up, it hasn´t fallen down, it hasn´t killed anyone so it must be ok. Really as an academic, you get very little positive reinforcement. (Pilot Participant B Interview 2)

In an environment where staff are expected to put in more hours than they are recognized for, promotion rounds are the only real opportunity for positive reinforcement or tangible reward. Fanghanel (2007, p. 12) refers to this problem as ¨the invisibility of academic labour¨ in which the university system ¨is only sustainable because people are completely exhausted¨ and ¨a large part of [academic work] was unaccounted for¨ by the system. Crucially, Fanghanel pointed out that generally, this problem of invisibility of academic labour:

> Afforded very little agency or scope to do things differently. Tensions with research exacerbated at this level, with very little choice for respondents to focus on teaching or research at periods that suited their own intellectual availability. (Fanghanel, 2007, p. 12)

As such, by misrecognizing the amount that academics actually work, the *field* acts to systematically reduce participants´ individual capacity for exercising choice over how they work with *capital* in the *field*. The number of strategies for accumulating *capital* and achieving position are reduced by the time demands placed on academics in meeting the most basic expectations inherent in their role, whilst denying opportunities for recognition of base level performance. This process of misrecognition (in which individuals as well as institutions are complicit), which Bourdieu (1998, p.103) refers to as ¨symbolic violence,¨ reinforces the dominant structures of the *field* – the status quo – and acts to make the development of a heterodoxy among participants in the *field* less ¨thinkable¨ or viable (Webb et al, 2002, p.119).

8.4.5 Finding support for positioning through alternative forms of capital

Despite the structures of *capital* and the strength of the status quo apparent at the site in the *field*, the participant also discussed a number of ways that it was possible to find support for a teaching-oriented position and to develop *capital* to support that position. In discussing her service to a program development committee, the participant explains that she was invited to sit on the committee due to her overall curriculum knowledge, which is ¨more than the knowledge many other academics have¨, many of whom only know about their own courses (Case Study A Observation Notes). As such, the participant was able to leverage her teaching-related knowledge in order to meet the service requirements of her role:

> Participant: The sort of service I do is often related to teaching and staff development, so it is service but I have managed to make my service…actually something that has an impact on what I do as well…
>
> Interviewer: so it feeds into your teaching?
>
> Participant: exactly, exactly. (Pilot Participant A Interview 2)

In this instance, the participant´s teaching expertise was allowing her to accrue *capital* indirectly, through her service to the faculty. The participant was also able to develop localized support for her position through her Head of School:

> Basically, anything I am interested in doing, and I have got quite a supportive Head of School who is happy for me to do that, it´s actually rather nice…[he] sees value in those other things that I do, so he is very supportive…he is actively trying to push this re-engagement with students´ academic level, trying to rebuild a [teaching] culture in the school…he has said outright he wants to get me promoted, it is on his KPIs, but I have to work out [how to do that]. (Pilot Participant B Interview 1)

Thus, the participant was able to use the support of a key figure in the department to operate in the *field* using strategies of her own choosing, rather than those of the status quo. Crucially, she was able to gain such support because of the epistemology of teaching and learning that they had in common. Like her, this Head of School believed in the importance of the engagement and identification of the students with the discipline of engineering. He also displayed many of the same orientations to teaching in the discipline as her when he was observed giving a guest lecture for the participant´s fourth year design course. During this lecture, despite it being strictly ¨chalk and talk¨ in the sense that he used his voice and chalk as the only aids, it was also thoroughly Socratic, and required students to examine their own conceptions of the issues surrounding fire safety as a means of examining the decision making processes in fire safety design. Whenever the topic required ¨content¨ in order to be worked through, it needed to be discovered and provided by the students themselves based on working through their existing knowledge and conceptions with support from the lecturer, before the topic could progress. As the participant and the Head of School discussed after the lecture, they both believed the lecture to have been effective because ¨it made the students think¨ for themselves about the design task (Case Study A Observation Notes). As such, the alternative epistemology of teaching shared between the participant and her Head of School constituted a form of heterodoxy in that it was a ¨set of beliefs and values that challenge the status quo and received wisdom¨ (Webb et al, 2002, p. xiii) about the nature of knowledge for teaching and how this should be valued.

The participant had been able to translate this into actual support from the Head, who had stated the explicit aims of both ¨changing the culture of the school¨ and ¨getting her promoted.¨ The participant had thereby developed a form of *capital* out of this shared epistemology, because it was the fact that he felt she ¨got it¨; that she understood and agreed with his approach to teaching and priorities for the students that meant he was happy to support her in ¨anything I am interested in doing¨ (Pilot Participant B Interview 1).

Despite this localised support for her position in the *field*, it may not be enough for the participant to be systematically rewarded in the *field* for her effort in her role, at least through future promotion. As such her strategies for participation in the *field* may not lead to any improvement in position or an increase in the ability to accrue *capital* in the *field*, as is represented in her trajectory in the *field* in Figure 21

(Chapter 6) I asked the participant if her Head of School will have a role in deciding on if she is promoted or not. ¨No, they can argue your case, but those decisions are made at a higher level. They are not made at the school level¨ (Case Study A Interview 1). The risk in pursuing alternative strategies for accruing *capital* through a focus on teaching therefore persists. For this participant, it was only her relative freedom in her role that is the result of her circumstances outside of the *field* that allows her to take such a risk. The structure of *capital* in the *field* was seen in this case to be underpinned by an epistemology of teaching and learning in which teaching was viewed as the execution of disciplinary knowledge; disciplinary knowledge that was founded on, produced and reproduced by theoretical (and by implication, positivist) research activities. Within this site in the *field*, it is therefore unlikely that the nature, effectiveness and value of the participant´s apparent PCK would be recognised, rewarded or emulated by the *field* itself.

8.5 - Habitus of the participant

"According to Bourdieu, practices are generated by a certain habitus…and, therefore, all practices give evidence of the structures of the habitus that generate them¨ (Nash, 1999, p. 178). As stated earlier, the purposes, decisions and actions of engineering educators; their strategies, (themselves contingent on and responsive to the structures present within the *field*), can be discerned and explained in terms of Bourdieu's notion of *habitus*.

> The habitus, as a system of dispositions to a certain practice, is an objective basis for regular modes of behaviour, and thus for the regularity of modes of practice, and if practices can be predicted…this is because the effect of the habitus is that agents who are equipped with it will behave in a certain way in certain circumstances. (Bourdieu, 1990a, p. 77)

In the present case, a range of data emerged which combined to give a picture of the participant´s *habitus*, in particular the ways in which her prior experiences continue to shape her ¨perceptions, appreciations and actions¨ within her current practices and context (Bourdieu, 1971, p. 83). As Crossley (2001, p. 83) explains, ¨an agent´s *habitus* is an active residue or sediment of his past that functions within his present, shaping his perception, thought and action and thereby moulding social practice in a regular way.¨ For the participant in this case, this was especially apparent in the ways that she drew her focus from her experience in and allegiance to engineering industry, and in her deeply held sense of identity as an ¨real engineer.¨ Consequently, she saw supporting the students to become real engineers (possessing the specific skills that she believed this entails) as a key outcome of her role, both for herself and for other participants including the students and the *field* as a whole. In this way she could be seen to work with a form of *capital* surrounding ´developing real engineers´ (partially drawn from the engineering industry node of the *field*) in order to create and preserve a special position for herself in the *field*.

In order to arrive at a description and explanation of her *habitus*, we will first examine the ways in which the participant chose to rank items on a list of Tasks, Goals and Indicators of Success. Items on this list were developed in the pilot stage of the research, and by asking participants to decide how they should be ranked, are intended to elicit their views about how they should be prioritised in terms of personal interest and importance to doing well in their role; in other words, the values attached to them.

The picture that is given of the participant´s priorities is then developed in the subsequent discussion, which is organised under the headings of epistemology, focus and goals. Epistemology is indicative of *habitus* because it concerns the values, beliefs and attitudes of the participant with respect to her discipline and the teaching of her discipline, and thereby forms a foundation for her practice and decisions about that practice. Her focus on particular aspects of her role indicates much about her interests and priorities in performing her role, which in turn are significant for the practices she uses within that role, particularly for teaching, and the rationale for these practices. Finally, her goals in acting in her role are indicative of the kind of position she wishes to occupy in the *field* and her strategies for taking this position. For this participant, issues concerning sacrificing of position within the *field* were also relevant because of how she was uniquely placed in the site in the *field*, in terms of how she chose to participate in it, and the way that she chose risky strategies to be able to do so. In this case, choosing to strategize with alternative forms of *capital* was significant for the *habitus* of the participant that was seen, and, by extension, was significant to the nature and composition of PCK that she was able to develop.

8.5.1 Ranking exercise

As part of participation in the pilot phase, before the case, the participant was asked to give rankings to lists of tasks, goals and indicators of success in terms of the levels of both:

- Interest to her
- Importance for doing well in her role.

Rankings were from one to ten, with one being of the least interest or importance and ten being the most. The aim of this task was to elicit discussions and decisions about how the participant strategized within the *field* and how much choice they have over their strategy and overall position. This is because by comparing levels of interest with levels of importance of aspects of their role, we are able to see how well participants are able to make these fit with each other. Theoretically, a diagonal line from the bottom left to the top right corner of a graph of these responses would demonstrate the highest level of choice and satisfaction that a participant would have with their position and strategies in the *field* (as was seen in the pilot stage of the research).

The results of the ranking exercise for this participant were discussed in detail in Chapter 6, and indicate that the participant was able to exercise a high degree of control over the relative importance and interest of Task and Goals in performing in her role, and she consistently prioritized the teaching aspects of her role. However, this was accompanied by a reduced level of control of the importance of Indicators of Success compared to their levels of personal interest to her. Taken together, from this we can see that despite the fact that she was able to develop and use strategies for position-taking that were suited to her individually, these strategies may not be sustainable or conducive to later advancement in the *field*, unless she is able to translate the forms of *capital* that are available to her into some form of systemic recognition of her position. This is a picture that is supported by observational and interview data from the case, as follows.

8.5.2 Epistemology of engineering and the epistemology of teaching engineering

Throughout the case study, the participant´s epistemology of engineering was apparent when she discussed the discipline itself and when she discussed teaching it, as well as when she actually taught it. For this reason, her epistemologies of both engineering and teaching are intertwined in the data. As such, they are discussed together here.

The participant´s fundamental position on the nature of the discipline (in her case structural engineering) is that it is art of balancing the theoretical and practical bases of the discipline. In her words,

> I define engineering as the art of applying science… You have to kind of have a foot in both camps. You have to be able to transition between understanding the importance of theory… you have got to get your theory right. The interesting bit is what you can create with it…It is how you actually bridge that, because you have to get the science right, you have to get the basics right, but that just enables you to do the interesting stuff…so the interesting bit is the art, you aspire to the beautiful building, but without the science you can´t achieve that. (Pilot Participant B Interview 2)

The ¨stuff¨ of structural engineering, as she sees it, is concerned primarily with skills such as interpretation, judgment, logical thinking processes and decision making, for which theoretical knowledge is put to use as a tool in a tool kit of working processes. For her, engineering skill is about thinking through problems using mental tools:

> You don´t graduate from university with a little briefcase of all the solutions for all the problems you are going to see for the rest of your life. It doesn´t work like that. You have to develop a confidence and an ability to use and know what is in your tool kit and to be able to look at a problem and dissect it down into parts. That´s what engineers do. (Pilot Participant B Interview 1)

This epistemology of the discipline rejects a focus on the ¨right answer¨ for any given problem, instead emphasising and embracing the role of ambiguity, open-endedness and also subsequently the role of the skills of interpretation and judgment. Concerning her fourth-year capstone design course:

> We put them in groups and we say here is a carpark, you are going to look at the impact of traffic on the local roads, you are going to look at the impact of parking requirements on the structural layout, and then you are actually going to design a structure from scratch. So it is completely open-ended, as you would have in design practice, and it is actually quite interesting when they get to - and that is a capstone, and they have been leading up to that, they have been doing other [types of] courses [that don´t have] that ambiguity and that lack of ¨that is the correct answer¨… they get to that course and it is quite interesting because sometimes the really top students, you know the kids who are, I would say, academically strong, don´t necessarily do well in that course. And sometimes the kids who are perhaps academically solid really - they have got a really good engineering brain, and they find their feet in that course and do quite well. And that can be quite confronting for students who are used to just nailing it, and all of a sudden they are not because they are not dealing with that ambiguity and that openness, and they need to justify and make a judgment and make a decision and back it up and be prepared to say well I think that x is right and articulate why you think x is right. (Pilot Participant B Interview 1)

It is moving into the engineering design role that makes the learning about ¨real engineering¨, according to the participant, because ¨they can go and touch a column, or a beam, or a wall, or a slab and it is something that…they can actually identify with, rather than some of the engineering science stuff which is a bit more nebulous¨ (Pilot Participant B Interview 1). However, at the same time, coming in contact with this ¨reality¨ of the discipline also makes the students uncomfortable because:

> When you get to engineering design it stops being engineering science. So with design there can be multiple correct answers and they don´t like that. It makes them very uncomfortable because they want to know what the answer is, and you go well there is no such thing as THE right answer, there are a multitude of answers, some are better than others for different reasons, but if your thinking and logic is sound, we can have different answers and they can both be right. (Pilot Participant B Interview 1)

In this view of the discipline, a key challenge for students is to learn to cope with such ambiguity and open-endedness. We see here how the participant views the nature of learning in the discipline as well as the demands on teachers for teaching it. For this participant, the role of professional expertise and the role of teaching expertise are inextricable, because both are needed to help students to meet this challenge of using engineering science for ambiguous design problems. In a discussion of the need for professional experience for teaching engineering in authentic ways, the participant revealed that she sees this as a balancing act between two interrelated but distinct skill sets:

> I don´t know how you could possibly teach a course like reinforced concrete design when you haven´t actually done it. Well you could, but it would be from a very theoretical perspective and then you lose some of those practical design skills that are equally as important as the theoretical – equally as important…I think it is a fine – it is a balancing act. You can go the path that some universities have gone where they

> basically outsource all of their teaching to professional engineers, and that is not a good thing either, because having been a practicing engineer, you do gloss over the theoretical basis. … You have to have a really good grasp of the theory, so there has to be a balancing act there. [But] there has got to be a thread of practice. (Pilot Participant B Interview 1)

Central here is that the expertise involved in the *teaching of engineering* is to achieve the balance between the theoretical bases of the discipline, whilst still developing the skills basis of professional practice. For this participant, authentic experience in industry, or at least a very firm understanding of it, is essential to effective teaching. This was true even when she was teaching the very theoretical first year Statics course, which is often considered to be content-heavy, with a low focus on skills, and is often taught accordingly. In the participant´s own version of this course, she was frequently observed to reference and to demonstrate the relevant skills and thinking processes that professional engineers use when she was explaining theoretical concepts to her students.

The participant can also be seen to make a distinction between the three roles of being a professional engineer, being a teacher of engineering, and *being an academic*. In discussing the interaction of these three roles or identities, she sees each as having something to bring to the education of future engineers, but it is the type of research that is undertaken by an academic that will determine if their research activities can act to support the teaching of engineering. After reflecting that she writes ¨civil engineer¨ as her occupation on her customs forms and that there is a need to keep skills current through ongoing industry experience, she says:

> If you are teaching into an engineering discipline you have to be - particularly in the structures area because it is something that doesn´t change but a lot of the design stuff does change, so you do need to be current in what you are doing, absolutely.
>
> Interviewer - So research gives you that?

> Participant - this is an interesting one. A little bit. But not a lot...It depends what sort of engineering you are doing and what sort of research you are doing and this is the sort of conundrum that I think particularly civil engineers have in that when you go out and work in industry, the sort of stuff you do in industry you would never write up as research, you just - it´s not - it is design, that is what you do…I have done both, and what I did as a consulting engineer is nothing like what I do as an academic. Absolutely nothing… (Pilot Participant B Interview 2)

The participant believes that research activities are limited in how they can inform teaching for practice in the discipline, because research activities can be so far from the nature of engineering practice, unless they have a clear practical orientation and application which could act to maintain some degree of currency of practice in the discipline. However, much of what occurs in industry would not qualify as research because it is related to design. In another discussion about research, the participant stated:

> I am an eclectic soul in my research, but again, my research that I do is very much based in industry. So it has been predominantly funded by industry, a lot of it is commercial-in-confidence and it has been usually looking at really practical, pertinent at the moment, right at that point in time issues, rather than - it is not theoretical. I don´t do theoretical research. I´m not interested in it. (Pilot Participant B Interview 1)

Taken together, these comments again show an epistemology of the discipline that stands in contrast to that which is generally held at the site, in which an increase in theoretical disciplinary knowledge equates to an increase in teaching expertise. Here, the participant expresses the view that the skill involved in teaching is much closer to the skill involved in practicing engineering than to being a research-focused academic. Consequently, she still identifies much more as an engineer than as an academic. Supporting this view is her observation that the academics who are the most collaborative over teaching are the ones who have experience in industry, or whose research involves considerable interaction with people in industry. She acknowledges that ¨I have no evidence for that, it is just observation¨ (Case Study A Observation Notes). If well founded, this observation suggests that a value for collaboration that is developed through experience in industry also serves engineering teachers, as collaboration over teaching can lead to increased reflection on teaching.

Although how the participant developed this epistemology of teaching engineering is not immediately apparent, it is clear that she still views herself as an engineer, and does not wish to move away from this role. However, certain data from the case show that whilst experience in industry probably helped her to develop these views, it is working on improving teaching in response to the students that has cemented them.

The participant´s epistemological position is fundamental to an aim of *teaching for practice*; that is, teaching in a way that helps students to be prepared for practice in industry as professionals. In the capstone design course, for example:

> To learn to be able to exercise judgment, justify, these are all the learning objectives...this is about them being able to go and find the information, because your employer is not going to give you – they will give you broad guidelines, but there will be times that they will say go and investigate x, y, z and come back and tell me what my options are. You will have never heard of x, y and z before, you are going to have to develop those skills. (Case Study A Interview 1)

As was seen in discussing her PCK, the participant´s approach to this principle of *teaching for practice* is characterized by teaching in which the role and processes of a professional engineer are made explicit and demonstrated during teaching activities, like a form of apprenticeship. Within this epistemology, learning must be active, experiential and contextualized to capture the nature of the engineering discipline, and teaching must create this environment, regardless of the inherent nature of the content.

Despite this alternative position, being one that is more often associated with educational theory and the scholarship of teaching than the traditional approach to engineering education, the participant often spoke in a way that would seem to eschew the role of educational theory in informing her teaching practice, or that of others wishing to improve their practices. She explained to me at one point that she learned about teaching through trial and error with students, but that this is not seen as legitimate by educational theorists. The implication here is that education as a discipline would not grant her the title of an ¨educational expert¨ and that her knowledge of teaching would not be recognized in that *field* in any codified way, despite the fact that her methods are arguably very effective for her students. Here she is demonstrates the belief that her teaching expertise is experiential rather than theoretical, and *herein lies its nature and value*. In this way, her approach accords with that of the PCK concept, in that her specific know-how for teaching is concerned with *how to effectively teach specific topics and subjects in specific contexts*. This is also consistent with her view of engineering as the skillful solving of ambiguous problems.

In a related theme, she discusses the ways in which improving teaching can be seen as a significant challenge for engineering academics, because discussion of educational principles is often devoid of any context which could make them meaningful or useful for academics from the engineering discipline, especially when those academics have little or no teaching training:

> What you find in engineering is that people often want to do a good job [of teaching], but they don’t necessarily want to wade through books and papers and theory, and they often just want examples of how it could work in their context and that is something that is often missing. And you can bring a lot of good people along on a journey of good teaching if you just simplify it. There are lots of people who never ever want to write an educational journal paper, but want to do a better job of their teaching and they sometimes get devalued. [These people need teaching examples that are] simplified and made contextual. (Case Study A Interview 2)

In this view, educational knowledge has to be contextual, rather than theoretical, to be valuable for teaching or teaching development. Having teaching know-how is a case of knowing *what works for whom under what circumstances.* This is how the participant understands her own teaching knowledge, rather than as the outcome of theoretical training in pedagogy.

8.5.3 Participant´s focus on aspects of her role: teaching, service and research

As has already been seen, the participant consistently chose to focus on the teaching aspects of her role, as well as service aspects which relate to her interest in teaching. Although she did state she has an ongoing interest in research, this was secondary to her teaching interests, and what research she did do was focused purely on practical and industry related research which could help to maintain her currency as an engineer, which in turn would inform her teaching. Her research activities consistently took a back seat to teaching, however, and the participant stated that she generally only had time for research in second semester, or outside of the teaching semester. At the time of the case, she had a number of research tasks that were overdue ¨I have three papers and one research report that is about a year overdue that I haven´t finished yet. There are lots of things to do¨ (Case Study A Interview 2)

Despite this, the participant also stated that she would be reluctant to go ¨teaching-focused¨ in an official capacity in her role, as she believed this would take her away from her identity as an engineer:

> I have to make a decision about whether I want to be a teaching focused position, which effectively is what I am because of the amount of teaching I get, but I am still down as a T and R, which has issues in terms of your [workload] weightings, so...I actually have some hard decisions to make because the engineer in me doesn´t want to be teaching focused. (Pilot Participant B Interview 2)

This comment echoes the tension shown in her ranking exercise between intrinsic and extrinsic goals and rewards. By consenting to a ¨teaching only¨ title, the participant may put herself in the way of greater extrinsic recognition for her participation in the *field*, especially as she would no longer be expected to produce research. However, this would involve relinquishing her sense of identity in participating in the *field*, which is strongly related to her reasons for participation.

In her view, as already seen, undertaking appropriate forms of research can assist with maintaining currency as an engineer, and thereby allows her to retain legitimacy and an authentic identity as an engineer. This was reflected in her focus even during teaching related activities, which regularly referenced and demonstrated engineering habits, engineering ways of working and the development of an engineering identity. Thus, at the core of her teaching focus was *a more deep-seated focus on professional practice in industry*. This aligns closely with her stated goal for teaching in the discipline, which she said was ¨to develop the next generation of professional engineers¨. As such, she sees her work as both a service to the students (in helping them to identify as engineers and develop the requisite skills to fulfil that role), and also as a service to the discipline, by helping to produce graduates that can better fulfil that role. In this sense, she is working to generate recognition for an alternative form of *capital* here; that is, developing ´real engineers,´ for which she can receive some recognition, for example through her supportive Head of School and through positive feedback she receives from graduated students some years after they finish her courses (seen earlier). In this respect, she is drawing on *capital* from engineering industry where the skills she has helped to develop in students are recognized, valued and traded as *capital* by players in that wider *field*.

Her professional practice focus was apparent throughout the case, when the participant discussed her teaching during interviews, as well as when she was actually teaching students. Even the design of assessment was undertaken with this in mind. In producing the design brief for the assessment of the fourth year capstone design course, she explained to me that she was seeking to find a balance between the structure the students needed to complete the task successfully and enough ¨reality¨ that the task could authentically replicate practice. Her overall aim was that students would make decisions ¨based on what is professional, rather than how it would be graded¨ (Case Study A Observation Notes).

Even her explanations of the content were peppered by such comments as: ¨as a reinforced concrete engineer, I find that it is really important to be able to…¨ and ¨You are going to be engineers, you need to start thinking smart, which in my book is to keep the steps as simple as possible¨ (Case Study A Observation Notes). Thus, presentation of content was consistently and directly linked to specific habits and processes used by engineers. The explanations of concepts that accompanied these comments maintained these links by constant referral to the big picture of working processes and the need for them to be used in industry. This constitutes a rejection of the privileging of content commonly seen in Higher Education, in favour of the process and skills focus she believes is explicitly valued and rewarded in the industry node of the *field*. In this sense the participant is demonstrating a *habitus* for participation in the *field* which draws on the industry node for authentication of her practices. This once again constitutes a heterodoxy in which the dominant values of the higher education node are challenged by this participant. It also reveals her position in a heteronomous pole of the *field*; that is, ¨that part of the field bound up in relations with other fields, and expressing their values¨ (Webb, et al., 2002, p. xiii).

When I first began to interview this participant, I asked her if everything she taught was related to her industry experience. She replied:

> Absolutely, so I am a structural engineer so I teach first year Statics which is the introductory structural engineering subject, I teach second year reinforced concrete design, which is the introductory subject to concrete design, and my [experience in industry from 1995-2001] was almost exclusively designing reinforced concrete infrastructure in South East Queensland and South East Asia...So that, and I now also do the fourth year capstone design which is an integrated design course that looks at giving students a professional design experience at university,

> so yeah, absolutely, everything I teach is directly relevant to what I did in practice. (Pilot Participant B Interview 1)

It is an artefact of this participant´s *habitus* that she considers her teaching to be intimately related to what she *did*, rather than what she *knows*. Even the Statics subject to be directly related to what she does in practice. Many engineers and engineering academics would argue that because this subject is theoretical, it is separate or a step removed from practice. However, her approach to teaching being what it is, is what allows this participant to focus on the professional practice relevance of the concepts and theory being taught, even when a subject is both foundational and theoretical. Thus, the participant seeks to cultivate the influence of her prior experiences in industry, rather than allowing them to wane out of her current disposition for practice in the *field*.

This valuing of her specific industry experience and her identification as an engineer both explains and supports her overall strategy for working in the *field*; she is interested in and pursues outcomes at the ¨real engineering¨ end of the *field*, in terms of the identity and skills set that students take into industry, and her role in developing these, rather than towards a narrower view of engineering education. For this participant, participation in the *field* goes further than the boundaries of faculty and university, or courses and programs, and instead actively fosters links with the industry node from which she can draw increased support for her role and approach.

8.5.4 Teaching, service and research goals

A number of specific goals for this participant were identified during the case, giving some further insight into the participant´s *habitus* for participation in the *field*, in particular the methods by which she sought to pursue the abovementioned strategies. In particular, feedback on teaching played an important role in determining what goals she would set for both short term and long term teaching activities. For the short term, when asked what the main goals for the week were, she replied:

> I try not to have the contact classes too planned too much, too far in advance, because I try to respond to the problems that they are having. The downside of that is that you are always under the pump to actually produce a class, and it has got to be done in a timely fashion so that the tutors who help you actually have a chance to look at the material and make sure that they understand the material so that they are able to assist in the class, rather than...it is terrible if the tutors aren´t prepared. They end up really holding the class back, and it frustrates the students. The students know when they have got a tutor who is not [inaudible]. So that is the biggest thing, I need to get that done this week. (Case Study A Interview 1)

It is interesting here that she chose to respond to this question only in terms of teaching related activities. Her response could have covered any aspect of her role as an academic, or could have focused on a range of duties she was expected to complete. Instead, her response covers only teaching related goals, as is consistent with her main focus in her role. In this example it is clear that the participant aims to respond to student progress and conceptual difficulties on an ongoing, week to week basis. In this way, a key goal for the participant is to be continually reflective and responsive in her teaching, so that she is valuing students´ experiences and opinions.

The participant used feedback from students for long term planning in a similar way. The focus in the long term was on the overall course design and structure of teaching sessions:

> I got my postdoc...to do some work, ask some questions of my first years and one of the things that came out was just how important those contact activity sessions were, and they were talking about how they hope that they do them in other years, and I hadn´t been. And they´re not exactly the same, so I have sort have taken that theme and changed them a little bit… (Pilot Participant B Interview 1)

This reveals a process of continual improvement of the way in which courses are delivered in response to what students find to be the most useful or problematic in the teaching sessions. From this feedback the participant was also able to get specific information about how students cope or struggle with particular topics or concepts:

> The other feedback I got from the work that he did was identifying key threshold concepts and what I thought the kids were struggling with the most - this is really interesting, how many years have I taught that! – was not the topic that they actually felt they were struggling with the most, and the topic they are struggling with the most has changed over the years, so now I have that information to feed forward to first semester next year and I am going to try to target my active sessions to tackle moments, which are apparently the killer bit for first year Statics. (Pilot Participant B Interview 1)

This example also shows how the participant aims to understand the ways in which student cohorts change over time and consequently how teaching should be adjusted accordingly. Combined, these uses of feedback from students constitute an overall goal of reflection for the purposes of optimizing future teaching. This should be considered as an intrinsically or indirectly rewarding goal, in the sense that in achieving it she is unlikely to win formal recognition or rewards at her immediate site in the *field*. Rather, the outcome will be in terms of the effectiveness of her teaching in helping students to become engineers. Pursuing this goal therefore does not help her to win any of the primary forms of *capital* available in the *field*, but it does help her to develop the form of *capital* identified earlier, that of developing ¨real engineers¨ which theoretically can be (albeit indirectly) validated and recognized by the industry node of the *field*. If she does derive benefit from possessing this kind of *capital*, it will be through the ways in which the industry node of the *field* can exert influence at her particular site bring this form of *capital* to bear on ¨playing the game¨ of the *field*.

When asked about her other goals, the participant persisted to give answers that were directly related to teaching. Some of these responses were more aspirational in nature, for example, concerning improving student engagement and student identification with being an engineering student. However, despite the less tangible nature of these goals, the participant was still taking concrete steps towards achieving them:

> Reengaging with the student cohort. We are seeing the impact of large class sizes now. After three or four years of 250 students in our second third and fourth year classes, there is a real disengagement and I think that that is a really negative thing...and that is part of the reason why I have been fiddling around with my tutorials and the way that I do those, is to try and get that reengagement with those students, and to get them to feel like they are actually part of the school, that it is something that they identify with… if you can find ways of engaging with them you can have a positive impact on how they see themselves as potential engineers. (Pilot Participant B Interview 1)

Similarly, she hoped to find ways to support students in what they find difficult within subjects and topics. She commented that many of her colleagues get frustrated with student difficulties with subjects such as Statics, but that she sees such difficulties as a ¨generational thing.¨ Even though student skill sets changing over the years, ¨they will be good at other things [instead], such as software. They deserve to be supported in the things they find difficult¨ (Case Study A Observation Notes). Here we can see a commitment to work with and respond to the characteristics of her student cohorts. As was seen in examining her teaching, this attitude became fundamental to the nature and composition of her PCK. As such, her *habitus*; that is the ways in which she mobilizes *capital* and pursues goals in the *field*, had a direct influence on the nature of her PCK.

Pursuing these aspirational goals had some intrinsic rewards for the participant:

> Even though I do find the 6 hours of class exhausting, I do actually enjoy the contact classes, and you just see students have that little moment

> when it just clicks and starts to make sense, and you think ok, now I have...And even though attendance was down a little bit, you are still getting 60 or 70 out of 90 kids turn up - that is a pretty good reward of engagement. (Case Study A Interview 2)

Despite this, such goals can also be seen to come at the cost of the other types of *capital* she is able to compete for. In talking to me about the need to run the same contact session with Statics students six times in a row, she observed that because the students have given feedback that they really value the sessions, there is a burden on her to deliver them. Although the faculty had offered tutoring staff to take the sessions for her, she wanted to ensure that all the students in the class do the activities in the same way, and felt that the tutor team did not have the knowledge to be able to do this successfully. ¨I am a control freak about my teaching – I just want students to do activities in a certain way¨ (Pilot Participant A Interview 1). As such, she is putting the goal of providing the same opportunities to all of her students ahead of more extrinsic goals relating to performance in her role, and the achievement of promotion.

To ameliorate this, she had developed some goals relating to developing tutors who could teach in a way that was more in line with her own epistemology of teaching:

> Participant - One of the issues that we have is, I would love to train a tutor and have a tutor that can take the class, {speaking quietly so she cannot be overheard} but our tutors are predominantly international and they are not used to that whole very active, open ended...they want much more structure...it is interesting, when I watch some of my undergraduate tutors, they are actually better in those classes than our postgraduate tutors. But I could never leave an undergraduate tutor in charge of that class.
>
> Interviewer - have your undergraduate tutors done it in the way that you would like them to actually teach?

> Participant - yes, because typically they have done those classes with me and they have been a student in those classes, so they have been on the receiving end. So I find those tutors really good. They are really engaging and they actually go up and they poke and prod students and ask questions… they will get them moving and my postgraduate tutors are a bit more reticent to sort of dive in and get involved. (Case Study A Interview 1)

In working to ameliorate this problem, the participant and another academic who work together on a teaching and learning development program conceived a training program that could give tutors and commencing academic staff some contextualized training of how to teach effectively in their courses. For the participant, this is about developing staff that have the capacity to teach in a way that is based on the same principles that she herself uses:

> The faculty has supported this to try to train up tutors to do more than just be tutors. So they can actually give them more of a leadership role in some courses, which is why if a really good structures tutor walked in my door tomorrow, I would probably send them off to do that program and then get them involved in the contact classes [for Statics]. [Another academic] has postgrads who are project leaders who have been through that. So it is giving them more than [the regular tutor training program] which is really basic. The [name of extended program] is about trying to give them a little bit more training to try to understand some of the theory behind how people learn, how to structure the - this is for tutors who might be acting autonomously...so if I had a tutor in a contact class running without me there, I would want them to have a bit of an understanding about why we do things in a particular way. (Case Study A Interview 2)

Even in these kinds of service activities the participant is trying to build the amount of *capital* available for developing ¨real engineering¨ by developing the kind of teaching that she sees as most appropriate for the achievement of this goal.

Theoretically, when more players in the *field* take up her epistemology and orientations to teaching in the discipline, there will be available *capital* for teaching in these ways with the goal of developing ¨real engineers.¨ This heterodoxy is an *avant garde* approach to shifting the status quo of the *field*, rather than conforming to it.

8.5.5 Sacrificing Position

Although the above data suggest the participant was consciously developing a heterodox position in the *field*, and hoped to accrue *capital* that could help to support that position, a range of data from the case suggest that the participant´s strategies in the form of her focus and goals being what they were meant that she was running the risk of sacrificing position in the *field*, especially due to her relative lack of attention to the conventional forms of *capital* that were available and how these were commonly used. In adopting the strategies described above came with consequent restrictions for her degree of freedom manoeuvre for and maintain position in the *field*.

First, her commitment to the extra contact sessions for Statics meant that she was unable to take a sabbatical or to free up time to focus on other things:

> I would [love to] have someone helping me out with the contact classes so that I didn´t have to do all six…I would like to take sabbatical in first semester, and go away and not have things go [badly or inconsistently in class]...I don´t know, that is me being a control freak, isn´t it. (Case Study A Interview 2)

The participant felt that giving up some of these sessions was not possible as there was no other academic that could be designated to take the classes, and the available tutors would need too much training, too often. By not giving the sessions up to other staff, she was spending time and effort that could be spent in other aspects of her role, such as research or service. I asked her if doing these sessions meant more contact hours than she would otherwise have to do and she said yes. I also asked if they counted for her workload allocation, and she said yes, but her teaching workload was already off the scale of what she was supposed to do, and so they were not something that she would be recognized for. When I asked if anything would fall by the wayside as a result, she replied: ¨Oh, research! I don´t get any research done!¨ (Case Study A Interview 1).

The decision to spend this time in this way can be understood in part by her interest in seeing her students do well. Given that 80% of students had given feedback that the sessions were important to them, she wanted to ensure that all students had the opportunity to do the same class in the same way. However, her decision to prioritize teaching so heavily was also related to her own personal interests and reasons for participating the *field*. In discussing how she ranked the goals on the list given to her for the ranking exercise, she commented:

> It was personal enjoyment…I think I have reached that stage in my life where – I would hate to be a young male academic who was the sole income earner for their family… I am lucky, I think I have a lot more freedom. (Pilot Participant B Interview 2)

In this sense, the risks she took in strategizing in this way was offset by her ability to leave the *field* if necessary. Similarly, in considering the indicators for success in her role she commented:

> Participant - What I am interested in and what people might see as indicators of success are not the same
>
> Interviewer – So interest is intrinsic and importance is extrinsic?
>
> Participant – Yeah. Yep. That´s me not giving a shit. (Pilot Participant B Interview 2)

It is clear that the participant was conscious of the effect of her own decisions could have on her position in the *field*, and chose to make them anyway. In this respect, her *habitus* gave her access to a unique position, which would not be available to many other participants in the *field*. It is significant, however, that if the same *habitus* that gave rise to such complex and developed PCK also brings with it the risk that such PCK would be lost to the *field*, should the participant choose or be forced to leave.

8.6 - Conclusions from the Case

The participant had developed a *habitus* for working in the *field* that was highly conducive to the development of a sophisticated and integrated form of PCK, in particular, a form that emphasized teaching-for-practice in industry. This is because she saw the task of better developing students to be ¨real engineers¨ as the outcome of continual improvement of her teaching, meaning that her teaching practices (and the body of PCK behind them) were increasingly sophisticated and effective for the purposes she intended to achieve. In this respect there was a high degree of overlap between the nature of the participant´s PCK and her *habitus* for working in the *field*. For theoretical purposes, it is useful to observe that by examining her PCK (in the form of beliefs, knowledge and processes) we were able to both describe and explain many of the specifics of her *habitus* in the *field*. It is therefore a conclusion that PCK is or can be an embodiment of *habitus* for teachers, insofar as it represents teaching practices and the beliefs, attitudes, rationales, focus and goals that support them.

With respect to the interaction between *field* and *habitus*, we can also conclude that a teaching-focused and professional-practice focused *habitus* can allow a member of a *field* to use selective strategies and take up a position in the *field* which facilitates the development of a sophisticated form of PCK, providing they can find ways to develop a supported heterodox position, and negotiate with some type of *capital* that can allow them to reach and maintain that position. In the present case, this was made possible through a combination of having received tenure, through tailoring her service towards her teaching-related interests, and through receiving strategic support from her Head of School for her specific approach to her role. However, as the participant herself acknowledged, this is not without a degree of risk, and is contrary to some of the stronger forms of *capital* in the *field*. For example, the ability to attract and compete for the *capital* associated with research activities (the dominant strategy for advancement and the most acceptable route for ¨achieving legitimacy¨ in the *field*) may be significantly reduced when such a teaching-focused strategy is adopted.

As a result, a preliminary overall conclusion from this case is that the *field* is unlikely to produce many participants occupying the same position as this participant, purely because they are not able to accept the same degree of risk and personal sacrifice (in terms of accumulation of dominant forms of *capital*) in doing so as this participant was. Further, given that the PCK she demonstrated was intimately connected to the nature of the *habitus* that she had developed in operating in this position, it is unlikely that PCK of this nature and sophistication will often be seen in the *field*.

9.0 – Case study B - ¨Because, look!¨

In the second case study a participant was chosen who took a much stronger focus on his own disciplinary expertise in his role as an engineering academic. Like the participant in the first case, he was a structural engineer specialising in concrete. However, in contrast to Case A, his teaching focussed almost exclusively on his own conceptions of disciplinary content rather than those of the students. This manifested in teaching practices aimed at reproducing and transmitting what the participant saw as a necessary and fundamental canon of engineering knowledge, which it was the students´ responsibility to assimilate. As a result, the participant´s PCK was observed to consist almost entirely of disciplinary content knowledge, with other component knowledge areas being absent or underrepresented compared to the previous case. Processes of reflection and integration were not observed at all within this participant´s practices.

Like the previous case, this participant´s experience in industry was seen to be significant for his *habitus* in working in the *field*, in that his experiences before entering academia had helped him to develop a strong conception of and belief in the importance of the core foundations of his discipline. However, he was also observed to make a clear distinction between the domain of the classroom and the domain of industry in terms of the tasks and skills that are required for each. It was his belief that the development of workplace related skills and practices in students should be left (at least in part) until after students graduate, and that a focus on skills development for industry should not detract from time spent on content-acquisition in the classroom. He saw the role of students being to adequately and appropriately acquire what he saw as the fundamental canon of knowledge for his discipline area. This opinion was in stark contrast to the policies of teaching and learning published by his institution which discussed the need for ¨practice-oriented instruction¨, and structured the engineering program to include two six-month internships.

The contrast between the participant´s *habitus* for working in the *field* and the espoused values of the institution raised questions about the nature of *capital* available to engineering academics at this site in the *field*. Despite the fact that a shift away from traditional approaches to teaching was promoted in the published policies of the institution, it was clear that the available forms of *capital* had not sufficiently evolved to reward academics´ efforts to innovate their teaching in line with these policies. Further, there were no apparent disincentives for academics with teaching practices that remained consistent with the more traditional techniques that the university policies argued were no longer sufficient.

The following chapter describes the case in detail, including excerpts from the observation of teaching sessions that allow for a picture of the participant´s PCK to be developed. This is contrasted with data that lend insight into the characteristics and configuration of relations at the site in the *field*. Finally, the *habitus* of the participant is examined.

It should be noted that for the week of the case in question, the participant was ill, and as a result was forced to spend some time off campus. This meant that the opportunities for data collection were reduced for this participant compared to the previous case study. However, with the exception of a consultation session time, the participant did not miss any of the scheduled contact hours with students, and so it was possible to observe almost all of his teaching time for the week. During the time that the participant was not on campus, an observation was conducted of the faculty engineering education research group of five academics. I also conducted an informal discussion with one of the members of this group concerning her perspective on the nature of the engineering faculty, the engineering program and the program of instructional innovation at the university.

Despite the more limited data from this case, it was possible to draw conclusions from the case, based on the *habitus* and PCK that was observed with the participant, as will be discussed in the sections below. In fact, partly it was the reduced amount of data that was available from the site, even when the participant was present, and the level of saturation in the data that were telling about his *habitus* and PCK, in particular his epistemology of teaching engineering.

9.1 - Background of the case

Participant B was selected for the case study as the result of working at an institution with a non-traditional curricular structure and a nominally alternative (i.e. less didactic) approach to student learning. The institution in question structures its engineering program to include internships during the degree, so that students get on the job engineering experience as they progress. This approach is based on the view that engineering is an applied discipline and therefore requires the development of workplace-based, applied and practical skills in students, in order for them to develop the requisite graduate attributes.

The institution also espoused a student-centred approach to teaching, and had published information about a program of instructional innovation that was underway, intended to shift teaching away from traditional models more in line with a constructivist approach. It is labelled herein as ¨Program X.¨ In its own words, the institution stated that ¨[Program X] highlights the importance of focussing first and foremost on how students come to learn and then on what teachers should do to support that.¨ A ¨quick guide¨ to the principles of this program (Case Study B extract from university website) is included in Appendix G. This summary of the approach describes the nature of the shift from traditional methods to ones that the institution expects will become the norm, but does not detail how this shift was to be achieved by teachers. Within this institutional context, a participant was chosen who had a strong theoretical research background, and a teaching portfolio that involved highly theoretical courses. The purpose of this case was to see if an institution that espouses an alternative epistemological approach to teaching and learning would have an effect on dislodging the traditionally positivist views of teaching engineering for a theoretically focussed teacher.

Table 28, below, shows the schedule for the week of the case as it played out. The green cells indicate lecture sessions for which the participant was teaching. There were no tutorial sessions scheduled for this week, and the participant advised me that for the weeks in which tutorials are run these are taken by post graduate students rather than himself, using example problems similar to those that he uses during lectures. The yellow fields indicated times in which the participant took part in interviews or discussions with me. Grey fields indicate times in which there were no observable activities, or the participant was working in his office. Blue fields indicate discussions or meetings that I attended, but which the participant was not involved in. Finally, the pink fields indicate the times during the week in which the participant was off-campus due to illness. This was a total of two working days in the week, however with the exception of a scheduled consultation session with students (1.5 hours) on the Tuesday he did not miss any contact hours with students. He also made no mention of scheduled meetings or activities that he was obliged to miss during these times.

This schedule (with the same number of teaching hours as for other weeks during the semester) shows a total of seven and half scheduled contact hours with students per week. By his own account, the remainder of his time was occupied with administrative duties (including emails, reporting, etc.), research activities and the supervision of postgraduate research students. The participant consistently described himself as time poor during the case. For the semester in which the case study took place, the participant was teaching in two courses. The first was a second-year equivalent course in concrete design (year levels not mapping exactly to every student´s experience at this university due to the alternative structure of the engineering program). The second was a postgraduate course also about concrete design. The participant was also responsible for supervising postgraduate students´ theoretical research projects, although no activities to do with this occurred during the week of the case.

Table 27 - Schedule of activities for Case Study B

	Monday	Tuesday	Wednesday	Thursday	Friday
9am		Participant is off campus due to illness	Participant is off campus due to illness		
10am				Engineering education research group meeting – 5 members in attendance	
11am	Interview scheduled for 11 am - participant arrives late due to being at campus medical centre				Interview with participant
12pm		12.30-2pm scheduled			
1pm					

2pm	Second year concrete design course – assessment quiz scheduled in lecture time	contact hours for students but participant is off campus due to illness. 3 students wait for him to arrive	No contact sessions scheduled	Office time for participant	Second year concrete design lecture
3pm		Participant is off campus due to illness No contact sessions scheduled			Office time for participant
4pm	Discussion with participant about sessions for the week ahead and his courses in general				
5pm					
6pm			Discussion with engineering education research group academic	Postgraduate course lecture	
7pm					
8-9pm					

Although due to his illness the week of the case study may not have been entirely representative for this participant, there are a number of reasons that the data gathered during this week are telling for this participant. During interviews he gave extensive discussion of his belief in the need to rely on lecturing activities for the transmission of content in his courses. This accorded with the teaching sessions which were observed, all of which were lectures, and which the participant stated were the same for the rest of semester. During observation of his teaching, data were collected which in the analysis phase of the research demonstrated saturation, in that the same phenomena were being repeated and with no new phenomena arising. This suggests that although fewer sessions were observed for this participant, this did not circumscribe the range or type of data collected, or the findings they could yield.

9.2 - The nature and composition of the participant´s PCK

For this participant, his epistemology of teaching and learning of engineering will be discussed as an aspect of his PCK, because it was seen to directly frame his apparent PCK, and it is easier to explain and understand the teaching practices that were observed after having considered the data available about his epistemology. His epistemology of the discipline had direct implications for the practices that he conceived as possible and appropriate for his subject matter, as follows. .

9.2.1 Epistemology of teaching and learning

Despite language difficulties arising from English not being this participant´s first language, he was very clear on his view of the nature of the engineering discipline:

> In engineering definitely you should start from basic and build up your knowledge, otherwise if you're in upper levels, but nothing in foundation, you have missed some part… we have this prerequisite knowledge for example it starts from Statics then goes prerequisite for Mechanics of Solids, that's prerequisite for structure analysis, that's prerequisite for concrete design, that's prerequisite for reinforced concrete design… believe me sometimes if a student for some reason a student has not performed well in that basic part we see immediately – that's why… the source base of that concept should be explained and they should understand [the basics so that] later on they can rebuild [the concept to a more advanced level].

In this view of the discipline, a foundational canon of knowledge is seen as being core to the nature of the engineering discipline and provides the basis on which engineers (or at least engineering students) operate. This view implies that all that is needed is a strength of knowledge of core foundational concepts, as this is the basis on which increasingly advanced knowledge is built. In this view, the theoretical content of the discipline is constitutive of the discipline itself, rather than what professional engineers do with that content. This view avoids a focus on engineering skills or practical application of knowledge during instances of practice.

This view of engineering as a canon of knowledge has particular implications for teaching and learning in the discipline, because it is bound to rely on didactic and Mode 1 transmission models of education in order that the canon can be replicated by students. Despite this, at times the participant expressed confused or conflicting ideas about teaching and learning in the discipline, suggesting an epistemological conflict at some level. Whilst on the one hand he argued for how his teaching relied on his industry experience and his ability to reference practical examples, he was also adamant that lecture sessions were necessary to him being able to cover the content successfully. Observation of his teaching practice also revealed a mismatch between some of his espoused ideas and his actual practice, especially in the sense that he considered his courses to be about design, but focused almost exclusively on the ¨right answer¨ to example problems.

To get to the bottom of this epistemological conflict, it is helpful to examine the range of statements that he made in reference to the nature of teaching and learning in the discipline. In discussing what students should be able to do, and how he teaches them to do it, he states:

> [The student] should be able …to comply the results to explain…according to engineering judgment…definitely [that] comes from that prerequisite knowledge…my belief is that for engineering definitely you should build up your knowledge, experience based on basic fundamentals … when we start firstly I give them the concepts, basic concepts and later on always I mention look, we use the same basic concepts but with my modifications, they are the same, but we modify for this behavior, we modify for the amount of behavior these are I believe that is very effective, efficient. I really do my best in fact will have emphasize on that concepts whenever it is required I go back and explain. (Case Study B Interview 1)

Unlike the participant in the first case, this participant was not explicit about what he understands to be the nature of engineering judgment, however, he is clear that he views his teaching as a process of referring to basic concepts whilst working on increasingly advanced theory. This teaching takes place as a performance that he carries out and the students observe, as evidenced by his continual reference to himself in the above quote. The participant believes that student difficulties with learning can be resolved by restating earlier conceptual knowledge that is foundational to the acquisition of more advanced concepts. In this view students are seen as passive receivers of conceptual knowledge, who are successful when they can assimilate the accepted, canonical forms of theoretical knowledge as performed by the teacher. In essence therefore, the student becomes the *tabula rasa* on which canonical knowledge is written. Teaching is referred to in terms of the concepts themselves and what he says about them, rather than what the student should do with them cognitively.

Somewhat incongruously, the participant claimed that his industry experience is important to his teaching because it enabled him to give practical examples of the application of concepts students are learning:

> Since I'm quite familiar [with industry], I enjoy giving some of that experience, I mean more practical examples….it is not theoretical things, some practical for working, detailing of reinforcement, and that's how I believe, I like it and also since I know the policy of universities… I try to keep going in that policy. (Case Study B Interview 1)

Despite this opinion about the importance of his industry experience, the participant is not clear about why it is valuable to the students´ learning. Rather in this quote he focuses on his own enjoyment in including these examples, and the fact that he is complying with the university policy of establishing the industry relevance of courses. As such, it is not clear how industry experience plays a role in his actual epistemology of teaching and learning in the discipline, so much as it contributes to his conception of his own role as an academic.

The participant also expressed the view that lecturing was vital to his students being able to learn the material, because of the nature of that material itself. His explanation of this was not entirely coherent, and so the discussion is reproduced here in order to avoid misrepresentation of his ideas, with some grammatical errors corrected for the purpose of readability. In this discussion, he talks about his understandings about the program of instructional innovation (Program X) that the institution was pursuing and what it meant in reference to his own courses and subject matter:

> Interviewer: I keep hearing about this [Program X] that they´re phasing in…are you affected by that at all?
>
> Interviewee: Reducing the face-to-face lecture time?
>
> Interviewer: Or moving towards - I think it was about moving towards student-centred learning more so than teacher-centered – I haven't had a close look at it yet.
>
> Interviewee: Yeah, I mean they have assaulted [us] and … they are here to encourage [that] mostly students should be somehow trained that she or he does not need to face-to-face - let's say lecturing – [and that we should] be able to provide all of what the student needs from internet or from one good example … We put everything - whatever they need - additional papers, additional sources, additional software they may use or they may not use, either we put it there or announcements on all lecture notes, solutions of the assignments, solutions to example problems - in fact [the program is about] mostly going towards that student-centred… [So the] student can manage [their own] education.
>
> Interviewee: So will that mean that you won't be doing lectures down the track or you will be doing less of them?
>
> Interviewee: Yeah I support that one however for example this particular subject… [it] depends from one subject to another subject - for example we have numerical analysis, this is not design - pure mathematics or finite elements base…my colleague said they can perform some online tasks for that, but design is something different, design is in fact sometimes we say design is mix of art and science. Two

> engineers they design two different elements, but which one is good one…both should be adequate … [and comply] with Australian code, but even there is better way in fact efficient one, more economic one - all right. Therefore I mean, it is I believe in this stage it is difficult, however, not possible, but it takes time more, we should have a broad facilities, otherwise without having instruments how you can do any tasks.
>
> Interviewer: So you mean that because of the nature of the subject matter that you're teaching you need those lecture sessions?
>
> Interviewee: Yes definitely.
>
> Interviewer: To get the students to understand?
>
> Interviewee: Yeah exactly, yeah because for example design procedure is not something mathematical, you should initially for example based on some heuristics values experience, propose something and then frequently refine to satisfy requirements… and in getting some assumptions, refinement of assumptions to satisfy the requirements in fact, but it is possible again of course nothing is impossible and again another problem for my subject, this subject concrete design as I mentioned [is that it is] very important to any majors. (Case Study B Interview 1)

In this interaction the participant expressed a number of opinions about his subject matter, and ideas about learning in general. He believes that student-centred learning and reducing face-to-face contact time are the same thing, and that student-centred learning means leaving students to manage their own education with reduced support from instructors. He believes this to be the crux of the policy of instructional innovation (Program X) at the institution. While he says he supports the initiative, he describes it using words such as ¨assault¨ and he does not support it in the case of his own subject matter. His explanation for this is somewhat unclear, but is linked to the fact that he sees his own subject matter as being about design, as opposed to ¨pure mathematics¨ and that instruction for design requires lecture sessions in order to be taught to students. Whilst ¨pure mathematics,¨ can be taught by ¨performing tasks online,¨ design is different, and requires lecturing. For example, he believes lecturing is necessary for showing students the process he describes as ¨getting some assumptions, refining assumptions to satisfy the requirements.¨ Once again, this reflects the view that his teaching role is to perform the content of the curriculum for students to observe. The process by which students should learn to replicate this performance is not accounted for in this epistemology of teaching.

In explaining this further, the participant stated:

> Look it's - still I believe that for lecturing we need at least traditional face-to-face, but we can minimize it, it should go together [with other methods]. I'm not sure, we don't know after 100 years what will happen even when they compare all [instructional methods]… I mean there will be very advanced things … very advanced concepts, but with my understanding in this level for design subjects they definitely we cannot in fact ignore face-to-face students they need to ask immediately their questions, they in fact have some practical let's say procedure for detailing, so on similar to workshop. (Case Study B Interview 1)

Whilst he concedes that what he sees as a student-centred approach may have some place in the teaching of engineering, in combination with other methods, he remains skeptical of the outcomes of this approach. He is of the opinion that ¨we don´t know what will happen¨ if the engineering curriculum is taught in alternative ways. He argues that because of the advanced nature of the concepts he has to teach ¨we cannot ignore face-to-face students¨ who need to be able to immediately ask questions and be shown procedures for applying concepts, such as can happen in workshops. His statements suggest that he sees face-to-face sessions and lecturing as synonymous. Interestingly, his logic does not support the need for lectures per se, and in observing the participant´s lectures, no time was given over to answering student questions. Only once during the observed sessions was a student observed to ask a direct question about the material. At all other times the students were completely passive. As such, his reasoning against the reduction of lecture time in the curriculum is not coherent.

At one point during discussions the participant did say that he would like to look in to using some sort of flipped classroom approach to his reinforced concrete course in the future, as a way to make the use of time more efficient. He says he has seen a colleague do this for a ¨pure maths¨ course but he is not sure how he could make this work for his ¨applied¨ course. Once again, his reasoning is not clear concerning why reduction of transmission of content during lectures is not seen as appropriate for courses that are ¨applied¨ or ¨about design.¨ Also, his desire to reduce content given by lectures is not concerned with improving learning, but with saving time. These data suggest that in considering and discussing alternative classroom approaches, he is not examining his fundamental beliefs about the nature of learning and teaching. For him, changing from lecturing to a flipped classroom is a question of changing the mode of transmission of content from face to face to online, rather than changing the focus of the educative process to cognitive and conceptual development in the student (such as is suggested by the theory behind more constructivist and student-centred philosophies).

This problem with his reasoning may be due to an un-negotiated conflict in his fundamental epistemology of the discipline. On the one hand he takes the view that transmission of content is paramount for teaching engineering, because engineering is centrally concerned with building up progressively sophisticated theoretical knowledge. By extension, students are the *tabula rasa* on which content is to be written. On the other hand, he also acknowledges that engineering design is something like art, that there is a thing called engineering judgment (although he is not explicit about what he thinks this is) and that practical experience in industry is somehow relevant in the classroom. The latter implies a role in engineering learning for skills and dealing with the ill-defined nature of practice, which codified, canonical knowledge does not on its own account for. As such, these two different perspectives are oppositional, a fact that the participant did not seem aware of or ready to engage with. Furthermore, as evidenced by his conflation of the term ¨student-centred¨ with a reduction of instructional support, it seems clear that educational philosophies and the epistemologies that support them were not something that the participant had consciously engaged with or examined.

Ultimately, there were data to suggest that the positivist ¨engineering as a canon of knowledge¨ position won out overall in his epistemology and associated practices. For example, in discussing how much the faculty prioritizes the transmission of theoretical knowledge over practical experience for students, the participant suggested that ultimately theoretical knowledge is more important in the curriculum, because, as with other universities, a reputation for strong knowledge transmission ¨brings in money¨ to the institution. In his own perspective, the internships that are included in the program ¨should be adequate and you shouldn´t go more than that for practical [experience, because] the rest will be gained by a graduate engineer…after they have built up a solid knowledge of engineering¨ (Case Study B Interview 1). In this view, learning engineering in the classroom and doing engineering in industry are seen as two distinct activities and should be kept that way. This epistemology sees learning engineering in the classroom as the acquisition of content knowledge only, and ultimately the skills involved in practice are not needed until a student graduates, and therefore fall outside his purview. This is in direct opposition to the epistemology of Participant A, who saw learning engineering as a process of becoming a professional engineer, and the teaching of engineering as supporting the learner in that process.

In a final piece of data relevant to this epistemology, the participant was seen to distribute a ¨student behaviour self-assessment¨ to students during class in a number of different courses. The quiz was given to students at the beginning of lectures and the students were told ¨this is simply for you to review your learning¨ and ¨these are the habits and study skills that make the difference between doing well and not doing well¨ (Case Study B Observation Notes). This document is a self-assessment for students about their frequency of use of particular study habits and skills.

Interestingly, although the participant stated that these behaviours were central to students doing well in their engineering courses, he was not interested in finding out the results, and advised the students that the quiz was not going to be collected back. Although this information could have been helpful for the participant to develop an awareness of his students´ approaches to their learning, and to develop his teaching accordingly, he was not intending to collect or use it. As such, the habits and skills of students for studying in the discipline were seen as their own responsibility and not his. At the end of the quiz the following paragraph appeared:

> If you ticked Never for most of the questions from 1-8 what makes you think you will be able to develop the knowledge and skills necessary to pass this subject? Learning takes work and time. If you ticked Sometimes for most of the question from 1-8, you don´t seem to be making a serious attempt at this subject. If you want to understand this material you need to make more of an effort. If you ticked Most of the time for most of the questions from 1-8, you are obviously making an effort, keep it up and see if you can manage your time a bit better to be able to tick Always for a few of these questions. If you ticked Always for most of these questions from 1-8, then all I can say is good work and keep it up. (Case Study B Learning Self-Assessment Quiz)

The admonishing tone here only reinforces a picture of an epistemology of teaching and learning in which the teacher is seen as responsible for the transmission of content, and the student is responsible for assimilation of that content. Whilst he cared very deeply about his subject matter, and that his students would successfully master it, it is the students who are responsible for their ability to do this. This attitude was supported by data from observation of teaching sessions, as will be discussed in the sections about PCK that follow.

9.2.2 - Orientations to Teaching

As has been seen, it was clear throughout interviews with the participant and observation of his teaching that he believed strongly in the need to present to students the canon of necessary content that he saw the engineering curriculum as being comprised of. This was related to and based on his own experience in industry and technical research. It is on this basis of experience in industry that the participant had formed firm views about the necessary fundamental theories and concepts that students must master. However, the participant maintained a distinction between the practices of engineering in industry and the business of learning engineering in the classroom. This belief meant that the participant was strongly committed to the transmission of content to students, especially using lecturing, in order to enable them to successfully assimilate the necessary content. Importantly, the skills for industry were seen as not relevant to classroom learning, and he was of the belief that such practical learning should not impinge on content-focussed class time, for example through the addition of any further internship requirements to the engineering program.

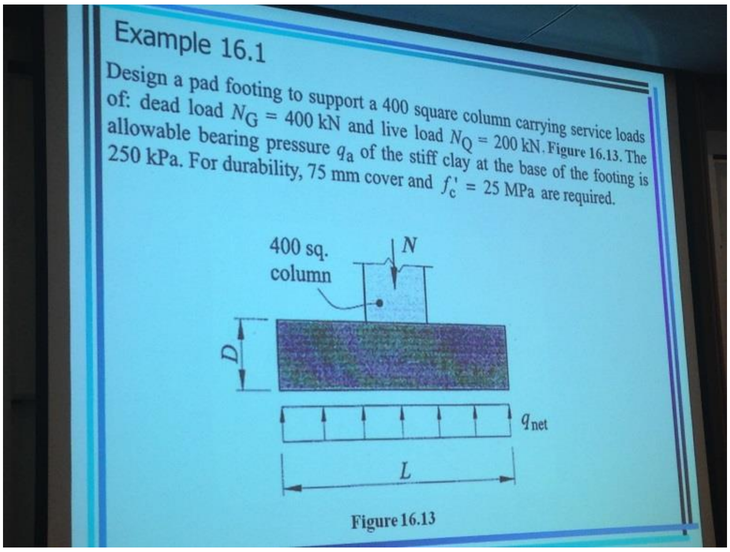
This opinion about the distinction between the classroom and industry was especially evident in the fact that for one of the courses he taught there were to be no tutorial sessions during the week of the case. The participant explained that this was because the lecture the week before had been conducted by an industry guest speaker. As such, there were no activities or example exercises that the participant wanted the students to work on as a result of that lecture. He said that activities in tutorials are based on example problems which work on theory learned in the previous lecture. The guest lecture from industry therefore had limited relevance to the course according to the participant, and he did not expect the students to do anything with the information that they had been provided by this guest. Despite the fact that the course contained class time given over to an industry speaker, this was not integrated into what students would actually be expected to learn.

Incidentally, this is in contrast to an exchange that was observed between other faculty staff in discussing the possibility of going from a thirteen week semester to a twelve week semester. In this discussion, one academic remarked to the Head of School that in his opinion this is ¨doable¨ if courses take an emphasis on the practice aspect – an emphasis on the skills learned rather than just content, for example with input from practicing professionals and guest lecturers. This is an opposite opinion to that of the participant himself, who would view this as a double time imposition on him being able to cover the content of the course, first through losing a week in which to cover content, and second, to have to give further contact time over to guest speakers.

In a further reflection of his orientation to teaching his courses, the participant commented that he uses lectures to work through one example problem in full and then leaves the students to work on the remaining problems themselves. He said there are usually more example problems than time to work on them but students can do the problems themselves outside of contact hours and he ¨makes himself available to answer questions.¨ He also commented that ¨the first worked example problem is similar enough that students should be able to see how to do the second¨ (Case Study B Observation Notes). In this we can see a clear alignment between his epistemology of teaching in the discipline and his actual practice, in that teaching is seen as a performance of content which students are then responsible for replicating. This is a marked contrast to the participant in Case Study A, who focused heavily on supporting the students in the process of understanding how to perform the process of calculations for themselves, and transfer the processes to new types of problems. Further, the tutorial sessions for Participant B´s courses were normally run by PhD students or postdocs, rather than by himself, although students could seek him out during consultation times if they chose. This contrast reinforces that the participant´s view of students was that it was their responsibility to successfully assimilate the content he gave.

In a final aspect of his orientation to teaching, the participant often spoke of his course as ¨applied¨ and involving aspects of design, especially compared to courses that he described as ¨pure mathematics.¨ In observing teaching sessions for these courses, it was noticed that reference to the word ¨applied¨ was concerned with physical objects in the world only, rather than the actual practice and processes of design. For example, ¨applied¨ usually meant the application of theory to a specific slab or beam (Case Study B Observation Notes), rather than the application of decision making processes (with support from theory) to solving ill-defined problems such as are commonly found in designing in instances of practice.

In an example of this, the following pictures taken in class show an example problem in which the design task is tightly defined, and results in the students only having to work the theory (rather than the problem context itself) to be able to resolve it. Participant B´s view of the words ¨applied¨ and ¨design¨ can therefore be seen as an extension of the ¨engineering as a canon¨ epistemology, in which theoretical knowledge is the focus, even when it concerns nominally ¨applied¨ aspects of the curriculum.



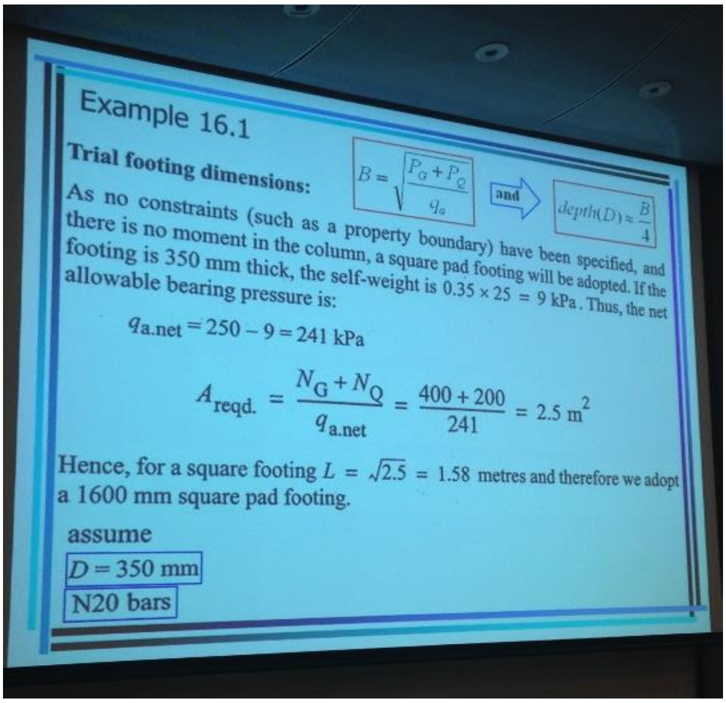


Figure 42 - Example problem for Case Study B showing tightly defined design task

9.2.3 - Using knowledge of discipline curriculum

This belief in the importance of the engineering canon, meant that the "knowledge of discipline curriculum" component was the strongest component for determining the nature and structure of the participant´s observed PCK. Each class and each course as a whole was structured principally around coverage of theoretical concepts. The participant acknowledged that sufficient coverage of each concept in the curriculum was a challenge because the curriculum had become increasingly crowded in the wider engineering program. This put pressure on both the participant and his students to transmit and master (respectively), each concept in its turn. This was especially challenging because each concept was cumulative: the mastery of one depending on mastery of the preceding concept. This set of circumstances reinforced the participant´s belief in the need to retain control of transmission of content in class time. Lecturing was the only type of teaching activity that was observed, with very little role for the students in these sessions, excepting to listen to the lecture and take notes.

These factors were the ones that were seen to most strongly govern the practices and interactions that were observed in the classroom in the week of the case. In the observed lectures the teacher had almost 100% of the talk time. This consisted of explaining lecture slides and drawing diagrams to illustrate concepts. His oft expressed phrase of "because, look!" is telling of this participant's teaching style, and, by extension, his *knowledge of instructional strategies and representation,* discussed further below under that heading. It consists of working from theory on PowerPoint slides to focussing on abstractions of physical forces and phenomena in visual form on the whiteboard. During explanation the teacher would repeatedly add layers to the visual depiction of the concepts being explained, particularly using mathematical notations, arrows to indicate forces, etc.

This technique for the transmission of content was accompanied by a steady stream of explanation, often given whilst facing the board. An example of these explanation is given in the following excerpt from observation notes

The slides begin with pictures of bridges. The participant is writing on the board about slab classifications. Talking about how slabs fall into each category, for example, supported or long span. Some students are taking notes. There has been no introduction or preamble about how what is being talked about relates to today´s topic or what has been learned up until now.

Participant starts to draw representations of types of slabs, for example slabs supported by walls or columns. Poses the question ¨why pre-stressed?¨ then answers immediately. ¨More susceptible to problems - why? Because the exposed surface of the slab...therefore to overcome we have the pre-stressed concrete.¨

The participant is writing a formula on the board to compare necessary depth of pre-stressed compared to conventional concrete. ¨Therefore we can save up to 20% of concrete.¨ Gives the example that it is used for shopping centres or as a pavement.

¨Let´s go to the slides.¨ Uses pointer and reads the outline: effects, types, hyper-static reactions.

¨Around 7.5 is the best scale. After that you can use pre-stressed slabs.¨ Gives another example of when pre-stressed slabs are useful - wide shallow beams. Drawing diagram on board.

¨Do you remember what is the critical perimeter?¨ Goes on to draw diagram without waiting for a response. ¨According to Australian code, at least two tendons should pass through the critical perimeter.¨

Participant says ¨let me have your comments.¨ No response given. ¨What is the critical direction for two way slabs?¨ He answers his own question almost immediately.

¨I believe you now have all the requirements we can move on to calculation from the codes for checking shear forces.¨

> ¨It is very important to become familiar with Australian codes (so that you can check equations are right).
>
> ¨Why? because...¨ Some reasoning is given here but it is not included in notes or slides and is spoken very fast. Students would not have the chance to get much of it down. (Case Study B Observation Notes)

In this example, the participant´s own disciplinary knowledge is clearly current and fluent. However, it seems to be communicated according to how it is organised for himself. Points are mentioned as he remembers and understands them rather than being organised according to how students currently conceive of the concepts and what they need to be able to understand at the end. The teaching is not revealing what the participant´s thinking processes behind the explanation actually are; the rationale that would reveal the nature of his professional reasoning is not apparent. For example, it is not clear to those watching why he considers which aspects of the process when he does. It is also not made explicit what the links among the concepts being covered are, for example, when is it prudent to refer to the Code (at what points in the process) and why. As such, the process the participant follows in performing calculations is deemphasized. It was also noted during this observation that the students in this session would have to be very fluent with the concepts and terms that are being used as they appear to be cumulative. Explanation and reasoning are very quick and continuous (with no breaks, recaps, check-ins) and so if a student was to miss anything or misunderstand something it would be difficult or impossible to catch up. The responsibility falls to the student follow the process and to incorporate new concepts into their existing understandings as they see the teacher perform them.

9.2.4 - Knowledge of student understandings

Students were mostly quiet and attentive during class, but it was unclear from the observational data how well they were following the explanations given during lectures. On one occasion a student asked a question, which the teacher answered, but no subsequent interaction occurred to indicate how well students understood the response. At times, the participant himself posed questions about the subject matter, but these questions were answered, usually immediately, by the participant himself, followed by continuing with the explanation of relevant theory for the session. Given their consistent lack of response to these questions, the students seemed to understand them to be rhetorical and not require a response. Because he did not expect or receive responses from students during class, it was not apparent from observation what the participant's *knowledge of student understanding* was, but it was clear that he was not interacting with students enough to be able to understand how they were responding to his teaching. A greater level of interaction may have been possible during tutorials or consultations, however, neither of these took place in the week of the case study and tutorial sessions are usually run by postgraduate tutors anyway, so it is not clear that he could have used them for an opportunity to develop this aspect of his teaching.

In one instance in particular, the participant commented to me after a class that he didn´t ¨know what was wrong today as the students are not normally so passive, normally they make comments or ask questions¨ (Case Study B Observation Notes). He said he thought they must have been not following or not understanding something but that he wasn´t sure what the difficulty was. Although he said that he noticed this during the session, he did not stop the lecture to check in with students, take questions or test where their level of understanding was. The student behavior in this session was not markedly different from the other sessions that were observed.

In another example, during a class the participant commented to me that he was surprised that more students were not at the lecture, especially as 50% of the end of semester exam will be covered in the next three lectures. ¨How can they still expect to pass?¨ (Case Study B Observation Notes). There is clearly a mismatch here, between the students´ value for and the participant´s value for attendance at the lecture sessions, a mismatch that the participant did not recognize or understand. If students were not consistently attending lectures, it would be useful for him to understand why so that this could be addressed, especially as he gave ¨attendance at lectures¨ scores of nine for interest and importance on the list of

Indicators of Success for him in his role (discussed later under Habitus 9.4).

In a final example, on one occasion a student was observed to answer a question that the participant had posed during class. He had asked ¨What do you think is the major disadvantage of unbonded concrete?¨ A student answered slippage, but the participant continued to give his own answer without acknowledging the student. On one occasion he asked the class ¨how is it going so far?¨ but like the other questions he posed, this seemed to be rhetorical in nature as he quickly went on to say ¨please come and visit me during consultation time, I am always happy to give extra help¨ (Case Study B Observation Notes). Once again, the responsibility falls to the student to make up any deficit in their understanding by taking action to seek help. When students are badly behind or when they don´t understand the nature of their own difficulty they may be uninclined to do this.

This set of data combine to show a picture of practice in which there is limited interaction between the participant and his students upon which a workable knowledge of *their* understanding of the subject matter could be formed. Rather, he interacted with his students via the content, and via the assessment instruments by which he would see how well the students had mastered the subject matter after the fact. The participant seemed uninclined to seek further information than this on how they were understanding his teaching, and it is reasonable to conclude therefore that this knowledge component did not form a substantial aspect of his overall PCK.

9.2.5 - Knowledge of instructional strategies and representations

For this participant, his key instructional strategy for transmitting content to be assimilated by the students involved verbal explanation with reference to abstract diagrams representing a specific and well-defined example problem. The picture below (Figure 43) shows a typical diagram used by the participant in support of his explanation of theory. On paper, this approach to lecturing may not seem so different to Participant A, however the content and style of their explanations and their use of diagrams was markedly different.

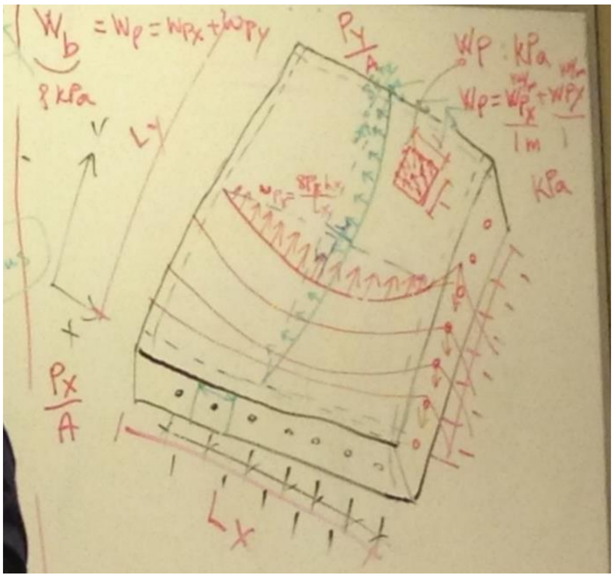


Figure 43 - Example diagram used to support instruction for Case Study Participant B

The usual process by which the participant went about lecturing was to begin talking about some aspect of the theoretical concepts being covered and then give reference to an abstract diagram for which the theory could be applied. The diagrams included mathematical notations as well as arrows and lines indicating forces, such as in Figure 43.

Generally, as the explanation of an example problem progressed, it would draw on more and more theory. As the calculation proceeded, the participant would add forces, lines, arrows or notations to the diagram, as shown in the above diagram of a slab (Figure 43). By using this approach students would have to keep pace with the demonstration as it progressed, because by continually adding to the same diagram the participant´s process of working through the theory and or calculations was not preserved sequentially for the students to review later. The level of detail, at least on this example would make it very easy for the students to forget the earlier steps or explanation. Again, this approach deemphasized the process aspect of learning in favour of theory.

Unlike for the use of FBDs in Case A, the explanation for how the abstraction linked to both the theory and the real object in the work, and the process by which the calculation was developed, was not carefully laid out or explicit during the observed sessions. Whilst the participant spent a lot of time *performing* the process of calculation for example problems, there was very little *explanation* about the process, which could help students to understand the process itself and replicate it again later for other example problems. Rather than focusing closely and step by step on the process he would use to perform calculations for an example problem, the participant´s demonstrations of calculations were a fast-paced stream of consciousness, in which the links between the theory and working were not clearly established.

The effect of this style was that the material was observed to be much less accessible to students than was seen in observations in Case A, especially for students who may have been encountering difficulties. There were no opportunities for students to stop and review the process they were following, to identify key decision points in that process and the particular steps that would have to be made, to examine their own understanding of the process being followed and its relationship to theory (for example by being required to answer questions), or to reflect on and rehearse the task just performed before moving on. As such, unlike for Case A where the participant represented the content in forms that would support the students own cognitions of the concepts, this method of instructional representation replicated the content in the form that it existed for the participant himself; that is, it was represented in terms of how he himself understood the subject matter, and not how *the students themselves should come to understand it.* In this respect, this instructional method represented the participant´s content knowledge, and not his pedagogical content knowledge, because it did not account for the means by which, as Segall (2004) puts it, content can be made instructional.

9.2.5.1 - Helping students to deal with theory by giving links among ideas and concepts and modelling expert thinking

Whilst the participant usually used diagrams such as these as a means of giving an abstract representation of the theory being discussed, a few other instructional techniques were observed which could help students to make links among the ideas and concepts being covered within a lecture or topic. In one instance the participant was observed explain the links among the concepts of the course by talking about how they were going to apply previous knowledge of beams and two extra considerations to designing slabs. In a few other examples he was seen to give some explanation of an overall process to be adhered to, such as in the following excerpts from observational notes:

> ¨The tail of the arrow always shows tension.¨ One student repeats this statement as the participant himself says it, showing that he is familiar with this convention. The participant continues to explain some of the notations on the diagram.
>
> ¨Generally as an engineer we try to used simplified methods…¨ The participant is explaining how to arrive at a simplified method of performing a calculation, concerning the order of operations. ¨you do this to determine that, then you can determine...¨
>
> ¨Now it is time for that example. Please try to follow step by step. When you understand the steps of one procedure you should be fine for others. Always they are similar, the steps remain the same.¨ (Case Study B Observation Notes)

In one instance, the participant was also observed to model expert thinking for the students in discussing that ¨engineers always have to reasonably simplify the problem¨ in how it is represented in the abstract (Case Study B Observation Notes). In this instance the participant supported this statement by showing a slide that compared two actual structures to simplified representations of them, thereby demonstrating how abstractions can relate to the realities they represent.

These examples show pedagogical practices which can help to support students´ cognitions of the relevant theory. However, these examples were seen to be the exception rather than the norm in the teaching practice of this participant. Most often, the participant´s instructional strategy involved providing content with very little explanation of how it fitted with the overall topics or concepts learned, or in the overall structure of the processes of calculation being used, or the overall structure of the course. In the following excerpts from observational notes, for example, theory is given along with some instructions of what to do, but with no explanation of why, and at what points in the process certain decisions have to be made.

> ¨What is a support? Half of the column width, etc.? Therefore at that critical cross section you will assume that the left load section has a cantilever - look...¨(drawing on diagram).
>
> ¨For shear we have another critical section located at distance d.¨ Continues with stream of speech.
>
> ¨Tail of arrow is always tension, therefore, look, this slide is tension.¨
>
> ¨That is codes of practice, always you should check bending moments¨
>
> ¨Flexural shear is check that distance d is....punching shear is a bit different, it is....¨ (method is given here, but reasoning is not.)
>
> Discussing self-weight ¨you should account for this early on in working.¨
>
> Discussing two methods of calculation ¨this method is more appropriate. It is a short way and better.¨
>
> The example is being worked through very quickly, faster than students could do it themselves and faster than they could answer or even consider the rhetorical questions he poses.
>
> ¨At this point you should go to bar chart that I have provided and on bar chart the closest one is 280mm.¨ (it is not stated verbally or on the slides why this value was selected). (Case Study B Observation Notes)

Whilst it is clear from these excerpts that the participant has a mastery of the subject matter being covered in lectures, it is not clear how well his explanations can be assimilated or replicated by the students themselves and therefore how successful his transmission of this information will be. This is in contrast to the teaching that was observed during Case A in which the participant could use information from her knowledge of student understandings, and from responses of students in class, to make decisions about how to optimize her instructional representations of content, even in a tightly defined theoretical course such as Statics and in a tight time frame. In the present case, these instructional representations were informed by the core canon of theoretical knowledge only, rather than from how and how well students were conceiving of that theoretical content. Therefore, whilst the participant´s knowledge of instructional representations for the discipline was very much in keeping with his orientations for teaching in the discipline, it was also limited by his orientation to teaching in the discipline, and his underlying epistemological position on teaching and learning engineering.

9.2.6 - Knowledge of assessment of disciplinary learning

Given the structure of the participant's knowledge of discipline curriculum (a series of important, related and cumulative theoretical concepts), it is entirely congruous that the major form of assessment that was observed consisted of administering exam based quizzes to test the comprehension of key concepts, and the application of those concepts to well defined problem examples. This assessment was administered at multiple points in the concrete design course in the form of gradable quizzes and a larger final exam.

It was not clear from observation if or how this assessment structure was formative for the teacher, because he did not give any discussion to how grading of exam based tasks informed his knowledge of what the students had learned. For example, if he was able to access and use information about how students had performed the calculation of exam questions, or if he was only responding to the final answer they produced in allocating grades. In hindsight, it would be useful to be able to ask the participant about this, however he has been unresponsive to communication since the week of the case and so this data is unavailable. Similarly, I requested more information about the four group-based design assessments worth five percent of the course grade each, a total of 20% of the course grade, but did not receive a response.

The information that was available for these assessments was that they were to be performed in groups of up to four students and that students would use peer assessment to determine how to allocate marks to individuals in the group. According to the course profile, the group marks for each of these assessments would be multiplied by an individual´s grading factor from peer assessment to determine the individual mark given. It should be noted however, that although the exam based assessments required students to achieve 50% to pass, there was no such requirement for the design assignments. Students could therefore pay very little attention to each of these design assignments and still pass the course, provided they performed well in the exam components of the course. It is therefore unlikely that these assignments were significant in the focus for the course, or as tasks for the students. Rather, assessment via examination was much more fundamental to the course design and the activities students were required to perform for assessment purposes.

The data from observation that is available concerning the assessment of disciplinary learning by this participant was a quiz that was administered during the week of the case for the concrete design subject. The session in which the students completed this quiz was observed as it fell within the scheduled contact hours for the class. As with the example problem included above (Section 9.2.2) this quiz mainly focusses on the students´ ability to arrive at the correct answer for tightly defined mathematical problems, such as ¨find the plastic centroid of the section and the design axial compression capacity of the section¨ and ¨calculate the development length required.¨ In one exception to this type of assessment question, Question 1 (b) asks students to explain ¨when the section is also subjected to a small applied compressive force, the moment of capacity will increase, why [does this occur]?¨ (Case Study B Assessment Quiz). In this instance, the assessment requires the student to explain their understanding of the reasoning for a particular concept, rather than simply recalling a conceptual rule and replicating how to perform a calculation with it. The remainder of this assessment piece, however, focusses on students correctly reproducing the mathematical calculations that will give them a correct answer. Of course, these methods may be entirely appropriate for the nature of the subject matter being assessed. However, the important point here is that the focus of the assessment in this example is very much in keeping with what has already been seen of this participant´s orientation to teaching in the discipline, and there is little suggestion that they will help the participant to develop an understanding of how students have learned in his course, as compared to the raw grades that students achieve. This is in contrast to Participant A, who used even exam based assessment pieces to test students´ working processes (and to build her own knowledge of them), and to adjust her teaching practices accordingly.

Although the data concerning his knowledge of the assessment of disciplinary learning is limited for Participant B, this may in fact be telling of this component of his pedagogical content knowledge, and constitute a finding in itself. With the participant for Case Study A, even though no opportunities for the observation of formal assessment activities were available, the participant was still forthcoming in discussing her understandings of assessment of disciplinary learning, and did so frequently and spontaneously. As has already been shown in the previous chapter, this occurred because this form of component PCK knowledge was interconnected to and inextricable from other PCK components, all of which were mutually reinforcing and were continually informing her actual teaching practices. For the participant in Case Study B, no such link among component knowledge areas was observable. We can conclude, therefore, that even if he had specific forms of knowledge of assessment of disciplinary learning (beyond rewarding students with grades for arriving at the correct answer on exams), this knowledge was not explicit in observation or discussion of his practices, and was not linked with the other component PCK knowledge areas that were observed. Thus, if this aspect of PCK was important to his practice, it was not through an integrative process such as was seen in the PCK of Participant A.

9.2.7 - Knowledge of teaching for practice in the discipline

In previous sections, this aspect of PCK was defined as knowledge of how to teach about the nature of practice in industry, and the skills required in professional practice, including knowing how to establish links to and demonstrate relevance of teaching topics to future professional practice. In only one instance was the participant observed to engage in a practice that would fit this definition. In this case he was talking about the use of software packages for design by professional engineers. He advised the students that professional engineers use software for design but using that software needs some background knowledge. ¨Although in your future career you will be using software, the basic concepts (that we are learning now) are what allows you to do the modelling, evaluating, compiling results¨ (Case Study B Observation Notes).

This was the only time that the participant was seen to link current learning to future professional practice, or to establish the relevance of specific things being learned to actual tasks of a professional engineer. Although he was often heard to refer to the Australian Code or the need to use the Australian Code for concrete design, this was never in reference to the professional context of designing, or the skills or practices of engineers in using this Code. Rather it involved referring to the Code to determine specific values to be used in performing calculations to arrive at a correct answer, and emphasised Mode 1 rather than Mode 2 forms of knowledge. For example, in one instance he was heard to comment ¨it is very important to become familiar with Australian codes, so that you can check your calculations are right.¨ In another he said ¨According to Australian code, at least two tendons should pass through the critical perimeter¨ (Case Study B Observation Notes). During the week of the case, the participant was not observed to discuss or reference his own professional experience with the students. Although he did mention during an interview that he using his own experience to give students ¨practical examples¨ this was not observed to occur during his teaching sessions.

In Chapter One we saw that the work of Shreeve (2010) had derived from phenomenological study, five distinct categories of relations between teaching and practice when the teacher is (or used to be) a practitioner in their discipline. The category of relations that best fits with this participant´s observed practice is that of *dropping in*. In this category, there is an ¨asymmetrical relationship between teaching and practice, with the focus on practice¨ (Shreeve, 2010, p. 694). Although this may seem contradictory for a participant who´s observed teaching contained little reference to actual processes or skills, it is clear that the focus of his teaching was on his own performance of the subject matter. Shreeve explains that within this view of teaching:

> There is an indication that being a practitioner, and by implication, an expert in one's subject area, is sufficient to ensure that the knowledge will be passed on to those who do not have the knowledge. There is an associated emphasis on … a tutor-focused transmission of information approach to teaching (Trigwell and Prosser 2004), where the tutor demonstrates and then expects students to replicate the skills of their practice. (Shreeve, 2010, p. 695)

This closely echoes the participant´s observed epistemology of the teaching the discipline, in which it is up to the students to reproduce his performance of calculations and abstractions, and to transfer those processes to other types or examples of problems.

Because this category of relations between teaching and practice assumes that students can replicate expert performances, it does not allow teaching to account for the difference between the task of the engineering learner and the task of the engineering professional. Learners in classrooms such as were seen in the week of this case are required to execute well-defined calculations. Similarly, engineers in industry must be capable of the same calculations, but these calculations are a smaller part of a wider problem-solving process which includes dealing with ambiguity in the problem context, working on problem definition and the appropriate development of abstractions to which theory can be applied. This category of relations between teaching and practice therefore precludes the development or application of knowledge of teaching-for-practice in the classroom. This component knowledge area was therefore not observed to be significant to the composition of PCK for this participant.

9.2.8 - Reflection on teaching

The participant was not observed to engage in or refer to any specific reflective activities or reconsider his own teaching. However, this may have been due in part to his being unwell and having less time for teaching related activities in the week of the case study. By his own words, the participant was time poor with regard to teaching, especially given the high volume of material that he believed needed to be covered in lectures in his courses, and this may have detracted from his ability to engage in reflective activities. However, reflection related activities were not discussed by the participant even in an aspirational sense in discussing his teaching practice.

In one instance in which teaching development or change was observed to have taken place, the participant discussed how he had chosen to add tutorial sessions to his concrete design course in order to help students to cope with the material. He had taken this step in response to a high failure rate for students in his course, and was confident that it had helped students to deal with the material more effectively and to do better in assessments for the course. In this instance, a change to his teaching practice (at least in terms of course design, as it was tutors who ran the tutorials, rather than the participant) was seen to result in improved learning outcomes for students. However, this was a one-off occurrence for this participant and did not result from planned, structured or habitual reflective processes.

9.2.9 - Integration of components of PCK

The participant´s knowledge of discipline curriculum that was observed in the week of the case was the strongest component of the observed PCK, to the point that other components (excepting the specific instructional strategies already discussed as strongly related to this form of curricular knowledge) were not observed to be present in any significant way during the case. As a result, a process of integration of the elements of PCK was not seen, and was not constitutive of the nature of PCK for this participant as it was for the previous case.

Despite the fact that his knowledge of disciplinary curriculum was fluent, substantial and current, this was developed through his experience in industry and his ongoing work with theoretical research in his discipline area, rather than through iterative reflection on teaching practice. The relatively undeveloped nature of the other PCK components for this participant may be largely due to a perceived insufficiency of time to dedicate to activities that would lead to their development. However, it should also be recognised that the participant´s underlying epistemology of teaching and learning for engineering was such that he was not compelled to consider their development as valuable or essential to his teaching practice, because knowledge of discipline curriculum was observed to be the exclusive focus of his teaching.

9.3 - Characteristics of the site in the field

In contrast with the observed teaching practices of the participant, which were observed to be largely in keeping with the tradition of engineering education favouring lecturing, there was a large amount of information available from the institution in which he worked detailing their policies of educational reform towards more student-centred and constructivist approaches to tertiary education. The information from these policies gives a picture of university classrooms in which a focus on practice in industry is seen as the most appropriate approach to teaching the engineering discipline.

9.3.1 - The structure of the engineering program and its educational rationale

The engineering program at the site for this case also includes two six month internships that students are required to complete, generally at the one year to eighteen month mark, and again closer to graduation. According to the university website, which directly addresses prospective students, the educational rationale for this curricular structure is as follows:

> Returning to university as a young professional will inform your further study and no doubt, your approach to learning will shift. Moving forward, you'll know which skills you'll need to pick up and why…When you do your second internship, you'll be close to graduating and so you're second internship will give you a valuable introduction to life after your degree. Many of our students finish their degree by studying part-time and working part-time as trainee engineers. (Case Study B extract from university website)

The website also gives a quote from a current student who states that ¨The theory [I learn in class] definitely relates back to the work I'm doing. Even the social and communication skills I'm picking up are important" (Case Study B extract from university website). The university therefore asserts a direct link between the learning in class and the learning in the workplace; that each will reinforce the other.

As a result of this program structure, the engineering degree generally takes five years to complete rather than four. The website addresses this issue, again directly to prospective students, thusly:

> Why should I sign up for a longer degree? The [name of uni] course is 5 years long, while other universities offer 4 year engineering courses...Complete a 4 year engineering degree and you're on your own when it comes to finding work once you graduate. While at [name of uni], you can benefit from our Industry Partnering Unit and our Engineering Practice and Work Integrated Learning subjects. Your internships may also involve paid work. That means you could potentially be earning while studying. (Case Study B extract from university website)

In discussing this with the Director of Undergraduate Programs for Engineering, he explained that often students will take more than the five years to complete the course, because once they have formed a professional network through completing the first internship, they often continue to work part time in industry and continue their studies part time or as and when they can, rather than following a set program structure or schedule. This suggests a fairly symbiotic relationship between the learning that occurs in industry, and the learning that occurs in the classroom. However this was not observed during the sessions for the participant of this case.

Whilst the published information about this alternative program structure is uniformly positive about its effects, data from other sources suggest that this should not be accepted as a given. In discussing the program structure with a faculty member who was active in the engineering education research group at the site, I asked her about her views on the effect of this for students. Her response was ¨it is sink or swim…and although the internships give the students a taste of a real engineering job, when they come back to uni things are very much the same as before they went on internship¨ (Case Study B Observation Notes). According to this academic, the way the courses are taught does not generally change as they progress through their degree with more practical experience. Further, with regards to the link between classroom learning and industry experience, she comments that in preparation for the internships students are required to prepare CVs, interview a practicing engineer about what is important in their job. However, these tasks are unconnected to their regular course work in other subjects. According to this faculty member, in doing these tasks, this is the first time students believe that communication is important to engineering, despite doing one course about it in first year. This would call into question the degree to which the classroom learning is maintaining the industry relevance of the program that is claimed on the website. Links to industry relevance were also not observed during the teaching sessions of the week of the case.

9.3.2 - Institutional policies about teaching and learning in engineering

At the time of the case, the institution for Case B had published a variety of information concerning its approach to tertiary education, and why this approach differs from traditional approaches. This information was organised under three headings which make up the framework for the approach to learning that the institution espouses. These headings (described as the features of the ¨Model for Learning¨ at this university) are:

- An integrated exposure to professional practice through dynamic and multifaceted modes of **practice-oriented education**
- Professional practice **situated in a global workplace**, with international mobility and international and cultural engagement as centre piece
- Learning that is **research-inspired and integrated**, providing academic rigour with cutting edge technology to equip graduates for life-long learning. (Case Study B extract from university website)

In order to help academics to enact these principles, the university had conceived of a program of innovation (Program X) intended to promote alternative approaches to instruction, principally, through the redevelopment of learning spaces that allow for more collaborative learning:

> A suite of projects and initiatives make up [Program X], aimed at ensuring our graduates are prepared for a global and changing workplace; our curriculum is mapped against the attributes we want our graduates to attain and the learning experience of students is relevant, high quality and engaging…The [name of uni] campus development provided an opportunity to shape the future of learning through the design of a new suite of spaces. This began with the [Program X] initiative which supported staff to reengineer their approaches to teaching and learning to make the best possible use of the new spaces. Now these spaces are up and running, the next phase of [Program X] initiatives will begin. (Case Study B extract from university website)

Despite the fact that this excerpt speaks about the campus redevelopment as having been completed, at the time of the case study, a large number of the learning spaces designated for the engineering faculty were still being built or were not yet available for use. The available literature about the program also spoke about the ¨reengineering of classes¨ as largely complete, however, this was not reflected in the classes that were observed for the participant in this case. Despite this, the published material about this alternative approach spoke of it in the present tense, and as something that students were uniformly experiencing:

> The [name of uni] approach to teaching is being reengineered to make use of the new spaces for students inside the new buildings on campus. Students are experiencing high quality face-to –face teaching in spaces that encourage collaboration and discussion. While some classes still feature lectures, students are also learning in smaller groups using techniques such as flipped learning. (Case Study B extract from university website)

Given that the observed sessions for the participant in this case included *only* lecturing activities, with *no collaborative or small group components*, the claims of the website about the consistency of approach to teaching at the site should not be accepted uncritically.

In a final point about the nature of the program, the engineering education research group academic also commented that student intake has two main sources, regular school leavers as with many other universities, and ¨alternative pathways¨ students who come into the program through a technical college or some other alternative. Thus, the makeup of the student cohort may be slightly different than at other universities, such as at the ¨sandstone university¨ seen in Case Study A. This informant commented ¨the alternative pathways students tend to make better engineers because they have spatial and practical awareness, but they struggle with the academic nature of the program, because this is different to the previous experience that they have had¨ (Case Study B Observation Notes). When these students get to a course such as one that is run by a colleague from the engineering education research group, in which they have to create lab experiments, rather than just run them, they tend to do better. ¨Traditional academic students,¨ on the other hand, get to that course and struggle because they are not being ¨told what to do¨ (Case Study B Observation Notes). These comments suggest that, at least from this informant´s perspective, a dichotomy persists at the site between the nature of classroom learning (academic, theory oriented, Mode 1) and industry-related learning (practical, experiential, Mode 2).

In summary of the characteristics of the site, the espoused principles of practice-oriented and constructivist learning, combined with an alternative program structure including internships, give potential for an alternative approach to engineering education to be seen in engineering classrooms, and an alternative form of teaching *capital* to be available through the use of such an approach. Theoretically, this context would give an academic wishing to pursue non-traditional approaches to engineering education a defensible position from which to do so, unlike as was seen in Case Study A, where an innovative approach to education was seen as risky and was actively discouraged. Further, the available materials from the university about its approach to education read as if it is academic staff have consistently taken up the innovation. If this were the case, rather than needing to defend innovative teaching, doing so should result in the accumulation of significant *capital*. Further, it should be risky for academics to maintain a more traditional, didactic approach to teaching at this site, as this practice should result in a decrease in teaching-related *capital*. However, for the participant in this case, this was not the case, calling in to question the significance of the policies of learning that are published by the institution for influencing the forms of *capital* available at the site, and the configuration of relations that result. Data about the epistemology of teaching and learning at the site and the available forms of *capital*, instead suggest that the structure of the *field* at the site is very similar to Case A, in terms of *capital* and how it may be competed for.

9.3.3 - Epistemology of teaching and learning apparent at the site

There was some limitation to the data available during the week of the case that could give a clear picture of the generally-held epistemology of teaching and learning of engineering at the site, and how this epistemology shapes the nature of teaching-related *capital* that is available at the site. There were a number of reasons for this. First, the participant spent some time off campus while he was ill. It is possible that had he been at work he would have been attending meetings with colleagues, which would give some indication of shared epistemologies, as was the case with Case Study A. However, he did not mention the cancelling of any meetings with colleagues and none appeared on his schedule for the week, which I was given prior to the case commencing. Whilst on campus during the week of the case he was not observed to meet or collaborate with other academics, for teaching or other purposes, although it is acknowledged that this week may not be representative.

Second, whilst there was an opportunity to observe a meeting of the engineering education research group during the time that the participant was off campus, the epistemologies of teaching and learning observed in this meeting are not considered to be representative of the faculty as a whole, because, according to a member of this group, there is very little involvement in this group from the rest of the staff. The group itself consists of only around eight members. Therefore, the educationally focused research activities (including discussions of the nature and value of teaching and learning) that take place in this forum are cut off from the rest of the faculty. This in itself constitutes a finding about the epistemology of teaching and learning of engineering at the site. It suggests that research activities concerned with engineering education are seen as separate from the core business from the faculty, be it teaching of students or technical research. As was seen at the site in Case Study A, this may indicate an underlying attitude that the teaching of engineering need not be founded on a set of intellectually developed skills or empirically derived knowledge.

Despite this limitation in the data, it may be considered a finding of the case that the participant was seen to be left more or less alone to pursue teaching in the way that he saw fit. As such, the development of PCK is seen at the site as a matter for the individual rather than the school or faculty. This was despite the overarching policy of educational innovation that the institution was pursuing. When asked what he knew about this program of innovation concerning the approach to learning, he was largely unaware of what it entailed, saying only that he thought it was about putting content-based resources online, rather than covering them in class, in order to reduce face-to-face contact time. Concerning taking up the approach for his own teaching, he said that he was interested in this approach as a way of saving time and covering more material in his course, but that he didn´t know how it would work and so he had not pursued it. There did not seem to be any imperative to action, nor any consequences for this lack of action for this participant, as he was not planning changes to his approach to his courses in the near future, although he did have some interest in evaluating his teaching. This is the first of a range of data that suggest that the published policies on learning had not translated into *capital* at this site in the *field*, as they were not seen to be significantly shaping the actions of actors at the site in the *field*.

During informal discussion about my case study at the site, the Director of Undergraduate Programs expressed surprise to me that the participant in question had been selected for the case study, as he did not see him as someone who had a particular focus on teaching in his role. This is in fact what makes the participant a useful test case for this study, as it is the contrast between his traditional, didactic approach, and the public policies of the institution that were revealing of the nature of *capital* being exchanged at the site of the *field*. The fact that the participant was largely left alone to pursue teaching as he saw fit stands as evidence that, even at a site that (nominally) seeks to change the traditional approach to tertiary education, the disciplinary expertise of academics can still take precedence over their focus on and skills for teaching. This was also reflected in evidence about the nature and distribution of *capital* at the site.

9.3.3- Capital and rewards at the site in the field

As with epistemology, some limitations existed to collecting explicit data about the *capital* that was possible to compete for at this site in the *field*, largely due to a lack of observed interaction between the participant and other members of the faculty. However, there were a number of significant instances in which data were available. First, the participant for the case had been tenured as a senior lecturer based on technical research publication, and his disciplinary expertise in structural engineering. He taught exclusively in theoretical courses in the structures discipline, with a specific focus on reinforced concrete. He also spent a lot of time providing research supervision to postgraduate students with a theoretical focus. Despite the website stating that he had an interest in ¨developing online and face to face teaching strategies,¨ (Case Study B extract from university website) at the time of the case he had not yet undertaken any activities in this line and his ideas about developing his teaching strategies were, by his own admission, unformed. His list of publications to date also do not show any education-related research output.

In this respect, he occupied a very conservative position in the *field*, because he was primarily dealing in research-related *capital*, such as that which results through publication of research and supervision of research students. In discussing this issue himself, the participant was of the opinion that although ¨one of the reasons they selected me was my industrial experience,¨ he also believed that if an academic staff member does not ¨perform or continue research he may have little promotions. That´s why I believe that to update yourself for promotion you have to…keep researching¨ (Case Study B Interview 1). In this respect, the *capital* and rewards available (at least concerning strategies for promotion) were very similar to what was seen at the more research-intensive university in Case Study A.

This finding was supported subsequent to the week of the case when, in December 2015, the university released a communique concerning its performance in the 2015 ERA ratings. Like the research-intensive institution in Case Study A (and using very similar language), the communique stated that the results demonstrate the university´s success in the field of research and linked this success to the institution´s strength as an educational provider:

> [name of university] is well on its way to achieve its vision of becoming a world-leading university…we believe that for universities to maintain their relevance, we need to make sure we are ready to look beyond today´s solutions and be ready for what lies ahead [through achieving research excellence]. (University communique, December 2015)

As such, despite its purported focus on ¨practice-oriented education¨ the ¨research prestige¨ form of *capital* can be seen to be as important for the present case as it was for the former, once again suggesting the ubiquity and strength of this form of *capital* throughout the engineering education *field*.

One final instance gave further insight into the way that *capital* and rewards were distributed in the site in the *field*. One of the members of the engineering education research group had developed a lab-based course in which the learning activities required students to design effective lab tests, rather than simply following predefined experiments. This approach to course design and learning activities is directly in keeping with the institutional policy of Program X, in the sense that it was predicated on a constructivist philosophy, and involved student-centred activities that were deductive rather than inductive. This relates closely to the cognitive demands on professional engineers in industry.

Despite this, the academic who designed and ran the course had to argue stringently within the faculty for the value of the course in the face of negative teaching evaluations. As the other academic in the research group explained, the ¨academically strong¨ students found it difficult that they were not ¨told what to do¨ in this course (as compared to more traditional courses) and would complain the course was inadequate as a result. This gives an indication that the traditional means of assigning *capital* for teaching through teaching evaluations remains strong at this site, and is aligned with a traditional philosophy of what makes for good teaching rather than the innovative one that is published by the university. This suggests that traditional forms of *capital* outweigh or cancel out the *capital* associated with teaching innovation. This combined with the security the traditional, theoretical/research position in the *field* that the participant was seen to occupy gives a picture of the distribution of *capital* that is very similar to Case A, despite the espoused difference in the institutional approach to teaching at the site.

9.4 - Habitus of the participant

Having already discussed the participant´s epistemology of teaching and learning in the discipline, the discussion of his *habitus* is organised under the headings of the ranking exercise, focus and goals. Unlike Participant A, there was far less data available for each of these headings, as he had less to say during interviews and discussions, despite being asked questions based on the same interview protocol as for Case Study A.

9.4.1 Ranking Exercise (completed as a rating exercise)

When asked to complete the ranking exercise, the participant found that he did not have adequate time to do so during the week of the case study. As a result, the instrument was explained to him in detail, with some examples discussed and left with him to complete later on. Unfortunately, it was not completed as a strict ranking. Instead, each item on the lists was given a rating out of ten. In other words, instead of ordering items from one to ten, the participant gave each item whatever rating out of ten that he chose, meaning that many items had the same scores as each other. The participant was contacted a number of times to see if the exercise could be redone, however he was unresponsive and the completed task was never received. As a result, his answers to this exercise are not directly comparable with other participants´. However, they do give some insight into his overall *habitus* and his focus and goals in his role.

Most notable in the answers as a whole was the fact that no items on the list were given a rating below a six for interest or importance. On the one hand this indicates that the participant did not want to give anything a low priority, but as a result he did not clearly discriminate among items on the lists. This gives some indication that his strategies for operating in his role may not have been well worked out or established, otherwise he would have been able to be more selective. However, it should also be acknowledged that one of the purposes of requiring participants to rank the items on the list is to make them give a clear picture of which items were more and less relevant and how they were prioritised in the academic´s role. When ratings rather than rankings are given, the participant is not required to make such discriminations between items, and can include high scores that are actually not meaningful. A scatter plot is not shown for these lists, because without strict rankings this graph would not show the diagonal line that is significant for showing the degree of choice that the participant is able to exercise over their position and strategies in the *field*.

The ratings for the list of Tasks were as follows in Table 29. The lowest scoring items on this list were ¨designing and developing new courses¨, and ¨service to faculty/school.¨ The first is in keeping with what the participant communicated verbally during interviews; that this is valued less than the act of preparing for teaching, and reflects a focus on a stable set of core content for the curriculum, rather than on developing new aspects or approaches to courses. The second is in keeping with what was observed during the week of the case study, in that he was not observed to have significant interaction with other academics or take part in any committees or meetings. This suggests a relatively isolated position in the faculty, in which his susceptibility to new educational innovations or institutional objectives would be low. It also indicates that either the participant did not perceive any particular risk associated with this relative isolation of position, or that he was happy to disregard the risk.

Table 28 - Ratings for Tasks for Case Study Participant B

Task	Level of Interest	Level of Importance
Preparing and revising lectures/teaching activities	9	10
Lecturing/tutorials	9	10
Writing proposals for grants	8	10
Writing papers for publication	8	10
Reviewing and improving existing courses	9	9
Designing and developing new courses	7	7
Conducting research	9	10
Service to faculty/school	7	7
Eliciting and evaluating feedback from students	8	8
Training tutors or teaching staff	8	8

The ratings for Tasks also show an equally high importance given to preparing lectures or teaching activities, giving lectures/tutorials, writing proposals for grants and writing papers for publication. Despite their equal importance, the teaching activities here were rated slightly higher for interest that the research activities for this participant personally. Despite this, the importance rating suggests that he sees the available *capital* for these activities to be more or less equal. Concerning ¨conducting research¨ he gave an interest rating of nine and an importance rating of ten, suggesting that research is in fact equally interesting to him as the teaching activities above, but the associated activities of seeking grants and preparing publications for that research are less so. This selected set of values is not surprising or remarkable given the picture of his epistemology and practices already established.

In rankings for Goals (Table 30) the lowest score was given both for interest and importance to ¨improving student feedback on my teaching.¨ This was curious given that the task of ¨eliciting and evaluating feedback from students¨ was given scores of eight for interest and importance on the previous list. It does not make sense that he would value the task of eliciting and evaluating feedback more highly than the goal of improving feedback. Of these scores, it seems likely that the lower score of seven for improving feedback is the more meaningful and representative of his actual attitude and practices, given that his observed practices involved very little activity that dealt with student responses to his teaching. In other words, the teaching sessions observed did not include any activities in which students were required to respond to the teaching in any way, the questions he posed were rhetorical and were answered by the participant himself almost immediately, the participant spent much of the time whilst lecturing with his back to the class and students were completely passive during the lecture session. As has already been shown in the discussion of epistemology, it is clear that the participant views his accountability in his role to be to the content and theory of the discipline rather than more directly to the students themselves. By contrast, the participant rated the goal of ¨ensuring my own relevance and currency within the discipline¨ at ten for interest and ten for importance.

However, the participant also gave scores of ten for ¨educating the next generation of engineers.¨ An important point here is that, as with the participant for Case Study A, this is seen as the core business and outcome of working as an engineering academic, but with significant differences between their ideas about how this should be carried out. Both participants clearly value an outcome of their role being that students graduate to become professional engineers who can contribute to the profession. This is very important to them both. However, with Participant A, this was seen to be the result of a dual allegiance to the profession of engineering as a whole as well as to the students themselves. For Participant B, giving a ten to this item does not necessarily indicate a goal that is associated with direct accountability to the students. Rather, it is through his activity working with and transmitting the content of the curriculum that he carries out this aspect of his role. As we have already seen, it is up to the students to perform in adequate ways to be able to achieve this outcome in response to his transmission of content. Thus, this participant sought legitimacy and security of position through a strict adherence to the theoretical bases of the discipline, and his status as an expert with that disciplinary content.

Table 29 - Ratings for Goals for Case Study Participant B

Goals	Level of Interest	Level of Importance

Ensuring my own relevance and currency within the discipline	10	10
Achieving promotion	8	8
Improving my rate of publication	8	10
Educating the next generation of engineers	10	10
Improving student feedback on my teaching	7	7
Developing a good research record and reputation	9	10
Improving the learning outcomes of students	9	10
Increasing the amount of funding I have for doing research	8	10
Enabling young staff to learn how to do research	8	8
Doing a better job of teaching	9	9

Despite this being his view of his role as an engineering academic, the participant also rated ¨doing a better job of teaching¨ highly at a nine for interest and nine for importance. This is seemingly incongruous with other data so far. It is possible that he was perceiving some pressure to improve his teaching from within the faculty, although he did not say this. This is supported by his request at the end of the week that I provide him with some feedback or evaluation of his teaching, as an outcome of his participation in the case study. He also asked me for my initial thoughts on his teaching and was concerned with the confidentiality of the data. He saw participation in the case as an opportunity to evaluate his teaching from another perspective. Whether or not the participant was prompted to this evaluation based on extrinsic or intrinsic factors, he seemed unsure of how to proceed in doing so without some outside assistance. It should also be noted that having been provided with some preliminary findings from my observations of his teaching he made no response or comment, so it is unclear if or how this evaluation was responded to in any way or incorporated into his practices.

Other items which scored highly for this list were ¨improving my rate of publication,¨ ¨developing a good research record and reputation,¨ ¨improving the learning outcomes of students¨ and ¨increasing the amount of funding I have for doing research.¨ This mix of teaching and research related goals, as with items on the previous list, acknowledges the two main types of *capital* associated with teaching and research, although, on balance, there are slightly more items for research that were rated highly. Given the problems with rating the items rather than ranking them, this may not be significant, especially as all items were rated highly, with little degree of distinction between them.

The list of Indicators of Success (Table 31) also shows a preference towards research based indicators, at least for level of importance. ¨Having research published,¨ ¨winning citations/awards,¨ and ¨seeing the outcomes or findings of research being used for industrial applications¨ all scored a ten for importance along with ¨achieving promotion.¨ Of these items, winning citations/awards and achieving promotion were rated relatively low for level of interest at six, indicating that though they are important indicators of success for this participant, he may be less interested in pursuing them than other items of the list. Similarly, ¨having teaching innovations or pedagogies taken up elsewhere¨ received a score of six for interest, although it scored only an eight for importance. These scores show an increasing preference given to research related activities and the forms of *capital* that surround research activities, with teaching taking a slightly lesser priority.

Once again items that involve collaboration with colleagues were also given low ratings of seven, for example ¨being asked to collaborate on research projects or publications,¨ and ¨getting recognition from professional engineering societies.¨ These lower scores reinforce previous data suggesting a relatively isolated position in the *field* for this participant, with little activity directed towards developing collegiate networks within the academic position.

Other remarkable ratings for this list included nines for interest and importance for ¨high levels of attendance at lectures or teaching sessions.¨ These scores were supported by a comment that the participant made to students during class that they should ¨remember to come to lectures as they are critical for the exam¨ (Case Study B Observation Notes). Here we can see that attendance at lectures is linked to student success for this participant and is therefore linked to his own success in his role.

Table 30 - Ratings for Indicators of Success for Case Study Participant B

Indicators of success	Level of Interest	Level of Importance

Having research published	8	10
Winning citations/awards	6	10
Achieving promotion	6	10
Being asked to collaborate on research projects or publications	7	7
Having teaching innovations or pedagogies taken up elsewhere	6	8
Seeing the outcomes or findings of research being used for industrial applications	8	10
High levels of attendance at lectures or teaching sessions	9	9
Positive feedback from students on teaching	8	9
Being able to use research activities to inform teaching activities and vice versa (e.g. first-hand knowledge of recent developments in research field being passed on to students	8	8
Getting recognition by professional engineering societies (e.g. demand for consultancy services, fellowships, etc.)	7	7

Overall, the ratings given to items on this list show a conservative approach to the engineering education role, in which the participant was reluctant to rate lowly any perceived aspect of the role. Because of this approach, the distinctions between items on the list was minimal, although, on balance a slight preference towards the importance of research-based activities emerged. The other indication that these scores gave was of a relative lack of interest in collaborative or collegiate activities that could be brought into an engineering academic role. This was supported by observational data from the case.

9.4.2 - Participant´s focus on aspects of their role

Some difficulties were encountered during the case study in eliciting data from the participant concerning his focus and goals in his role. He was not forthcoming during interviews about his specific goals and focus in his role, suggesting that these had not been well worked out. The comments he gave in reference to these issues were general in nature, as follows.

In discussing his background in coming in to the academic role, he focused heavily on his industry and research experience, and understood these things, and the strength of his disciplinary expertise that resulted from them, to be the key reason why he was given his position. In particular, he mentioned his involvement in the body who developed the Australian Standards (or the Australian code) for his discipline of structural engineering, and its influence on his teaching of one of his courses. His comments suggest that teaching in this course was based mostly around designing in compliance with this code because ¨if students can use this code they can defend what they have done¨ (in the design of a structure) (Case Study B Observation Notes).

Such comments give an expectation of a course in which much discussion and class time is given over to considering the application of the Australian code to design problems, and the processes of decision making that this would involve. However, classes looked markedly different than this, as was seen in discussion of the observed sessions, and featured only one or two explicit references to the Australian code, during the observed sessions. Furthermore, despite describing the course as ¨applied¨, the observed classes featured only strictly defined example problems, and the assessment in the course involved only 20% design based assignments, the rest being assessment in exam formats. Therefore, it is not clear how the participant´s purported industry focus related to actual strategies for teaching his applied course.

In discussing how to complete the rankings activity, the participant was reading the lists of tasks and commented that he believed that preparing courses was much more important than reviewing and evaluating them. This opinion is in keeping with his epistemology of the discipline, in which the content of the discipline is the focus and the most important component. Within this view, it is not surprising that having presented the content appropriately, there would be little need to review it, as the content itself is seen as relatively stable. Further, a lack of attention to the role of the students in the educative process and their responses to the educative process, means that there is nothing to evaluate the presentation of content *against*. It also suggests that the participant was not strategizing to accrue more *capital* through improving or innovating his teaching, despite the focus on published policies of learning at the institution. Rather, he was content to strategise chiefly through *capital* accrued through research outputs, and to meet a minimum standard of teaching by focusing on the quantity of disciplinary content that he transmitted during teaching activities. In this sense, this participant was seen to be situated in a conservative trajectory in the *field* very similar to the conservative one that was theorized in the map of the *field* in Figure 21 of Chapter 6.

This also accords with his focus during interviews and incidental discussions on the volume of coursework that he was required to cover within the semester. He commented that at other universities the material for his one of his courses was covered over two semesters, rather than one. As a result, he saw himself as time poor, particularly in terms of class time for covering the content of the courses. He viewed this as a reason to avoid trying alternative approaches to his courses, as any loss quantity of what he viewed as requisite content was seen as a risk to the students´ foundational knowledge for the discipline. Although he commented that using a flipped classroom approach could theoretically free up some room in the curriculum, he did not believe that this would work for him as the applied nature of the course required that he perform the content for the courses during lectures. In this sense, his view of the curriculum as content-crowded can be seen to add to his need to control the way that content was delivered. Despite being sick during the week of the case, he felt unable to miss any classes. He was clearly of the belief that unless the students attended lectures and saw his explanations they would be unable to assimilate the material or come up with successful answers for the example problems that were set.

In summary of this participant´s apparent *habitus* in the *field*, he appeared to adhere to a strictly positivist epistemology of the discipline of engineering, which had clear implications for a traditionally didactic and transmission approach to teaching. Significantly, responsibility for what the students would actually learn and how they might do so was seen to fall outside of this epistemology of teaching, and his view of an academic´s teaching activities. Rather, the participant saw himself as directly accountable to the canon of disciplinary knowledge that he saw as fundamental to engineering, and it was through performing this canon that he sought to accrue teaching related *capital*. Although the participant was prepared to discuss the importance of industry based experience for teaching in his courses, this was not seen to dislodge the positivist view of the teaching of engineering, and the traditional teaching practices that result from this view, because the participant seemed to uphold a clear distinction between what engineering students should do and what professional engineers do. In essence, rather than focusing on the quality of teaching that occurred in his courses, and how it could develop students towards practicing engineering, he was seen to focus on the quantity of foundational content knowledge that could be covered in those courses. In this respect his *habitus* for participation in the *field* strictly adhered to the conservative status quo that has been theorized throughout the analysis of the data so far, and rather than seeking to challenge the structure of the *field*, he was dedicated to pursuing a conservative and well-trodden trajectory through it.

9.5 - Conclusions from the case

As was seen with the participant from Case Study A, this participant showed a singular dedication to his role as an engineering academic, even to the point of attending campus to teach class when he was unwell. He rated most highly the goal of ¨educating the next generation of engineers,¨ but saw his role as to do so by performing for students (and requiring students to independently reproduce) a stable core curriculum of canonical engineering knowledge related to the structures discipline. He also saw the responsibility of assimilating this canonical knowledge as falling to the students themselves.

Because of this epistemological position on the nature of teaching and learning for engineering, his teaching practices revealed an almost exclusive focus on the *knowledge of discipline curriculum* component of PCK, and he used instructional strategies that allowed for the demonstration of his own conceptions of that curricular knowledge. Rather than focussing on processes supporting students´ own development of appropriate conceptions of theory, and the skills and processes students should adopt in applying that theory in practice (Mode 2 knowledge), his teaching practices accommodated Mode 1, codified forms of knowledge only, and did not venture into the ill-defined, experiential world of practice. In fact, in both interviews and observed practices, he maintained a distinction between the task of learning engineering, and the task of being a professional engineer. He was of the view that learning to be an engineer was something that students could do, for the most part, upon graduation. In this respect, his *habitus* in the *field* did not recognise the influence of the engineering industry node upon the structure of the *field* as a whole, despite his transition into the academy from a career in industry. His strict adherence to the ¨canon¨ instead was in agreement with and supporting of the status quo, in which notions of Mode 1 ¨engineering science¨ types of knowledge (both among staff and students) are privileged.

This position (both epistemologically and in terms of his location in the structure of the *field*) was seen to circumscribe the current form and potential development of the participant´s PCK, because the exclusive focus on the content bases of the discipline prevented the recognition of the value and applications of knowledge from other component areas of the construct. For example, knowledge of students´ understandings of the discipline, and knowledge of teaching practice fell outside the scope of the teacher´s role and the educative process according to this participant´s orientation to teaching the discipline. Similarly, the processes of reflection and integration were not necessary to enacting this epistemology within his approach to teaching practice. As such, for development of these PCK components to occur, or some integration of the components of a construct as a whole, some epistemological shift would be required.

Crucially, the structure of the *field* at his institution allowed for his epistemological position and set of teaching practices to go uncontested. This suggests that despite the public policy of educational innovation at his site in the *field*, there was not yet a developed form of available *capital* that could act to reward academics for pursuing such change, or to discourage academics from resisting change in the way that this participant was seen to. As a result, his epistemological position or subsequent practices concerning teaching had not been modified or dislodged at the time the case took place. The structure of relations at the site in the *field* was also not significantly different to that of the site for Case A, and took its structure from very traditional forms of academic *capital*.

From this we can conclude that even at sites where a discourse of educational innovation is present, and where constructivist and Mode 2 forms of knowledge are nominally valued, such policies alone are not enough to alter the configuration of relations of the engineering education *field*. This in itself is perhaps not an entirely new or revolutionary conclusion, however it does indicate the strength that the *capital* from the Higher Education node of the *field* has to exert on the structure of the engineering education *field* overall. Furthermore, while traditional reward structures persist for recognising contributions to teaching (through teaching evaluations, rather than the development of PCK) and research (through publication and grant winning) over and above – or at the cost of – recognition of other forms of achievement and contribution in the academic role, any significant change in the structure of relations of the *field* are unlikely. By extension, traditional tertiary teaching practices and resistance to the change that is called for across much of the engineering education literature will likely remain largely unchallenged and entrenched in the discipline as a whole.

10.0 – Case study C - ¨the only game to play¨

For the final case in the study, a participant was chosen who was known to have a track record in engineering education research. The participant in this case worked at a regional university with a large cohort of external students, and subsequently did much of his teaching online using the university Learning Management System (LMS) as well as teaching regular, face-to-face classes. Despite his interest in engineering education research, this experience was not observed to be linked to his approach to his teaching practice, or to have resulted in significant change in that practice. The participant also had an interest in technical research and had published in this area as well.

The engineering sub-disciplinary area for this participant, in contrast to the last two cases, was in computing and telecommunications. Whilst this was expected to make some difference to the actual contents of his PCK, it was expected and found that the nature and composition of his PCK would not be affected by engineering sub-discipline. Rather, his PCK shared some aspects of its composition with that of Participant A, although the processes of reflection and integration were at some points lacking, and were not consciously pursued as they were in Case A. This had parallels with the participant´s observed *habitus*, in that he demonstrated a set of strategies for operating in the *field* that were not determined by conscious goal setting based on his own priorities. Instead his strategies were responsive to perceived opportunities (and limitations) that the site in the *field* provided. As such, the characteristics of his site in the *field* were seen to have a significant effect on the possibilities for his teaching practice created via his *habitus*.

In particular, the narrow definition of quality of teaching that was observed at the site (that it was confined to the successful administration of the LMS for any given course) and an almost exclusive focus on the importance of the appropriate publication of funded or technical research above any other academic activities, was seen to circumscribe the opportunities for academics at this site to develop and pursue strategies of their own choosing. For example, a number of engineering faculty members were reported to be interested in pursuing research related to their teaching practices in the classroom, but believed there would be no recognition or reward for doing so and were therefore not willing to spend the time required.

Furthermore, the participant reported that a recent restructure of the university faculties, a decrease in administrative staff made available for use at the school level, and an increase in the administrative tasks that academics themselves were required to undertake, had resulted in an increase in pressure and demands of the academic role. He described this increase as the difference between hard and ¨punishing.¨ Despite this sense of pressure, the participant was recently promoted to Associate Professor in the latest promotion round (around 6 months after the case took place). Therefore, the strategies and practices he was observed to use can be considered as having been successful for improving position at this site in the *field*.

10.1 - Background of the case

The institution in this case had begun life as a technical college before becoming a regional university around 20 years ago. Its homepage promotes the fact that it is number one in the state for graduates in full-time employment (according to a graduate survey) and that it focusses on flexibility in learning by offering courses online. Despite this marketing towards student needs and vocational outcomes, during and subsequent to the case the university was also seen to focus extensively on the prestige associated with publishing research.

The university had recently undergone a significant restructure of its faculties, combining each of the separate faculties into two super-faculties. The participant expressed the opinion that the aim of this restructure was to standardise the student experience across each of the schools, and that ¨what a student sees in nursing when they log in [to the LMS] should be the same as an engineering student.¨ This opinion reflects the wider institutional view that was observed during the case that the main and most important interface between the university and its students was the LMS. The participant was sceptical of the benefit of such standardisation, given that the needs of nursing compared to engineering students may be very different.

For the participant in the case, his time was devoted more or less evenly to research and teaching duties. However, in interviews he was adamant that administrative tasks were increasingly impinging on this time, and that it was very difficult to keep up with everything. His schedule for the week of the case is represented in Table 34 below. Whilst it shows a portion of time each day in which he is working in his office, by the end of the week the participant reported that the need to complete administrative tasks had prevented him from getting to the work that he hoped to do, such as working on his current research projects. The participant put this increase in administrative tasks down to a decrease in administrative staff made available for use at the school level, and that this change was part of the university-level restructure. He believed that academics were increasingly being made to complete administrative work themselves, that this was taking them away from their ¨real work¨ and that this was not being recognised in workload requirements.

All of the sessions shown in green in Table 32 are the times in which the participant had face-to-face contact with students. It should be expected that some of the office time shown in grey would also be taken up by teaching-related tasks conducted online via the LMS, such as responding to student enquiries in discussion forums, posting materials and updating course sites, etc. However, the distinction between working on the LMS as an administrative task and as a teaching task is not clear, particularly as the definition of quality in teaching that was observed within the school only extended to the effective administration of course pages on the LMS, as will be seen in later discussion. The participant himself, however, in discussing teaching, defined it as contact with the students, suggesting that he draws a distinction between LMS tasks that are teaching related, and those that are administrative.

In addition to the time shown on the schedule, the participant also reported that he was in the habit of getting up early in the morning (around 3 or 4am until 6 or 7am) in order to complete work from home without distractions or interruptions, particularly when facing deadlines or particular time constraints. He stated that this is the time that he ¨gets the most done.¨ This extra time spent working from home in the early hours of the morning constitutes a considerable increase in his weekly working hours.

Table 31 - Schedule of activities for Case Study C

	Monday	Tuesday	Wednesday	Thursday	Friday
9am		Office time for participant	Office time for participant	Office time for participant	Classroom session for third year computer systems course
10am	Participant worked from home on his ¨research day¨ but spent the day responding to emails and doing administrative tasks	Preliminary interview with participant	Supervision meeting with PhD student	Discussion with participant about his role in the faculty	
11am			Meeting between participant and his Head of School about school retreat		
12pm		Office time for participant		Classroom session for third year computer systems course	Office time for participant
1pm		Electrical and Electronic practice course in computer lab (residential school session)	Office time for participant	Professional practice lecture on the use of PowerPoint	
2pm				Follow up interview with participant	
3pm		Supervision meeting with final year project student	Discussion with Teaching and Learning support staff member for Engineering school	Participant leaves campus to collect his kids from school	
4pm		Discussion with participant about supervision duties and teaching in general			
5pm					

Another aspect of context worth noting at the outset of discussion for this case, was that the university positioned itself as offering ¨flexible¨ learning to students, ¨making it easier than ever to fit study into your life¨ (Case Study C extract from university website). This meant that non-traditional tertiary students, especially those who are employed part-time or full-time, or not able to attend classes on campus or study on a set schedule, could enrol in courses and programs that would not otherwise be available to them. The result of this was that because of the need to provide courses ´flexibly,´ online activities needed to be predominantly asynchronous, because not all students could take part in them at the same time. This is a significant limitation on the possibilities for online teaching practices, because many teaching activities, especially many involving collaboration and direct interaction, are necessarily synchronous. This circumstance is likely to significantly impede or redirect the free development of PCK for academics that need to base their teaching in asynchronous online activities.

It should also be noted that although much of the participant´s teaching was done online, this was not the special focus of this case. To examine the difference between PCK for face-to-face and online teaching specifically would require another set of research questions and data collection activities, which it is not possible to pursue within the scope of the present project. Rather, the present case focused on how the institutional context of a regional university with online provision of teaching affected the overall practices of an engineering academic. Furthermore, it was noted during the case that the participant treated online and face-to-face teaching activities as more or less equivalent in his role, with neither taking a greater importance, and no clear difference in their relative status. However, in certain instances it was found that the pedagogical content knowledge the participant used in teaching activities for face-to-face classes was not applicable to activities for the online students in the same course. For the online students, no equivalent activity was provided, suggesting that the limitations of teaching online asynchronously were not dealt with in the participant´s overall body of PCK.

It was sometimes unclear what distinction the participant made between administrative tasks that take place on the LMS and teaching tasks that occur on the

LMS. For example, he discussed calculating and submitting grades as an administrative task, despite the fact that it is closely related to teaching and learning. Answering student emails was also treated as an administrative task and a drain on his time that took away from the more important tasks of teaching and research. However, overall the participant tended to discuss teaching in terms of those activities that involve contact and interaction with students that related to the subject matter itself, which for the online environment can include forum discussions, answering student questions, etc. If future research was to explore the differences between PCK for face-to-face and online learning, it would need to consider and explain the ways that tasks are understood and categorised by the teachers themselves. It may be significant, for example, to consider the difference between teaching tasks that take place in synchronous versus asynchronous modes, in order to sufficiently answer questions about the differences to teaching practices and bodies of teaching knowledge that these modes for teaching can have.

At any rate, the present case was restricted to analysis of aspects of teaching that were susceptible to observation, which included observation of face-to-face interactions with students, the self-reported beliefs, attitudes and behaviours from interviews, and the documentary artefacts of teaching such as lecture slides, task sheets and the ¨how to study in this course¨ guide that the participant provided to online students.

10.2 - The nature and composition of the participant´s PCK

As with the previous participant, understanding the PCK of Participant C must begin with examining his epistemology of teaching and learning engineering.

10.2.1 - Epistemology of teaching and learning engineering

The participant made a number of statements that indicate his epistemology of engineering and teaching in engineering. Despite the fact that he worked in the sub-discipline of computing and telecommunications, the epistemology that he espoused and put into practice can be understood to apply to the engineering discipline as a whole, and in fact has some points in common with the epistemology of Participant A.

His attitude to problem-solving in engineering agreed with that of Participant A. He stated ¨engineering problems can´t be boiled down to one black box. It involves understanding context and the interface with other people involved in the problem¨ (Case Study C Observation Notes). Like Participant A, he then gave an example of this that applied to his own sub-discipline; he used the analogy of coding a program for the context in which it will be used by the end user for whom it is intended. He also discussed the difference between ¨formal¨ and ¨informal¨ problems, stating that ¨an informal, perhaps less structured approach to problem tasks can be more appropriate¨ (Case Study C Observation Notes). Here he is referring to the degree of structure and definition inherent within a problem itself, and is of the belief that, as ill-structured problems better represent the reality of practice in industry, it is better to use such problems in teaching in order to encourage a focus on working with the context of a problem, rather than focussing on the ¨right answer¨ outcome.

This attitude was also reflected in an observed supervision session with a final year project student, in which the participant encouraged the student to use the booklet ¨Systems Engineering for Dummies¨ to guide his approach to the project task. When I asked about this afterwards, the participant commented that he has noticed that students struggle to shift from the undergraduate mindset of working with defined problems and set deliverables:

> This booklet is an attempt to get them to refocus on the project level task of defining the problem. The project is intended to develop the kind of skills that are relevant to working on industry type problems. Students are encouraged to choose something they are interested in and that is relevant to whichever field or role they want to go into. (Case Study C Observation Notes)

The participant also stated that he had spoken with local industry about the kinds of things they are interested in in graduates, and that the final year project problems are meant to reflect that, such as collecting data and bringing it back to base for the company to put to use. Thus, the participant´s epistemology of the discipline concerning problem-solving links with a focus on the vocational outcomes of engineering education, and the need for students to possess the capabilities required for working with problems in industry. This professional practice focus matches well with that of Participant A, although it was not expressed in such detail as in that case.

Concerning the implications for teaching that this view of the discipline entails, there were some contrary data in this regard. In one session that was observed, the participant had rewritten a practical task about installing Linux to be more open-ended, contextualised and industry-focussed. He had removed explicit instructions and instead encouraged the students to discover and work through the appropriate process themselves, with support from their peers. This example will be discussed further under 10.2.4 (Knowledge of Instructional Strategies). Whilst this fits well with his espoused epistemology, other statements that he made and practices that were observed concerning teaching are less coherent with this epistemology.

In a session for the professional practice course about presentation skills and appropriate uses of PowerPoint, each of the points in the lecture was made in reference to the course assessment only, and not to the industrial applications of presentation skills, despite the purported focus of the course. Furthermore, in discussing his views of teaching generally, he explained that although he enjoys contact with students because it makes his job more interesting, he is not sure that it is necessary to perform lectures for face-to-face students in addition to providing a study book. He acknowledged that although lectures do ¨provide more context and social context¨ and that this ¨has value,¨ he wonders if it is worth the time (Case Study C Observation Notes). In this sense, he sees his time in performing lectures as a resource that is not worth expending compared to the benefit the students can get from it. Rather than focussing on using lecture sessions as a chance to further the professional-practice focus that he sees as appropriate to the discipline, this comment reflects more of a ´provision of content´ approach, because lectures are seen as more or less pedagogically equivalent to study guides.

However, in this instance, it is possible to distinguish between the participant´s own inherent view and value for teaching, and the wider institutional views on teaching that this could be understood as a reflection of. As will be seen later, the institutional view of teaching that was observed during the case was exclusively concerned with the organisation and provision of content-based material (usually online through the LMS), in which the role of the learner is to ´go away and do´ something to create their own learning opportunities from those materials. In making the comments about the redundancy of lectures, it is likely that the participant was commenting as much on the institutional circumstances that restrict his teaching activities to the provision of content, rather than his own views about the nature and value of teaching.

The participant discussed the drawbacks of teaching online being that students are ¨just names.¨ although he said that this makes teaching more challenging and interesting to be able to connect with the students. These comments suggest that although he is working within circumstances that focus on the provision of content, he can still emphasise and enjoy the task of ¨connecting¨ with students. Furthermore, he states ¨because most of the external students are mature-aged, I have to say, I find it easier to connect with them¨ (Case Study C Interview 1). Although the institutional view of learning creates a barrier between learner and teacher in the form of the LMS, this participant retains a focus on and a value for personal interactions and relationships within the teaching process. In Case Study A, it was seen that this kind of focus on and value for connecting with students, combined with an emphasis on the professional outcomes of engineering education, was pivotal to the development of increasingly effective PCK. Whilst the circumstances of *habitus* and the PCK observed in the present case were very different to the first case, this alignment of epistemology suggests a potential for similar PCK development under the right circumstances.

10.2.2 - Orientations to Teaching

The epistemology of this participant was reflected in his orientations to teaching in a number of ways. His view of his own role within the learning process was often concerned with helping students to manage problem-solving tasks when those tasks are ill-defined. For example, in discussing a practical task for the residential school students that he had redesigned over multiple years of teaching, he stated that the task in its current form had been developed with a view to finding a balance between guiding students in what to do, but still leaving them to both figure out the problem and be able to work through and solve it, so that they can repeat such a task on their own later and without support. For this reason he had avoided giving set instructions to the students as part of the task. The task itself was framed within a workplace scenario in which the employer expects that ¨because you are computer engineers, you should be able to set up and maintain the office computer network¨ (Case Study C Observation Notes). The use of a professional scenario in this task reflects the participant´s view that ill-defined or ¨informal¨ problems characterise the nature of engineering work in industry, and that students should practice how to deal with them in order to be prepared for their future life as professionals.

As with Participant A, the participant in this case also demonstrated some Socratic elements to his teaching. Although not as frequently as in the first case, he was often observed to frame the content of his classes by questioning students about concepts. Mostly, this was for the purposes of helping to develop working definitions of key concepts, such as in questions like ¨how would you define an operating system?¨ and ¨we have used the word process already, what is a process?¨ (Case Study C Observation Notes). Unlike in Case Study B, these questions were never rhetorical in nature, and students were observed to readily provide answers. This was usually followed by the participant confirming the accuracy of the response, requesting more detail, and/or consolidating the answer by providing more information himself. This approach appeared to be an attempt to build up students´ existing schemata for the relevant concepts, and to frame the content that would proceed from then on.

In one instance, questioning also played another role. In discussing the choice between using a Command Line Interface (CLI) and a Graphical User Interface (GUI), he asked the students what their own preference was. Most students replied that they prefer a GUI but ¨it depends what you are doing.¨ The participant agreed and continued with the topic by saying ¨the point I want to make is…if you are making a commercial device…even if you decide on a GUI, that is only the first decision, but it is an important aspect to keep in mind¨ (Case Study C Observation Notes). In a similar instance, the participant also asked students ¨who has worked with an API before? In what context?¨ (Case Study C Observation Notes). By questioning students about their experiences and preferences in this way, he is included them as knowledgeable participants in a discussion of the subject matter, and is validating them as future professionals.

In contrast with this approach, however, is the fact that the participant also explained that this group of students had a mix of experience with the subject matter and that for some it was an introductory course. The less experienced students possessed a ¨very limited understanding of computers and computer networks¨ (Case Study C Interview 1). Given this, the participant´s approach to eliciting student experiences and opinions does not seem to be aimed at or inclusive of this group, because this group would probably not be able to answer such questions. In addition to this, the participant explained during an interview that although he had published a guide to ¨how to study in this course¨ (about diligence, time on task, etc.) ¨good students will often do well anyway.¨ He saw this as a ¨chicken and egg scenario¨, because ¨good students¨ would take up those study habits suggested by the guide and the low achievers would not (Case Study C Observation Notes). These points suggest an orientation to teaching aimed mostly at the higher achievers in a group. Despite this, the participant also stated it was ¨an interesting balancing act to make it interesting enough for the more advanced students but not too challenging [for the inexperienced]¨ (Case Study C Interview 1).

Overall, the participant´s observed orientation to teaching matches well to his own statements in which he discussed the value and pleasure in teaching to be in making connections with the students. In addition to this, his observed practices support a desire to promote future professional practices and skills in the students, particularly in how they deal with less structured tasks and problems.

10.2.3 - Knowledge of student understandings

Whilst the participant in this case did not articulate such specific categories of knowledge of student understandings that was seen in Case A, there were some general areas of knowledge of students that he exhibited. These reflected a generally supportive and empathic view of his students, and a desire to support them in their learning. For example, despite the fact that many of his students are ´mature age,´ the participant discussed the role of accessibility of information in the information handling skills that he sees in his cohorts. He spoke about the fact that most information that is relevant to courses these days is readily available via Google and that they go there rather than to the library:

> Students will find something on the internet and cling on to it and will not let go so that they can look at the problem more broadly. To be able to use the internet as a resource, for example, you need to take the broader view so it doesn´t take them in the wrong direction… Most of their knowledge is information from Google…and it´s unfiltered. So what I am trying to do is get their heads around that…to get them to try to think [about how to select and use information appropriately]. (Case Study C Observation Notes)

In this respect, the participant´s knowledge of his students´ habits has affected his perception of the discipline curriculum, because such information literacy skills are more relevant now than when students would get information from books in the library. Information literacy therefore becomes part of the curriculum that he needs to teach in order to support more effective knowledge development in the students.

With respect to the teaching strategies that work for students in his cohorts, the participant explained that ¨ultimately different things work for different people as the process of literature tells us before. I don´t think any single activity or process really helps. I think it is [about] providing them with as many opportunities as possible to acquire the skills or realise the concepts, and so on¨ (Case Study C Interview 2). This suggests the need for multiple and diverse an instructional strategies, in order to meet various students´ needs. Despite this view, he was also of the opinion that ¨the external [model of learning, compared to the face-to-face one] probably works better in the sense that students have to be more focussed to survive or to pass the subject. They have to be better organised…the external students have to do that…just to keep up. [Because of this] I guess they are starting from a higher base¨ (Case Study C Interview 2). This is a sink or swim view of the student´s role in the learning process that once again suggests that his teaching practices better support the students that find it easier to achieve highly compared to those that may struggle. The participant did not address during interviews any knowledge of how to support students that may be more challenged by the subject matter or mode for learning, or knowledge of how to help such students make up the difference between themselves and their higher achieving peers.

Despite this apparent limitation to the extent of his knowledge of students, the participant was observed to spend time getting to know students during the session that was observed for the practical course. While the students were working through the task in groups, the participant checked in with each person to see how they were going with the process. During these conversations he was observed to talk to each student (5 in total in the observed session) about their disciplinary area in the engineering program, their stage of progress in the program, and what they wanted to do next in their careers. It is not clear if or how the participant would use this information about the students in a particular way to inform his teaching, however what was clear was that he valued the relationship with the student and was willing to spend time getting to know them beyond what they did in his own classroom. This attitude accords with his overall epistemology of teaching which emphasises and values the relationship between teacher and student.

10.2.4 - Knowledge of discipline curriculum

In discussing the nature of his subject matter, the participant stated that it is made up of a lot of small concepts:

> Almost like a lot of puzzle pieces. There are not a few complicated threshold concepts. You need enough scaffolding to build the whole

thing up… [but] if you just take one concept that´s not complicated at all… If you look at the computer systems, there´s probably – I don´t know – a guess would be around 100 or 200 individual concepts. (Case Study C Interview 2)

This view of the subject matter was borne out in observing a classroom session for the third year computer systems course, which was structured around breaking down topics into core concepts to be focussed on each in their turn. The below picture shows an example of a PowerPoint slide containing concepts that the participant discussed and explained consecutively. The slide also shows the hierarchical structure among aspects of a system, with each aspect to be learned as a separate concept in the course. This constitutes an organised and structured conception of the discipline curriculum, part of the teaching of which involves passing on the structure itself, as well as component concepts, to students. The white box in the picture obscures the name and logo of the university on the PowerPoint slide.

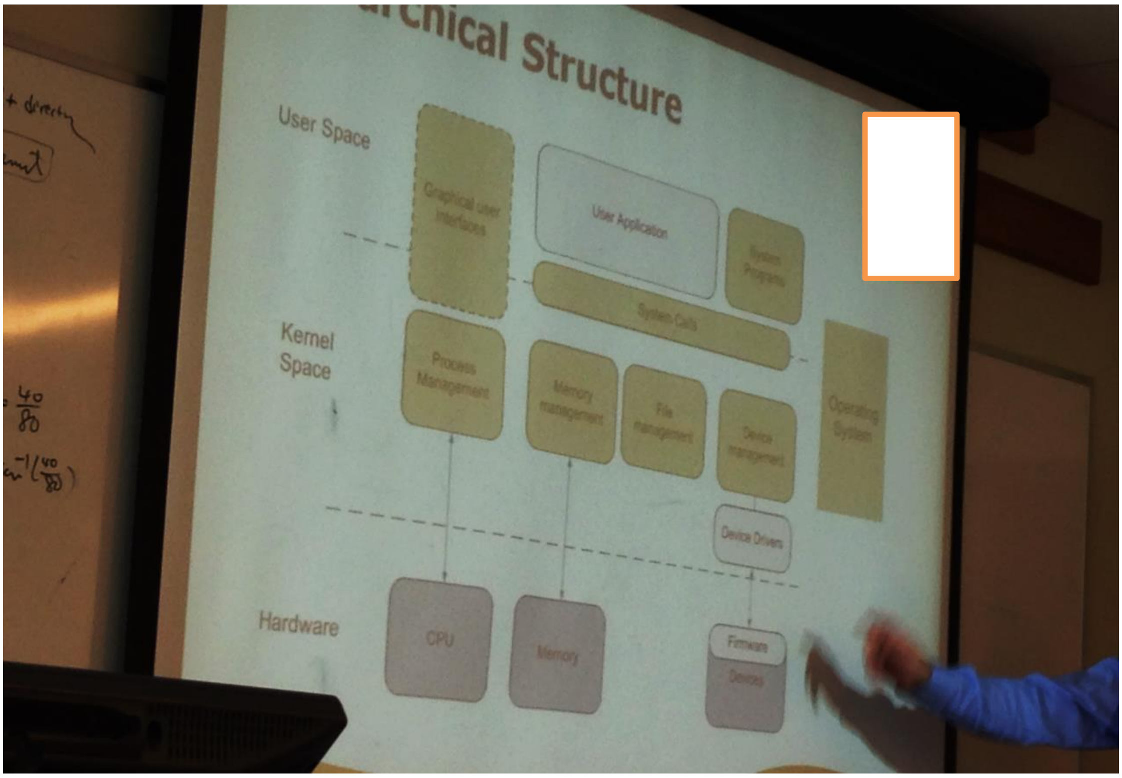


Figure 44 - Slide showing units and structure of a concept

In observing the participant interacting with final year project students, a further dimension to his knowledge of discipline curriculum emerged, and showed that he conceives of the discipline curriculum in stages. In the interaction with the project student he was observed to say ¨remember, [the project] is not like coursework where we give you deliverables beforehand. You have to work out what you are going to do¨ (Case Study C Observation Notes). The remainder of the supervision session was then focussed on considering what activities the student would need to undertake to work through the process of developing and carrying out an appropriate project. A similar approach was seen in a supervision session with a commencing PhD student.

Unlike the coursework curriculum which was characterised by distinct and organised packages of concepts, the project stage of the curriculum was much more self-structured and self-directed for the student, and needed to be for the student to develop the skills they would need for professional practice, as was discussed under 10.2.1. Therefore, his conception of the curriculum at this stage was that it consisted of processes and skills, rather than content packages of concepts. This view of curriculum has something in common with that which was seen in both Case A and Case B. For Participant A, her conception of curriculum was oriented to skills and processes even when it was centred on foundational theory (usually referred to as content), because she was of the view that even theory needed professional skill to be applied in contexts of practice. Conversely, for Participant B, his view of the curriculum acknowledged foundational theory only, and skills and processes were seen as something to be learned later, outside of formal education, and after the engineering degree was complete. Participant C´s staged view of the curriculum is somewhat of a compromise between these two positions, and may result from the pedagogical difficulty of teaching in a discipline in which theory, working processes and skills are all believed to be important by the participant himself.

Furthermore, for the sessions that were observed, the ¨coursework¨ classes (the professional practice course and the third year computer systems course) took a ´content package´ approach to teaching the curriculum, whereas the sessions with project students and residential school students in the practical course took the ´professional problem solving´ approach. This is seemingly illogical in the case of the professional practice course, in which it would make sense to use a professional problem-solving approach. However, a clear distinction between these types of sessions was the mode in which they were to be delivered, rather than just the type of subject matter they dealt with. The first two (content package) courses, although they were observed in the form of face-to-face lectures, were also delivered online asynchronously. The sessions were recorded so that they could be podcast for external students, and all other aspects of the course would likewise need to be made available online. The ´packages´ of content would therefore form module-sized deliverables for online students. The ´professional problem-solving´ type sessions, by contrast were necessarily synchronous, involving the participant interacting with students immediately. It is not clear if the participant was himself aware of the distinction that was made between these types of sessions, and the difference between his approaches in each type may have been a natural and unconscious response to institutional requirements for provision of teaching in particular modes.

The difference in the conceptions of curriculum for each of these modes may be a further indication of the pedagogical limitations of working online and asynchronously. For example, the need to teach about ill-structured problems and professional context may considered as unavailable or inappropriate for teaching online and asynchronously. The separation of these aspects of the curriculum into two stages may have been the participant´s solution for dealing with such limitations. This is a tantalising clue about distinctions in PCK for synchronous versus asynchronous tasks, which would require further research to be investigated fully and in order to draw firm conclusions.

10.2.5 - Knowledge of instructional strategies and representations

As has already been considered under 10.2.2, the ´coursework´ classroom sessions with the participant that were observed largely consisted of iterative cycles of introducing topics or concepts, questioning students, eliciting responses, confirming and expanding on responses, and fitting concepts into wider subject matter structures. This was the case for both the third year computer systems course and the professional practice course. Even though these classes focussed on content packages of concepts to be covered, the use of the Socratic techniques, as described earlier under 10.2.2, required students to meet a level of activity and engagement, such that these activities were not purely didactic (at least for students who were present for the face-to-face sessions).

In one example, the participant also included an active task, designed to help the students to deal with the abstract nature of a particular computing concept. In explaining what this task was to involve, the participant told me that students need to ¨execute maths functions in an order that is written on a piece of paper using a calculator in a set time – about 30 seconds – before passing the sheet off to another student to process the next task¨ (Case Study C Observation Notes). This activity is an analogue of the digital task of process management in computing, and helps students to build up appropriate conceptions of the concept. The participant mentioned that he would like to include more active tasks like this in his courses and that he is ¨working on this,¨ although he did not specify how (Case Study C Observation Notes).

Of course, this activity, as with the face-to-face students answering questions that were posed by the participant, would be unavailable to the online cohort in the course, because this activity would not make sense to or be replicable by a listener of a podcast. This instructional strategy therefore did not apply to the online students and no equivalent activity was provided online. Whilst the structures of topics and explanations of concepts that were presented in PowerPoint slides and audio recordings would be preserved for online students, the active and non-didactic aspects of the instructional strategies in these sessions would not.

For the other group of sessions (the project student supervision sessions and the residential school practical session), where the curriculum was concerned with developing working processes and skills for application in professional-like contexts, a range of instructional strategies was observed. Where the focus was on processes in the project supervision sessions, the participant spent a lot of time explaining overall processes to be followed or giving explicit instructions about steps to take, as is exemplified in the following excerpt from observation notes of that session

> This student is asking the participant about which project to choose. Participant is giving advice. ¨I would focus on Wi-Fi...we have used these (network traffic controllers/monitors) in other projects and the benefit of them is...They are cheap so it would be easy for you to develop...so you would sign it out and develop it and then come up here and do in on a larger network, that would be interesting. We had a similar basic project four or five years ago...then we didn´t have phones with network connectivity, now we do. I would look at how people could use their phones to connect with their routers... we are talking about disaster areas right so you take some of those routers and drop them in the area and people can talk to the outside world.¨ Participant draws a diagram of this concept. ¨The way I would see it is we would make some assumptions...as a scenario you would use drones for deployment.¨ (Continues drawing diagram). ¨Initially these would connect with each other. The next part is how these people find each other on the network without a constant server.¨ Explains a scenario, for example a cyclone has taken out GSM network.
>
> Student: ¨would we have to develop the software interface for people to use?¨
>
> Participant: ¨Ideally, you would want to use something that is already available, because that would be a project in itself.¨ Explains to student that he needs to get an idea of what is possible, ¨without limiting yourself have a look around to see what is possible, then start narrowing yourself down (for the project). You might or you might not look at the... (e.g. hardware)...you might use off the shelf. You can´t make a decision about that yet, because you haven´t done the background work. It is going to be largely about configuration.¨ (Referring to diagram) ¨If you go in the other direction you might have to look more at software. But you have to do the background work. (Case Study B Observation Notes)

In other instances, the participant was seen to avoid giving students explicit instruction on processes, particularly where developing their own process for solving problems was the skill that was being focused on in the teaching activity. For example, in the Linux network setup activity for the residential school students set steps in the process were not provided. Instead the task was expressed in the following form on the student worksheet:

- Install Linux (CentOS 64bit 6.5) on all your computers
- Decide on a network typology
- Do a background search on DNSmasq
- Install/configure DNSmasq for your network – this should give you a DHCP server as well as a DNS server
- Do background research on Network Address Translation (NAT)
- Do background research on firewalls, iptables and Shorewall
- Install/configure Shorewall – this gives you a firewall as well as a NAT. (Case Study C Lab Class Student Worksheet)

The participant introduced this task to the students as follows:

> First of all you will have to work in a group, but that does not mean that you will all do the same things. It is not one of those pracs that we give step by step instructions. You have to figure out what to do, so talk to your group members. (Case Study C Observation Notes)

Whilst this activity is not in the form of problem based learning (PBL) or discovery learning in their strict sense, it does remove some of the structure of the problem compared to a list of set instructions for how to do each step in the task, and requires students to call on their existing knowledge and skills to negotiate the process of solving the problem, as would be the case in an engineering workplace.

In addition to these kinds of instructional strategies, a number of instances of previewing future learning and using real life examples were used by the participant in the observed sessions. However, these instances were infrequent enough to not be considered significant to his overall body of knowledge of instructional strategies and representations.

10.2.6 - Knowledge of assessment of disciplinary learning

The only instance in which the participant´s knowledge of assessment of disciplinary learning was discussed or observed during the case was in an interview in which the participant mentioned his use of quizzes throughout an online course as a means of checking in on student progress and involvement in the course:

> Just by looking at the quizzes, I can follow up if they have done the activities or not...from the first week there were two who definitely didn´t look at the material because he got like five out of ten, and short of being brain dead…I mean, that´s why I use it now, because I think ultimately, a lot of the learning is happening when they are doing the activities and that kind of stuff. They´re self-directed. (Case Study C Interview 2)

In this comment it is clear that the participant views the quiz assessments as formative in the sense that they help the student to gauge their own progress. Furthermore, the quizzes are useful for the participant himself, because they allow him to gather information about the students´ levels of engagement with and understanding of the course. Here, the participant´s knowledge of assessment does not serve only for grading purposes. Rather, it also informs his knowledge of student understanding. This is an instance of integration within his PCK

10.2.7 - Knowledge of teaching for practice in the discipline

As with knowledge of assessment, the knowledge of teaching-for-practice aspect of PCK was minimal but present for this participant. The instances in which it was observed are as follows. In discussing the practical task with the residential students, the participant was observed to instruct them about the necessity to keep a lab book, in order to note down:

> What decisions you made, and why you made them. You might think today it is obvious why you did what you did, but next week or in a few

> months you will forget. So it is a good practice to get into. It is not for me or for anyone else, it is for yourself. (Case Study C Observation Notes)

This advice to students is related not only to the practices that are useful in engineering industry, but also, implicitly, to the participant´s own experiences of forgetting his decisions and needing a lab book. By discussing this, the students may get the benefit of his experience. In a similar instance, the participant discussed during an interview how he makes a point of showing his professional practice course students his personal Engineers Australia card in one of the first lectures of the course, and how he talks about how membership to this body requires him to undertake ongoing professional development. He then compares that industry requirement to the aims of the course, as a means of emphasising to students the relevance and value of the course, compared to how they will be expected to conduct themselves as professional engineers.

The participant also mentioned instances in which ongoing links with industry have informed his teaching, in particular, the final year projects that industry would like to see students graduating with. By talking with industry about what they value in graduating students, either in terms of the skills and characteristics, or the specific knowledge they have been able to develop during their degree, the participant aims to cater his teaching to produce more industry ready graduates. In a specific example of this, he explained that the residential school practical task that I observed had come about in its present form because smaller firms employing engineers had told him that they would expect computer engineers to be able to configure their own computers. In this case, knowledge of teaching for practice directly influenced his knowledge of instructional strategies, and prompted him to rewrite the task to be more open. Despite the presence of examples such as these, the influence of his knowledge of teaching for practice on his actual teaching practices appeared to be incidental rather than structured or consciously organised.

Among Shreeve´s (2010) categories of relations between practice and teaching, this approach best fits with the asymmetrical category with an emphasis on teaching of *moving across.*

> Here there is a sense of moving across into teaching, but taking practice into this world. Unlike the previous category, experiential knowledge is used to enable students to understand what it feels like to be a practitioner, not simply transferred to students. The world of practice is recreated for students through curriculum design and learning activities…practice is still present in tutors' awareness, and practice knowledge is used in teaching. This use is constituted through bringing in artefacts of the practice to explain processes. (Shreeve, 2010, p. 695)

As such, Participant C exhibited some evidence of teaching-for-practice in his observed sessions, although this was not as structured or systematic as for the category of teaching-practice relations seen in Case A.

10.2.8 - Reflection on teaching

Observation and interviews revealed a number of incidental cases of teaching development or change for this participant. As discussed above, he had reviewed and rewritten the practical task that was observed to be more open and less structured, in accordance with the nature of problem solving in industry (as he sees it) and in response to the comments of small engineering firms who expect graduates to be able to configure their own computers.

In another instance of teaching development, the participant discussed adding synchronous tutorials to an online course in order to improve student engagement and levels of activity. In this case, he had scheduled an online synchronous tutorial to take place in which he could work with students on their current topics and difficulties. He did so at times that students had reported they were available to attend but found that he had only around five out of fifty students in the cohort attend. As a result, he discontinued these activities because for this few students ¨it was not worth the time¨ (Case Study C Interview 2). This was not followed by reflective or evaluative activities which could give some insight into why the students were not taking up the extra sessions.

Despite these incidences of teaching development, they do not constitute conscious reflective activities, because they were not undertaken with a view to expanding or modifying the participant´s repertoires for teaching. Rather they were isolated instances in which the participant had recognised an impetus for change, but in a way that was not based on a wider systematic view of improving his teaching. Therefore, reflection is not considered to be a significantly developed process within his PCK.

10.2.9 - Integration of components of PCK

Although some of the observed components of PCK were only present minimally, every component knowledge area of the PCK construct was observed to be present in this case, and in a number of cases they were seen to be integrated in some way with other components of the construct. For example, by knowing how his students tend to handle information freely available on Google, the participant´s knowledge of discipline curriculum was modified to include some information literacy objectives. His knowledge of assessment in the discipline also informed his knowledge of student understanding by generating information about how students were understanding his course. Knowledge from the teaching-for-practice component caused him to rewrite the task for the practical course. Finally, his conceptions of the discipline curriculum related closely to his use of particular instructional strategies. Where the curriculum was perceived as being concerned with the delivery of ´concept packages´ his instructional approach was characterised by iterative cycles of questioning and introducing and elaborating on new concepts. Where he saw the curriculum as being oriented to the development of problem solving skills and processes for use in industry, his instructional approach focussed on explaining overall processes and supporting the student in developing the context for problem solving.

Whilst this level of integration is not as thorough and coherent as was seen in Case Study A, it may indicate a level of PCK development which is self-reinforcing. In other words, where one component knowledge area of PCK is developed, the level of integration that is present will allow this to have flow on effects to other areas, therefore consolidating the body of PCK as a whole. However, without the presence of the process of conscious reflection on teaching, it is by no means clear that the future development of component knowledge areas will necessarily take place. The development of reflection processes as a systematic aspect of teaching is therefore considered necessary for the development of a more sophisticated body of PCK, beyond what the participant is already exhibiting. As will be seen below, the characteristics of *field* and *habitus* that could create the impetus for the development of reflective processes were not observed at this site in the *field*.

10.3 - Characteristics of the site in the field

A variety of data were available during the week of the case which reveal characteristics of the site in the *field*, including the generally shared epistemology of teaching and learning and research apparent at the site, and the ways in which types of *capital* are recognised, relatively weighted, competed for and accumulated. There were also some significant data concerning the role of engineering education research at the site and how changing support for this form of research has seen it pass out of use as a valid academic activity at the site in the *field*. Data about these issues were gathered at a variety of points during the week of the case; from the participant during interviews and incidental conversations, from observation of a meeting between the participant and his Head of School, and through an interview conducted with a member of staff who had been employed to oversee the engineering education research activities within the school and liaise with the wider educational research community within the university.

This particular staff member was employed based on the efforts of two staff members who had an interest in engineering education research, and who wished to establish a position for a faculty member who could oversee the engineering education research activities within the (then) faculty of Engineering. Since the time that the position was first advertised, both of the staff members who had championed engineering education research had moved on. The first, the then Dean of the faculty, had retired, and the second staff member had been transferred out of the school at the time of the university restructure. As a result, the engineering education research group which had been driven by these staff for a number of years had lost direction, cohesion and, crucially, the yearly funding that could support its activities. Consequently, the new member of staff did not have an engineering education research group to coordinate activities for, and had to work to establish a new role for herself to support teaching and learning related initiatives within the university more broadly. She is now listed in the staff directory as a lecturer with parentheses stating the area of Learning and Teaching Support, although she does not teach any courses.

In addition to these factors, there were a number of circumstances at the site in the *field* that proved to be pivotal to the present case. The university restructure into two super-faculties was reported by the participant to significantly affect the daily work of academics, particularly around issues of administrative duties and the expectations placed on academics for their contribution to daily administrative processes. The following discussion illustrates the participant´s view of the restructure, and its implications for academics´ work:

> [Since the restructure] all important decisions are done for the whole academic division. So, for all academics across-the-board. And, the other unit, the school level, again there's not much room or scope for making real meaningful decisions about anything… So, it's really, the academic division is micro managed almost at a very high level than the normal.
>
> Interviewer: What implications does that have? Like has that made a difference to how you work on a day-to-day level or is it business as usual?
>
> Participant: Yes and no…I'm [still] teaching, doing research…That hasn't really changed as such. But, the process has become more complicated. And we were a pretty well-working faculty I would say across the university. We were probably one of the best-run faculties in a way, very

> lean admin. We had a good team. We're all working within a team of people. You knew who to talk to if they had an issue and then you how to solve it… [Now I] spend more time and still don't get things sorted. People don't know what they're doing like that. One thing that I noticed which had direct implications for my work log and my known flow, speed, time was finalizing grades and getting grade results, for example…(Case Study C Interview 1)

He also reported a university-wide expectation that the student experience be standardised across faculties and schools, in terms of the interface that students meet when logging on to the LMS. According to the participant, the university felt that the LMS should look the same and contain the same components for students regardless of which program, faculty and school they were enrolled in.

> There was all this pain on this message of ´one [name of uni]´, so students should all see the same thing but it--a lot of that was supposed to just say a student in nursing sees exactly the same experience, exactly the same place than the one in engineering. Before [the restructure] we had five silos and the five faculties. Now, we have four or five silos in terms of the different divisions. And Academic Division is like the least important one… Our core business is teaching but like we have to dance to everybody else's tune about like - the learning teaching systems designed the new [LMS], which has no regard for education or teaching or anything. It's just about look and feel and interface, design and all that stuff… (Case Study C Interview 1)

A similar expectation of standardisation relating to research was reported by the Learning and Teaching Support staff member, who said that in order to be recognised and valued by the university, any educational research project would need to produce findings and/or deliverables across all faculties and schools within the university, regardless of its scope, focus or intentions. She commented that academics were struggling with this expectation as it was not always relevant to their educational research focus to make their work cross or multi-disciplinary. She considered this a significant disincentive for academics to focus on educational research.

Each of these factors was seen to combine to affect the epistemologies of teaching and research that were apparent at the site. They also had a role in determining the nature of *capital* available at the site and how it could be competed for by academics in the Engineering school.

10.3.1 - Epistemology of teaching and learning apparent at the site

As was discussed earlier, the university for this case promotes the fact that it offers ¨flexible¨ learning through its online course offerings. In its own words via the home page:

> Online, distance, off-campus and external study modes are all used to describe a flexible classroom that comes to you! If you like the idea of studying on the go, fitting study around your job and learning the same courses as on-campus students, then online study at [name of university] is for you! You will be joining over 70% of our students who study online and we can't wait to welcome you to our community. (Case Study C extract from university website)

Despite this reference to ´community,´ this model of learning in which students can take part in their courses when and where they choose, means that the primary interface between the university and the student (at least for the 70% of students who enroll online) is the Learning Management System (LMS). As mentioned earlier, this necessitates that most activities in online course provisions occur asynchronously because requiring students to perform synchronous tasks would reduce the claimed flexibility of online courses. As was seen in the previous sections, at least for the participant´s own courses, this led to different instructional strategies being used for online versus face-to-face students, because active tasks that were performed in class and on campus were not replicable for online students. As such, although online and on-campus students can study in the same course, they are unlikely to experience the same courses in the same ways. Rather, online course provisions primarily consist of a focus on delivery of content, such as through study guides, lecture podcasts and other didactic, content-heavy materials. At the level of the Engineering school, data were collected which mirror this emphasis on content delivery through the LMS as the primary focus of teaching and learning. Not only is the LMS the focal site for learning, provision of content was seen as synonymous with teaching itself.

In a meeting between the participant and his Head of School (HoS), a discussion about the need to ensure standards of quality of ´delivery and content´ led directly into discussion of the administration of course pages on the LMS. The meeting in question took place in order to catch the participant up on a staff retreat that had already taken place for the staff of the Engineering school, which the participant was absent for. The retreat had covered:

- a review of certain aspects of the program (including which campuses from which to offer certain majors);
- the quality in delivery and content issue; and,
- how staff can strategise to meet research publication targets.

The discussion of the program progressed quickly and was completed within about ten minutes, after which the participant and his HoS proceeded to talk about the issue of quality in ´delivery and content´ for learning. Their discussion revealed that this issue was considered analogous with quality in teaching itself. The HoS commented that ¨I see quality as one; monitoring, and two; improvement [of the LMS]¨ (Case Study C Observation Notes).

In order to address the issue of quality in teaching, participants at the retreat had been required to give their opinion about which aspects of online course delivery were mandatory versus which were desirable. They were then asked to show suggestions for improvement on a diagram. These documentary artefacts from the retreat were reviewed in the meeting and showed flow charts that included processes such as peer review and self-review, but no improvement processes were detailed.

One result of participation in these activities was the suggestion of using ¨quality circles¨ or the coffee table sharing of ´expertise´ for organising their LMS as an ongoing monitoring activity within the school. The HoS commented that there would be a need for champions to make this happen, but that given academics are very independent, the champion would also need to act as a facilitator. The participant pointed out that those that are engaged will take part and those that aren´t won´t take part. Despite this, he suggests that the staff should undertake a peer review of each other´s course pages on the LMS (Case Study C Observation Notes).

At this point, the participant and the Head of School agree that this idea will go on the agenda for the next staff forum to ¨see how it works¨. The case study participant was to act as the facilitator for the activity, and they then discussed people who are seen as being ¨on top of their LMS¨ as possible test subjects (Case Study C Observation Notes). This indicates that quality here is seen as boiling down to the organization and effective administration of the LMS, rather than any other form of expertise for teaching. Therefore, quality may be improved by holding demonstrations of how the LMS may be organized and administered by staff that are already perceived to be doing this. The requisite standards for quality in teaching are seen as already present among some staff, and improvement in quality is viewed as the sharing of their practices to a wider group.

The participant´s assertion that ¨those that aren´t engaged won´t take part¨ being recognised as a threat to the success of this strategy, they also discussed the need to require certain academics to take part in this proposed process when they receive negative course evaluations from students (Case Study C Observation Notes). Course evaluations are the only measure of quality in courses that are mentioned, and the assumption between these participants was that negative evaluations could be ameliorated through improving the organization and administration of a course page on the LMS. The discussion did not recognize any other reasons for students to give a negative course evaluation, and rather assumes that a ¨better¨ course page on the LMS will lead to better evaluations from students. The students are therefore expected to have the same standards and expectations for teaching and learning that the staff do.

The HoS also expressed that:

> It is convenient to look at quality as a two stage set of requirements. The first stage is mandatory and easily checked as an administrative task. The second stage is for support, improvement, sharing, and is not punitive. This stage is for those that want improvement. (Case Study C Observation Notes)

The minimum standard for the delivery of content is therefore considered to be ¨administrative¨ only, and any higher standard of achievement in the quality of delivery of courses is only optional. It is not discussed what this higher standard of achievement may look like, or any ways in which staff can pursue such higher standards, except though the sharing of exist practices by other staff.

Overall, this conversation shows that, at least within this school, quality in teaching (considered only as the delivery of content) is not recognized as a form of expertise or as something that is valued beyond the basic administration of each academic´s course page on the LMS. The core business of the school, therefore, is seen as providing students with materials via the LMS that they can ´go away and do´ something with. Doing better at teaching can only encompass doing a better job of pushing content to students and it is not necessary for instruction to take place which could help them to use the content to develop their understanding.

When quality in teaching is only considered in terms of efficiency in delivery of content, the responsibility falls exclusively to the student to be able to execute some form of learning with the content that they are provided with. This epistemology of teaching and learning actually accords well with the notion of flexibility that the university offers prospective students, because by emphasizing that students should engage with courses when and where they choose, the ´go away and do´ approach of both teacher and learner is what students are actively encouraged to expect and value.

However, such an instrumental focus on content delivery ignores the real role of teacher and student in the educative process, in particular, the necessity for teachers to develop and use some form of expertise in ¨making content instructional¨ (Segall, 2004, p. 491). It also misrecognizes the inherently pedagogical nature of content, which Segall (2004, p. 491) argues is never just content ¨per se,¨ rather it is ¨always by someone and for someone, always positioned and positioning, and consequently is always pedagogical.¨ The consequence of this argument is that even when teachers do not realise the pedagogical implications of the way they write and present content in a course, they are having an effect on the learning of students. Teachers will always remain pivotal in learning processes, because they are the means by which content is created and presented to students. This role can never be fully assumed by the LMS itself, and so to ignore the role of the teacher in making content instructional is to ignore an important, if not central, aspect of quality and how it could be improved.

In a further demonstration of the apparent educational epistemology at the site, the participant discussed an instance in which his grading of a students in a course resulted in a high proportion of high achieving students. Upon presenting these grades to academic board, he was questioned about how he would mitigate this problem. When he explained to the committee how and why the high achieving students had met the criteria of the course to a certain standard, he states their response was:

> They didn’t care…In reality, it’s is a limit on how many HDs are acceptable and … they weren't interested in any explanation or whatever. The question was, “How are you going to mitigate that problem and how are you going to address that so that it is going to be better the next time around?… I tried to push them. I said, "Okay. I reviewed my results. This is my explanation. End of story."
>
> Interviewer: And that still didn’t fly?
>
> Participant: They kept coming back. One of the things was that some people basically said, "Okay. HD is a high distinction." So, that means…

> only very few students should receive a high distinction in that particular course in any particular year. If that is not the case, then the assessment has to be rescaled or you have to make something different to make it harder…I was going backwards and forwards and was making my case at the learning and teaching committee at that time at the academic board… Academic [Division] concluded I need more training. They didn't say it that way but they said, "Okay. There is an issue. You need more training." (Case Study C Interview 2)

Academic board could have said to the participant that his criteria were not strict enough, or that the criteria did not appropriately test mastery of the subject matter. However this was not the case, and instead he was directed that only a certain number of students should receive a HD. Such a numerically focused measure was also reflected in institutional attitudes to research achievements, discussed later. This position is in direct opposition to the aims of criterion referenced assessment, because it aims to grade students based on normative assessment, rather than to award grades according to pre-defined standards of achievement set out in the course criteria. In the normative assessment approach, grades should fit with a predefined distribution of achievement, regardless of the standards that are achieved in reference to what the subject matter itself requires that the student master.

Despite this, the university nominally recognizes the benefits of using criterion referenced assessment within courses. This position is published and defended within a set of resources that can be accessed from the university homepage, provided under the heading of the ¨first year course leaders´ toolkit.¨ These documents state that:

> Grading in Australian universities has moved away from practices, such as norm referencing towards a criterion-referenced assessment regime. This move has taken place because universities are increasingly required to demonstrate transparency and consistency in their assessment of student learning outcomes. The use of assessment criteria increases transparency and consistency because it can be used to make expectations about student performance clear to students and staff

> alike. This enables students to develop sound judgement about their own, and others', performance. Using criterion-referenced assessment also facilitates the development of shared understandings between teaching staff about student performance. (Case Study C extract from university website)

As such, the university´s published position on the basis for grading, and the actual practices of grading in the governance processes of the university, do not agree. It is not clear what precipitated this tension between principle and practice, and it would be speculative to try to conclude about this. However, it is notable that although criterion-referenced assessment came into general use some decades ago, many staff involved in the governance of universities predate this advent. Clearly, older practices of normative assessment are enduring in the *habitus* of the higher administrative positions in the *field*. At any rate, the difficulty that this created was left to the participant himself to resolve, as he was told he was in need of ¨retraining.¨ As such, the epistemological conflict here was treated as being caused by the participant himself and his lack of knowledge of ¨appropriate¨ grading practices, rather than the result of an inherent tension between enduring institutional practices and espoused educational principles. As a result, the message was that he must adjust his *habitus* for participation in the *field* to conform to the orthodoxy of the institution.

Overall, the data suggest an epistemology of teaching and learning at the site in which the educational values and practices that are generally shared within the institution are influenced primarily by its own governance needs, policy directives, and enduring administrative practices. This creates limitations on the basis for teaching and learning – limitations that are dealt with through a doxa which accommodates only the views of learning that fit with these circumstances, such as to only consider teaching in terms of delivery of content through the LMS, or to ´grade to the curve.´ At the meeting between the participant and his Head of School, for example, these epistemological positions were seemingly accepted and unexamined, suggesting that participants at the site in the *field* act pragmatically in adapting their educational epistemologies to prevailing circumstances. In

Bourdieuvian terms, the ability to adapt epistemology (however consciously or unconsciously) to fit with the institutional circumstances of ´playing the game´ at the site should allow participants to both survive and progress in their position in the *field*, which given the participant´s recent promotion, appears to be the case here.

Although the participant accepted this epistemological position uncritically during the observed meeting with the Head of School, his criticism of the grading practices, and his own reported views, teaching practices and pedagogical content knowledge suggest a personal epistemology that is not actually in keeping with the generally shared views. In the observed face-to-face sessions, he was much more focused on the interactive elements of teaching and on his students´ constructions of understanding, particularly concerning problem solving processes. This disagreement between the two epistemological positions suggests that despite the participant´s own epistemological leanings, he recognizes the epistemological view of the site in the *field* and can act pragmatically and flexibly to accord with this view.

10.3.2 - Capital and rewards at the site in the field

Given the shared educational epistemology at the site, and a range of other data from the site, a clear picture emerges of the types of *capital* available for transaction by academics in the Engineering school, and how these forms of *capital* are defined and delimited. These *capital* collectively represent symbolic goods within the economy of the *field*, the transaction of which allows participants to compete, survive, and, ideally, advance.

Concerning the *capital* available for teaching and teaching-related activities, the discussion between the participant and his Head of School strongly suggests that the *capital* available for teaching is limited to activities surrounding the effective administration of the LMS, and that efforts for teaching beyond this are not well-recognized or rewarded. Supporting this view was the participant´s opinion about changes to his position as school coordinator for learning and teaching. Up until the previous year, at the time of the restructure, the position had been a paid role, but according to the participant, ¨now it is not a position, it´s a role…before I got paid for it and now I don´t¨ (Case Study C Interview 1). This suggests that not only was the *capital* available through teaching and teaching related activities limited, the ways in which teaching related activities are rewarded has reduced in line with the university restructure.

This finding aligns with data surrounding the engineering education research activities apparent within the school. An interview was conducted with the Teaching and Learning Support staff member who was brought in to coordinate the education research activities within the school as well as liaising more broadly across the university. Her appointment was the result of the efforts in engineering education research of the former Dean and a senior staff member who had been championing an engineering education research group. However, when those two staff members left the school and the activities and funding of the education research group dwindled, continued participation was something that staff felt they did not have time for. In discussing this, the respondent explained that despite this lack of commitment to the education research group:

> People love the topics that they have been studying in engineering education. And they have become passionate about certain things…There´s quite a few people that are interested in authentic assessment and different ways of doing that. There's quite a few people that are interested in how to design and offer and develop different modalities using technology. So online but some people might call blended and how you do all of that is big thing. People are suddenly interested in problem based learning and team based work, collaboration… First year students and how to support under represented students, traditionally under-represented students like first generation students who were not from families with university background in their life or maybe some lower income families or…indigenous students. (Case Study C Engineering Education Staff Member Interview)

This range of topics is closely tied to specific teaching practices in the engineering school. In the respondent´s own words, ¨you have people who were passionate about topics related to improving, enhancing the engineering student's experience which is pretty important¨ (Case Study C Engineering Education Staff Member Interview). However, even where education research was of significant interest to an academic, the respondent reported that they can´t make time to get the work done:

> They were saying that it was about scheduling that there was a problem because that was the lowest priority in their work load. So even though they wanted to do it, it always took the back burner… I think the biggest dilemma that people face is that they're overworked, overloaded. They feel overloaded with the amount of responsibilities that were placed on them. And they have to prioritize certain things and their engineering education research just isn't…It can't be. I mean unless they've just…
>
> Interviewer: Unless they get promoted on it, you mean?
>
> Respondent: Yeah, and they won't…they were denied. That people have been denied [for promotion on education research]. (Case Study C Engineering Education Staff Member Interview)

As such, despite the apparent interest in pursuing educational research projects, including topics that have the capacity to directly influence teaching within the school, educational research was not being recognized as a valid activity and one that could gain an academic recognition, and is therefore not being pursued. It is therefore not seen as a valuable ´good´ or form of *capital* for transacting at the site. Previously, when the education research agenda had champions in the faculty, including the Dean, a greater degree of participation and activity was achieved, suggesting that some form of recognition was available for staff who had an interest in this field. However, without such champions, education research has passed out of recognition as a valid activity and out of use as a form of *capital* at the site.

Data from the meeting between the participant and his HoS, further indicate the ways in which research *capital* is defined and delimited at the site. After discussing the quality in teaching issues detailed above, the meeting between the participant and his Head of School moved on to discussing how to meet research publication targets within the school. At the staff retreat, this part of the agenda focused on understanding and meeting the ERA targets that had been set for the school. Excellence in Research for Australia (ERA) is Australia´s national research evaluation framework, and is the key mechanism by which universities are rated against one another for their standards of and achievement in research activities. As such, by considering how to meet such targets within the school, this activity was geared towards the wider university´s advancement in the field of research. Crucially, discussion at the retreat did not cover anything concerning strategies for improving or increasing research activities themselves, rather it focused only on how to strategically publish and report on publications for ERA purposes.

Discussion between the participant and the HoS in the meeting centred on the numbers of papers already published and under which categories (for example, which sub-discipline of engineering). The observation of this discussion proceeded as follows:

> Participant and HoS are discussing how to meet ERA quotas, for example, shifting telecommunications papers under the electrical banner. According to HoS, mechanical is doing better (HoS mentions some of the more prolific publishers).
>
> HoS: ¨If we got any one of those world class it would be good. If we get all four [categories] that is best.¨ He mentions that ¨mums and dads want their kids to go into areas where the university is world class.¨ This comment suggests that being world class in a field would involve being published in a world class journal for a given topic, and that this is linked to enrolment patterns for students. ¨So we are world class and industry relevant, etc.¨ (he states this in comparison to the other research intensive universities in the region).

> The case participant asks about contentious points that came up during the retreat. HoS replies ¨do we go mechanical or do we go materials¨ (with regards to what publications to focus on for targets).
>
> Participant: ¨what action can you take in the research aspect?¨
>
> HoS: ¨to map targets against progress. We have to make sure targets are realistic and that we have a commitment to that...Generally what we sell is electrical and mechanical. I can´t sell communications...That was a directive of the VC¨ (to label telecommunications publications under the electrical banner when reporting on publications). The HoS and participant are discussing putting codes in (to university reporting systems) to report publications in a particular way ¨If we are careful about which journals we are publishing in it might make it harder for them to take it away from our overall score. You have to have an ERA strategy group with the school¨ (in order to have a plan and execute a plan for how to report in such a way as to get the ERA scores higher).
>
> HoS is commenting that short term student intake is dependent on word of mouth, for example the positive experience of previous students. ¨the news about not being world class does not spread quickly¨ (so that is a long term problem and goal to work on). ¨If I want to go and tell mum and dad that I have a staff member who has published fifty papers this year they wouldn´t look at me. But if I tell them I have a staff member and what their research has achieved and how a company is using in Toowoomba, they will care…We encourage both sides.¨ Based on this discussion, the number of papers published seems to be key to if world class status can be claimed or not. ¨We already have 50 papers in that area so we are already in the game.¨ (Case Study C Observation Notes)

There are a number of implications contained in this discussion of research activity. First, it should be noted that it only addressed technical or theoretical research publication, and did not acknowledge or account for any educational research activities that may be taking place within the school. Second, recognition of activity and discussion of strategy herein only addressed the *publication* of research, and ignored all research activities that would have to take place before publication could be achieved, such as designing and executing a viable study. If staff were struggling with meeting school-based targets for ERA reporting, it is not clear that this was because of publication strategy problems, and it is in fact much more likely to be the result of difficulty in finding time to plan and execute the research itself, and to do so to a high enough standard as to be accepted for publication. This possibility is supported by the participant´s own comments during the case that time spent on administrative tasks often prevents him from finding time to achieve his research tasks. However, the meeting did not address how staff may be supported in this regard, for example, by finding more time for research through research assistance or for improving the quality or efficiency of research activity.

Finally, in this discussion the Head of School makes a connection between the school´s ability to publish research that can be claimed as ¨world class¨ and its ability to attract and increase enrolments, especially at the cost of other popular local universities. Whilst he does acknowledge that the word of mouth about research achievement is slow to spread, and therefore does not affect enrolments in the short term, he also discusses that ¨mums and dads¨ want their kids to go to a world class university in terms of research publication. He makes comments about which sub-discipline publications are more ¨sellable, ¨ presumably for the purpose of attracting enrolments (Case Study C Observation Notes).

These ideas about the role of research publication in influencing enrolment patterns are incongruous with other data from this site in the *field*. For example, the university claims a high rate of mature-age enrolment, in which case the opinion of ¨mums and dads¨ is unlikely to significantly or consistently influence rates of enrolment. Further, the university primarily positions itself as offering degrees that result in high rates of employment upon graduation, which has little to do with the nature or rate of research publication that the university can achieve. Rather, this selling point, combined with online course offerings in all programs, focuses on attracting students to enroll in university when they otherwise may not be willing to undertake tertiary education. Given this, it is not logical to link the research reputation of the university with the basis on which the university attracts enrolments.

However, this is a measure of the strength of the *capital* associated with research for the higher education *field*, because the prestige associated with research remains important within this institution. Despite focusing on enrolling students who are mature age and external, the university is still clearly interested in the forms of prestige that can be accrued through research publication and sets school-based targets accordingly. This is seen in the fact that the HoS explicitly compares the institution to two research intensive local universities. The Head of School in this instance can be seen to take up the research publication focus, as it is his responsibility to ensure the school can meet its publication targets. His position on the value of research publication is evidenced by his comment to the participant that with respect to ERA targets:

> We either play the game or we change the game and we can´t change the game. It´s the only game to play. Once you call yourself a university you are in that game. (Case Study C Observation Notes)

Two further instances of data supporting this finding of the importance of research publication were gathered subsequent to the case being completed. Like the institutions in Case A and B, the university in this case sent a similar memorandum concerning the 2015 ERA results as the first two. This communique claimed ¨significant improvements¨ and said that the institution has now achieved ¨world-class ratings or above in seven 2-digit codes¨ (extract from university communique, December, 2015). Although this is significantly less than the level of ratings in the other cases, it is notable that all three sites place importance on these rating in the same way.

The site for Case C also ran a program of publication excellence awards ¨to encourage high quality research publications,¨ and more specifically, ¨to reward the publication of articles in high impact journals.¨ Within this scheme, individual academics are encouraged to submit one article that they believe to be high impact, and the university subsequently assesses each submission using the same metric as is used in the ERA process; that is, the impact factor based on citation counts per article of the journal in which the article is published. Although this is described as an ¨objective and transparent process¨ it does not actually attempt to assess the quality of the research article that is submitted. Rather, it focusses only on the citation count of the journal itself. In the information published by the institution about the awards it is stated that:

> The awards are designed to encourage [name of university] researchers to make strategic decisions about the journals in which they seek to publish, in order to help them get the best return on their research efforts and as a crucial step in improving the research performance of [name of university] as an institution. (Extract from university communique)

Here, the ¨return on research efforts¨ via publication is equated to (or conflated with) the overall research performance of the university. Rather than supporting the activities that go into producing research, or supporting the quality of those activities, this awards scheme seeks to incentivize the output of publication. The highest prize in these awards is $2000 towards research activities and a total of $4500 is given out in each round. This amount would not go very far towards improving the overall amount or quality of research at the university.

This epistemology of research values the quantifiable output of research only, and, as with the educational epistemology that was in evidence, does not account for issues of quality, such as the significance or rigor that characterizes good research. Within this epistemology, research need not be good, so long as it is productive in terms of publications. This suggests that the form of *capital* available for research will likewise not be concerned with quality, but with rate and (quantitative) standard of publication. It is more important within the university to be able to claim to be world-class (by rate of publication and by selectiveness of where and how to publish) than to develop the quality of research conducted. Instead of focusing on producing research that is inherently of a high standard, and that can increase disciplinary, scholarly or educational knowledge within the school, or that can make a contribution to bodies of knowledge more generally, the focus both at the school and institutional level is on producing publications that can improve the reputation of the university. As such, staff who are recognized for their ´runs on the board´ in terms of publications, rather than those who work to improve research quality, will become increasingly successful in accruing and leveraging the *capital* surrounding research.

In addition to publication strategies, other data suggest that *capital* is available for research through activities that are associated with the funding of research, particularly funding that attracts some national or inter-university prestige. In an example of this from the case, the participant had become involved in a multi-school research project which had won funding from a large federal grant for regional universities. This grant attracted a great deal of attention within the university, and news of it was publicized internally, for example on the university homepage and through internal email bulletins. Although not being part of the original grant team, the participant had stepped in as a project leader when the project encountered difficulties (by his report through a lack of leadership), in order to organize the project and ensure the funding was expended. He reported this as his only major research activity at the time of the case, but did not have a direct role in actually executing research. Rather, he was focused on coordinating the efforts of others, such as the funded PhD students on the project, and pushing to have key deadlines and milestones met. At the time of the case he commented that they did not have a set of coherent research questions that the project was seeking to answer (despite being two years into the project) and he was concerned with establishing some core objectives that the project could meet.

As with the data concerning publication of research, the data here suggest that *capital* is available through research funding, when funding is recognized as enhancing the reputation of the university. This was especially apparent for the case of this grant, as the project focused on developing ¨digital futures¨ for online learning, which aligns with the university´s own strategic approach to gaining enrolments. As with publication, this example of *capital* for research does not appear to be concerned with quality, as the project in question had not established core questions or objectives upon which arguments for rigor and significance (core elements of quality in research) could be based. Rather, *capital* was accrued because the project was considered to be high-profile. Given the participant stated that his role in this research project was his only major research activity at the time of the case, and that he subsequently won a promotion, involvement in such a project is likely to constitute a valuable form of research-related *capital* and a significant basis for reward through promotion for individual academics. As will be seen in discussion of the participant´s *habitus*, this form of *capital* had significant implications for strategies that can be seen to be successful for improving individuals´ positions in the *field*.

In summary, as with the other case study sites, the dominant form of *capital* at this site in the *field* was bound up with aspects of research that would directly bring the university prestige; those being funded research and ¨high impact¨ publications. This form of *capital* emphasizes ¨acting strategically¨ and ¨incentivising¨ performance, but fails to address the quality of research which the university ultimately wishes to claim.

10.4 - Habitus of the participant

As with participants in the previous cases, the participant was asked to complete a series of rankings in order to indicate his priorities and strategies for gaining position in the *field*. Overall, the combination of responses, along with data from interviews and observations, indicates a *habitus* for working in the *field* which is highly flexible. The participant was able to adapt his strategies for working in the *field* in order to accrue *capital* and ultimately achieve promotion, even when his own interests and epistemologies were not in keeping with the prevailing conditions at the site in the *field*.

10.4.1 Ranking Exercise

For the list of tasks, the participant gave a set of responses with the majority of items fitting closely to the line of control between interest and importance. Six out of ten responses fell close to this line. Of four remaining tasks, two fell above the line, showing they were considered by the participant to be interesting to him but not important to doing well in his role, and two fell below, showing they were important but not interesting to him. The two tasks that fell below the line were ¨writing proposals for grants¨ and ¨service to faculty/school.¨ The two that fell above the line were ¨designing and developing new courses¨ and ¨conducting research.¨

It is in keeping with findings about the research *capital* in the *field* that the participant rated the task of ¨conducting research¨ as unimportant to his role, whereas ¨writing proposals for grants¨ and ¨writing papers for publication were rated as the top two tasks for importance. Equally, the teaching related tasks of ¨designing and developing new courses,¨ ¨training tutors or teaching staff,¨ ¨reviewing and improving existing courses¨ and ¨preparing and revising lectures/teaching activities¨ were among the lowest ranked items for importance. Although for many tasks on the list, the participant´s interest matched well to level of importance, the outliers for the scatter plot of this list give an indication of the ways in which his position in the *field* required him to act against his own inclination, for example by performing tasks that were not of interest to him but were important, or by losing time that he would like to spend on tasks that were interesting but not important.

Table 32 - Rankings for Tasks for Case Study Participant C

Tasks	Level of Interest	Level of Importance
Preparing and revising lectures/teaching activities	7	5
Lecturing/tutorials	8	6
Writing proposals for grants	3	10
Writing papers for publication	10	9
Reviewing and improving existing courses	4	4
Designing and developing new courses	5	1
Conducting research	9	3
Service to faculty/school	1	8
Eliciting and evaluating feedback from students	6	7
Training tutors or teaching staff	2	2

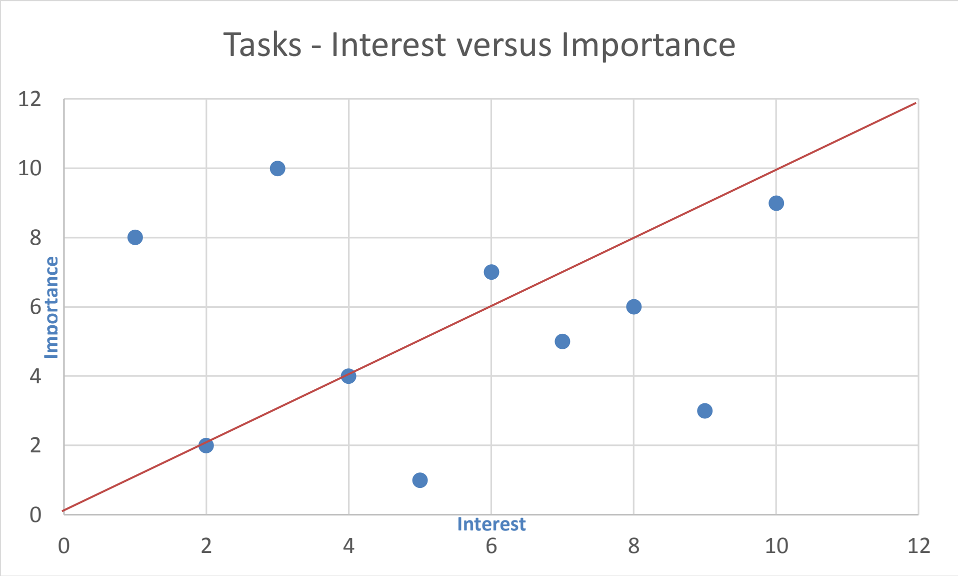


Figure 45 - Scatter plot of rankings for Tasks for Case Study Participant C

For his list of goals, a similar pattern of items with a close fit to the line of control was observed, with five outliers indicating areas of compromise between the participant´s goals, and the goals that would be important to him doing well in his role. As with tasks, the outliers of ¨improving my rate of publication¨ and ¨increasing the amount of funding I have for research¨ are listed as important but not interesting, also in keeping with available data about the forms of *capital* available for research at the site in the *field*.

The participant also ranks ¨improving student feedback on my teaching¨ as important but not interesting. As was seen in discussing the epistemology of teaching at the site, this is likely to be considered only as feedback in the form of student evaluations, and linked to the organization of course pages on the LMS, rather than any broader or more qualitative forms of feedback on teaching. As such, the participant´s lack of interest in this goal does not necessarily compromise his stated value for his interaction and relationships with his students. This is supported by the fact that the participant rated the goals of ¨educating the next generation of engineers¨ and ¨improving the learning outcomes of students¨ as the two most interesting goals, but not important within his role.

Table 33 - Rankings for Goals for Case Study Participant C

Goals	**Level of Interest**	**Level of Importance**
Ensuring my own relevance and currency within the discipline	7	6
Achieving promotion	2	1
Improving my rate of publication	3	9
Educating the next generation of engineers	10	2
Improving student feedback on my teaching	1	8
Developing a good research record and reputation	8	7
Improving the learning outcomes of students	9	3
Increasing the amount of funding I have for doing research	5	10
Enabling young staff to learn how to do research	6	5
Doing a better job of teaching	4	4

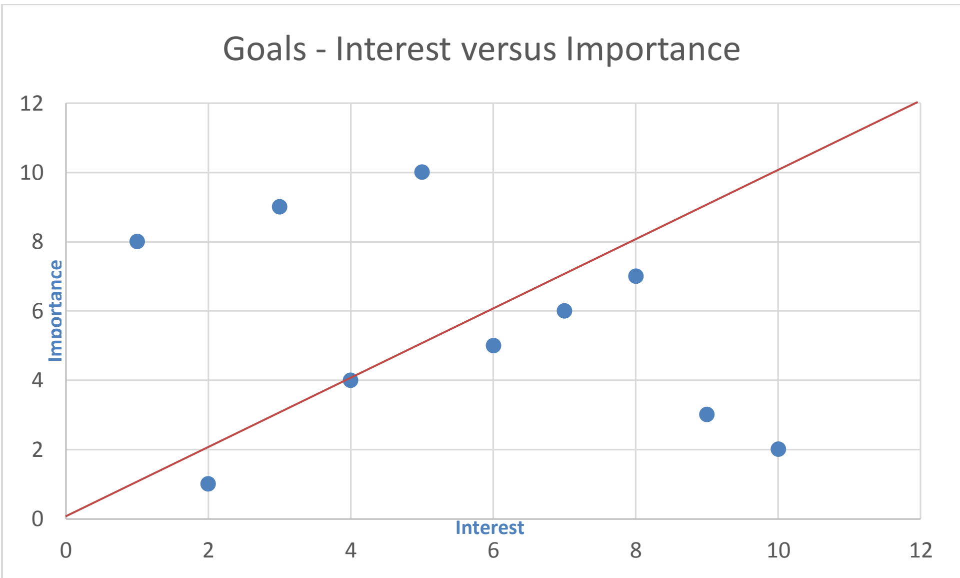


Figure 46 - Scatter plot of rankings for Goals for Case Study Participant C

For indicators of success, the most notable item was ¨having research published¨ which the participant rated as both the most interesting and most important indicator. In this aspect, his interest matched well to the *capital* available to him. However, he also rated ¨having innovations or pedagogies taken up elsewhere¨ and ¨being able to use research activities to inform teaching activities and vice versa¨ as interesting to him but not important to his role, and therefore not something that is likely to win him *capital*.

In the case of ¨being able to use research activities to inform teaching activities, and vice versa,¨ this is a particularly interesting finding because, as the data has already shown, the Head of School of Engineering viewed being ¨world class for research¨ as a key draw for prospective students. Despite this, the participant asserts that a nexus between research and teaching is not recognized as valuable within the institution. A body of research exists that discusses claims that such a nexus has the capacity to improve the quality of teaching, and hence all academics should be expected to perform both research and teaching in order to make the proper contribution to the academy (Griffiths, 2004, Prince, et al., 2007, Trowler & Wareham, 2007). This view is mirrored in the epistemology of teaching at the site for Case A, in which an increase in disciplinary expertise through theoretical research was believed to increase expertise for teaching. For the present case, although a similar position is asserted by the Head of School in believing that world-class status in research is appealing to students (or at least their parents), according to the participant no *capital* exists which can reward this research-teaching nexus. This supports the data which suggest that the available *capital* for research does not support actual research activities. Rather it only supports the activities that bookend the research process and directly attract prestige to the institution; that is, winning funding and having research published. Therefore, individual academics are left to engage in actual research activities without reward or support.

Table 34 - Rankings for Indicators of Success for Case Study Participant C

Indicators of success	**Level of Interest**	**Level of Importance**
Having research published	10	10
Winning citations/awards	6	6
Achieving promotion	3	3
Being asked to collaborate on research projects or publications	5	9
Having teaching innovations or pedagogies taken up elsewhere	7	2

Seeing the outcomes or findings of research being used for industrial applications	4	8
High levels of attendance at lectures or teaching sessions	2	1
Positive feedback from students on teaching	8	7
Being able to use research activities to inform teaching activities and vice versa (e.g. first-hand knowledge of recent developments in research field being passed on to students	9	5
Getting recognition by professional engineering societies (e.g. demand for consultancy services, fellowships, etc.)	1	4

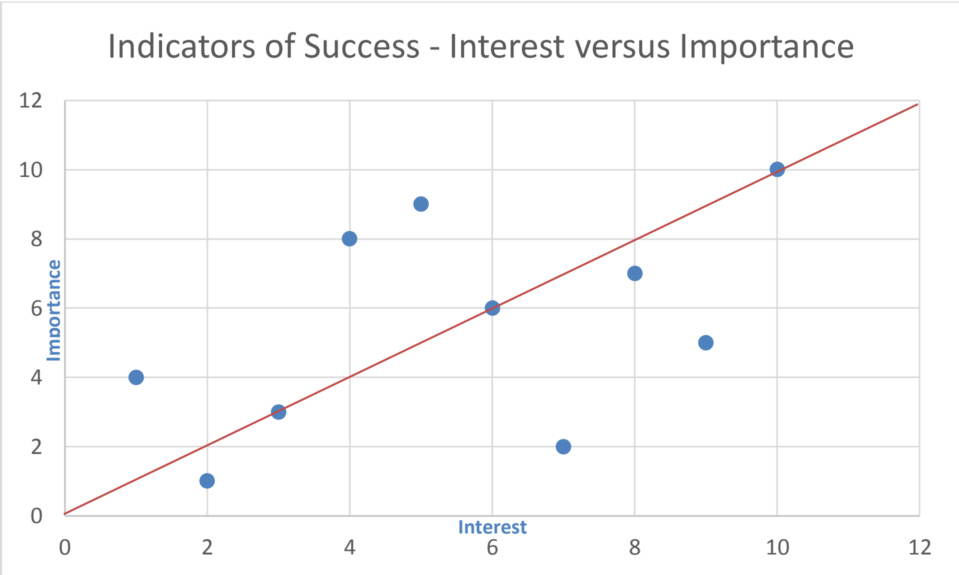


Figure 47 - Scatter plot of rankings for Indicators of Success for Case Study Participant C

Overall, the rankings exercise showed some areas of fit and misfit between the participant´s own interest in aspects of his role, and the items which are considered important within the institution. For example, although the participant was interested in actually conducting research and writing publications, he was less interested in writing proposals for grants, or increasing his amount of funding or rate of publication, which he believed the institution saw as important. Similarly, he ranked highly his interest in educating the next generation of engineers and improving their learning outcomes, but did not believe that this focus would be rewarded. As such, although a lot of items on the lists were in agreement for levels of interest and importance, there were some significant tensions between the ways in which the participant would like to operate in his role, and the strategies that would actually be rewarded. Data concerning the participant´s focus and goals in his role, as well as strategies he chose to use, suggest how he dealt with such tension, with the result that he was promoted in a recent promotion round.

10.4.2 - Participant´s focus on aspects of their role

In consideration of his priorities within his role, when asked during an interview if he could go either teaching-focused or research-focused, which he would choose, the participant replied that:

> I wouldn't want to do either of them to be honest…I had a position come out few years ago, that was a very--almost a perfect match to my interest, what I was doing at the time and all that but it was an exclusive research position and no teaching at all. And I didn't want to do that because a lot of the satisfaction you get from your working with students and I didn't want to lose that. At the same time, if I imagine that position away and just do teaching all day, I'll start banging my head against the wall really quickly I think. (Case Study C Interview 1)

On paper, therefore, the academic role which requires a balance of teaching and research is ideal for this participant. However, a variety of comments during interviews suggest a level of dissatisfaction with his job. This had been amplified by recent changes associated with the university restructure:

> It sounds a little bit cynical and negative I suppose. But, for me, it hasn't made the job easier…okay, in gaming, this is the distinction between hard and punishing. Hard is something, the challenge you can overcome. I don't mind hard I suppose, but I think a lot of things have become punishing. They kind of--paperweight signoffs, you have to go through travel request for example - It's just impossible now. We have a new performance management thing in, right, in which, I looked at the form. It's going to take me a week to fill in the form kind of thing. (Case Study C Interview 1)

The participant also discussed a variety of areas in which he had compromised on strategies for performance in his role. Apart from epistemological tensions concerning teaching, such as the tension between normative versus criterion referenced assessment, and the focus on pushing content via the LMS instead of building relationships with students, there were compromises to be made with research as well. The participant had at least two engineering education focused research projects that needed time to develop further but which had been put on the back burner due to him becoming involved in the large, federally funded research project that was discussed earlier. Regarding these education research projects, he said:

> Everything is on hold. And well, I suppose, I'm meant to do something [on my peer-assessment project, but]…actually, almost the last year, I spent 80% to 90% of my research on helping others and working with PhDs and fellow researchers on the [large grant] project-related stuff. For example, I still want to do [work on another educational research project that was ongoing]. (Case Study C Interview 2)

The participant described his involvement in the large grant project, for which his other research work was on hold, thusly:

> When the money came in, the people that were driving it at the time that was at a very high level, they're no longer there. It's only that this funding, they go, "What are you going to do with that?" And it was all a mad scramble and they called for a project. And the whole thing was very messy at the time and very frustrating. I actually didn't put any application forward [initially] because it was just so badly managed and everything about that. Somehow I ended up with this one anyway. And I said, "Okay. I'm happy to provide, I guess, advice and leadership from behind like stepping back and letting others take a lead role… And at a few times, I almost walked away from it. But, I'm interested in the field. And I think have a fairly good reputation in the field…I didn't want to see the project burn… And the question was, "Are they going to can the project?" We just want to continue working for it… People get excited in this group about the concept, the whole thing is working nonstop. I

> didn't want to let that down. It meant that I had to spend a lot of time initially on the administrative side and the management side like getting a reports, having the meeting between five different groups justifying why and all that which took a lot of time but I think that was worth it. (Case Study C Interview 1)

For the project in question, the participant was playing an administrative role, as he said ¨on helping others and working with PhDs and fellow researchers,¨ in order to keep the project on track (Case Study C Observation Notes). The project was focused on a technical innovation in the engineering education field for delivering online learning experiences via a computer-interface. Although the participant had been active in a similar project in the past, his main contribution ad been on the technical side, with some educational focus. The grant team had been successful in winning the funding based on the argument that development of this innovation, not just for engineering, but for other disciplinary areas as well, would contribute to the development of ¨digital futures¨ and a ¨digitally literate society¨ (extract from research project homepage on university website). As such, the argued significance of the project clearly aligned with the university´s own strategic objectives of increasing enrolments tertiary education online, and for building their reputation for the quality of their online programs.

In this sense, contribution to the large grant project represented a form of *capital* associated with education research, but not specifically with engineering education research within the Engineering school. Rather, contribution to this project constituted a form of *capital* sourced from outside the school, because of its link with other disciplines and with the university´s broad strategic aims. Had the participant chosen to pursue his own engineering education focused research instead, it is unlikely that this would have resulted in *capital* for research being accumulated, because as was seen earlier, education research, unless aligned with wider institutional goals and across the range of disciplines within the university, was not being recognized and rewarded within his school.

Despite this action on the part of the participant which turned out to be strategically effective, by his own account he was not consciously seeking or particularly hopeful of being promoted. At the time he stated regarding promotion that:

> It would be nice but it's not like essential I suppose. We won't change anything about what I'm doing, the way I do it. It's just the title and more money. Which is a nice thing supposedly. Which would be some recognition because I think in the end--no, that's probably arrogant, but I'm putting in a lot more than a lot of people to get some kind of recognition. (Case Study C Interview 1)

This suggests his focus in strategizing as he did within his role was on gaining recognition for his hard work, especially compared to other academics who he believed regularly put in less effort than he did. In discussing this more deeply, he confided that much of his motivation for entering and pursuing a career in academia was a personal need for recognition of his success from his family. Having realized that intellectual success was not something his family would ever value, he now questioned his ongoing motivation to remain in the *field*. When I asked him what he would like to work on or achieve next he replied that he did not know. He did not have any clear goals for his future as an engineering academic.
Although the participant´s PCK demonstrated sufficient development across the range of component knowledge areas, and a suitable epistemological basis for further development, he had not developed any particular interest in improving teaching practice, and the site did not provide him with any impetus to do so. In fact, to focus on quality in teaching beyond the organization of content on the LMS would likely be a risky strategy that would take away from his ability to accrue *capital* in other areas.

Concerning research, the participant discussed and demonstrated an interest in a range of engineering education research questions, and had some ¨runs on the board¨ for education research in the past. In particular, he had won an award from an engineering education research association for a project he had conducted around peer assessment. Despite this, his ongoing engineering education research interests had taken a backseat to his participation in a large scale grant that was of strategic significance to the university. In this respect, this choice of flexibility over personal preferences for participation in the *field* meant that the participant conformed to the status quo rather than challenging it. Ultimately, this flexible *habitus* for ¨playing the game¨ and the participant´s set of strategies in response to the *capital* that was readily available at the site was rewarded through promotion around six months after the case took place.

10.5 - Conclusions from the case

A range of implications arise from this case. First, the participant´s *habitus* for participation in the *field* can be considered as successful for maintaining and improving position in the *field*, at least within the institution to which he belonged. This can be seen to be the result of his willingness to be flexible to the prevailing epistemologies and available forms *capital* for teaching and research that the site promoted. This flexibility may have been easier to achieve for this participant compared to other academics, due to a lack of a strong sense of personal goals within the *field*. This issue notwithstanding, at various points during the case he was seen to put aside his own demonstrated epistemology of teaching and research to conform with the available forms of *capital* at the site, and in order to work for recognition for his hard work within his role. This epistemological and strategic flexibility was what allowed him to adopt locally successful strategies that ultimately resulted in promotion.

The need to focus on research projects with high-profile funding and publication drew him away from his own interest in conducting research with an engineering education focus. Similarly, the lack of reward or support for quality in teaching beyond a focus on the organisation of content on the LMS, discouraged any activity surrounding broader notions of teaching quality. Significantly, a broader notion of teaching quality that would be necessary to promote some kind of systematic or conscious focus on processes for PCK development, was absent at the site. In particular, without any scope or reason to develop his reflection on teaching practice, conscious PCK development is unlikely to occur. Even though there are data to suggest that his PCK is developed enough to be self-reinforcing, and that a focus on PCK development would therefore be likely to be productive for developing increasingly effective teaching practices, the participant´s context lacked the circumstances that would either cause or allow this to happen.

Overall, the forms of *capital* for teaching and research that were observed at the site, although productive for pursuing the university´s own strategic aims and policies, were directly discouraging of PCK development, even for an academic whose own epistemological position was appropriate for such development.

11.0 - Discussion of overall findings, conclusions and implications

The following chapter is organised into three sections in order to address the various aspects of the research questions that we are now equipped to discuss in order to answer the main research question:

What is the influence of field and habitus on the nature and composition of the PCK of engineering educators?

These sections and the relevant sub-questions they address, are as follows:

- Pedagogical Content Knowledge
  - *What is the nature and composition of PCK for engineering education?*
  - *Which of the 6 domains of PCK are in evidence in observed practice and in participants' reflections on practice and how?*
  - *In what ways is PCK responsive or resistant to a teacher's habitus within their socio-cultural field?*
- Habitus
  - *What is the link between a teacher's habitus in the engineering field and their PCK?*
  - *What types of habitus are supportive of or inhibiting to the development of PCK for engineering education?*
  - *How do Engineering teachers position themselves for success in the field? (E.g. ´ways of playing the game´, the strategies and types of capital used) and how does this vary among participants and sites?*
- Field
  - *What are the variations in capital and how it is competed for in different sites within the field?*
  - *What is the influence of various nodes of the field and how can this been seen to affect the type and distribution of available capital?*
  - *What possibilities for habitus does the engineering education field reward?*

- *In what ways is the engineering field supportive of or inhibitive to the development of effective PCK?*

11.1 - Pedagogical Content Knowledge

The richness and complexity of PCK seen in Case Study A demonstrates that it is possible to find engineering educators with highly-developed and complex bodies of pedagogical content knowledge, as described by the adapted model of Park and Oliver (2008). This finding validates the use of this model as an observational tool for evaluating teaching practices in tertiary settings and applied disciplines. Not only were the component knowledge areas of this model found to be applicable in tertiary settings, the processes of reflection and integration described by this model, by which pedagogical content knowledge can be developed, were also in evidence.

As such, the nature and composition of PCK for engineering academics was not found to be *necessarily* different in its fundamental nature than for teachers in other settings and disciplines, such as the secondary teaching settings for which the model was originally developed. There were two exceptions to this. First, the teaching observed in Case A was seen to include a component knowledge area concerning teaching-for-practice, by which knowledge of how to practice in engineering industry helped the teacher to make up the gap between how the discipline is studied in the classroom and how it is practiced professionally.

The second fundamental dimension of difference in the nature and composition of PCK was seen between the participants, in particular, between Participant A and Participant B, for whom the epistemology focusing on transmission of the engineering canon was seen to affect his orientations to teaching practice to the point that PCK development was significantly limited. It was also observed within Case C that limitations on the development of the participant´s PCK existed, although in this case this was seen to result from his flexibility to conform with institutionally advocated epistemologies of teaching and learning in his practice, rather than adhering to his own implicit beliefs for carrying out his teaching. Although the B and C participants did demonstrate knowledge for teaching that fell into the categories outlined in the model, they were not observed to have developed, or fully developed, in all of the component areas.

Whilst Case A proves the possibility of a sophisticated body of PCK which both fits with the Park and Oliver (2008) model and is appropriate for use in engineering education, I argue that collectively the three cases showed that such development was subject to specific conditions within the *field* site in which teaching took place, and to the specific *habitus* of the participant in playing the game of the *field*. The particular mechanism which was seen to have this moderating effect was their epistemology of teaching and learning for their discipline, and how this affected how they went about their teaching practice, as well as how it shaped the nature of their knowledge for teaching.

All three participants demonstrated comprehensive knowledge of discipline curriculum being put to use in their teaching practice. This is not surprising given the requirement of disciplinary knowledge for academics in general and the theory-based nature of engineering as a discipline. For Participant B, this component knowledge area formed the dominant basis of his PCK, to the point that most other component knowledge areas and processes were under-represented in his PCK or were altogether absent from his observed practice and self-report. This was seen to be the outcome of his particular orientation to teaching in the discipline, the focus of which was on the transmission of what he saw as a canon of engineering knowledge. The need for students to develop skills and processes for use as practicing professionals was discussed by the participant as something they could learn later on, outside of the classroom. As such, his PCK was organised by and responsive to his own understanding of the subject matter rather than his students´ understandings of the subject matter, thereby preventing the development of PCK components in which knowledge of how to make content instructional for students is explicitly or implicitly required, such as K1 knowledge of student understandings, K3 knowledge of instructional strategies and representation, K4 knowledge of assessment of disciplinary learning, and K5 knowledge of teaching-for-practice in the discipline. Similarly, the processes of reflection and integration were excluded from his body of PCK by the intense focus on transmission of the canon. This is an example of the problem caused by lack of coherence between components of the model because ¨increased knowledge of a single component may not be sufficient to [develop PCK] and stimulate change in practice¨ (Park & Oliver, 2008, p. 264).

For Participant C, some development was seen in all of the categories of component knowledge, as well as some instances of reflection and integration being observed. His body of PCK is therefore seen to fit the Park & Oliver (2008) model, although there was not much evidence of reflection on teaching taking place in a structured fashion, or that overall PCK development was occurring. Although his epistemology of teaching in the discipline leaves room for further PCK development, there were contextual reasons why this was not occurring for this participant, as will be discussed further under Habitus.

Participant A showed the most comprehensive development in her PCK, including all component knowledge areas and processes being well-developed and inter-dependent. For this participant, a number of component knowledge areas were seen to have developed in ways that were distinct from the other two participants. First, her knowledge of student understandings of the discipline formed the basis of all of her teaching efforts, and where PCK knowledge areas were integrated in instances of teaching practice, this knowledge area was always represented in that instance of integration. Further, this knowledge area formed the basis from which her reflection processes took place, in that it was the reason she was motivated to engage in conscious reflective practices. Her reflective activities were based on both the need to be continually responsive to the students´ conceptions and misconceptions of the subject matter, and on an overarching general aim of continually improving the ways in which students could learn through her teaching. As such, both her knowledge of student understanding and her reflective processes (as well as the subsequent integration of all other component knowledge areas throughout her teaching practice) were seen to result from her particular orientations to teaching in the discipline, which in turn derived from her overall epistemology of teaching and learning engineering. As was seen in that case, this epistemology focused on the processes and skills that students need to develop for use as professional engineers in industry. In this respect, student understanding was her primary concern, and was more important to her than the content of the discipline itself. This epistemology therefore became the driver for the reflection and integration processes that were seen, which in turn drove PCK development.

Second, this participant´s methods for bringing her experiences from industry into the classroom (forming the component knowledge area of teaching-for practice) were fundamentally different than those of the other two participants. Using Shreeve´s (2010) categories for describing relations between teaching and practice is a useful means to examine these differences. For Participants B and C (whose approaches to teaching about practice can be seen to fall into the *dropping in* and *moving across* categories respectively), an asymmetrical relationship is observed between teaching and practice. For Participant B, the focus is on being a practitioner ¨and by implication, an expert in one´s subject matter, [and this is seen as] sufficient to ensure that knowledge will be passed on to those who do not have the knowledge¨ (Shreeve, 2010, p. 695). Participant C, by contrast was seen to focus on being a teacher above being a practitioner, but with some focus on taking practice into the teaching world (Shreeve, 2010). In this approach, there is some attempt to enable students ¨to understand what it is like to be a practitioner¨ (Shreeve, 2010, p. 696). However, his *habitus* for participation in the *field* showed a disconnect between his experience as a professional in industry and his *habitus* for participation in the *field*.

By contrast, Participant A´s actions related to teaching-for-practice can be said to fall into the *balancing* category, in which there is symmetrical exchange between the worlds of teaching and practice and this gives rise to interactions in the classroom that support the development of practice knowledge among students (Shreeve, 2010). In the case of Participant A, this process of exchange was continually present in her teaching practices, especially in how she demonstrated expert thinking for performing professional tasks, in how learning tasks were compared and related to professional tasks, and in explicit discussions of students developing engineering ways of thinking and being. By developing teaching in such a way as to support professional skills and identity development among student engineers who would eventually become professionals, the participant was both drawing on and feeding back into the world of practice in industry. This constituted the only instances of the development of Mode 2 knowledge that were seen in the cases.

Shreeve explains that approaches like those of like Participants A and C for bringing practice into the classroom ¨allow a much greater insight into the contexts of practice, the meaning, or the ontological dimension, of understanding process, emotion and social context¨ (Shreeve, 2010, p. 700) Significantly, however, Participant C´s observed instances of teaching-for-practice were more sporadic and incidental compared to the consistency and frequency of those of Participant A. For this reason, the teaching-for-practice dimension, where PCK is for applied disciplines, rightly constitutes a distinct category of knowledge in the PCK model, rather than being subsumed under other categories. Because ways of teaching-for-practice can be qualitatively different, this dimension of teaching requires special consideration in understanding PCK for applied disciplines and the development of that PCK. Shreeve (2010) also suggests that further examination:

> of different ways to experience relations between practice and teaching may be useful… [and lead to] a greater awareness of different ways to experience teaching, not simply focusing on the skills of teaching, can lead to conceptual change as a teacher…It might, therefore be relevant for practitioner [teachers] to be presented with variation in relations between practice and teaching in order to change the experience of the relationship and thereby improve their teaching. (Shreeve, 2010, p. 700)

This is a pertinent recommendation for engineering education in particular, which for some years has been grappling with issues of currency and appropriateness of the industry knowledge that is necessary among academics (Cameron et al., 2011) in order to be able to teach the discipline effectively and authentically. The data here, along with Shreeve´s (2010) own findings, suggest that *how* knowledge of industry is applied to teaching may be far more important to teaching and learning outcomes than *what* that knowledge is. The proposal of a distinct knowledge category for teaching applied disciplines, as well as a consideration of the ways it can be applied to specific teaching practices, has the capacity to advance these discussions significantly, rather than persisting with an unresolved focus on how many years of industry experience is necessary or how to ensure the currency of that experience.

Shreeve´s recommendation concerning ¨ways to experience teaching¨ also highlights a fundamental issue for the development of knowledge for teaching. The case studies showed that bodies of PCK were seen to be directly responsive to *habitus* through the effect of the teacher´s epistemology of teaching and learning for engineering on the teacher´s orientations to teaching in the discipline. For Participant A to develop the epistemology that was seen during the case and to action this epistemological position in her teaching practice (in other words, to change her way of experiencing teaching), by her own account, took years of experience in working with and responding to students, as well as consciously avoiding teaching in the manner that she herself was taught. The process she described in which she revised her conceptions of teaching and learning and her actual teaching practices over many years constitutes a form of educational training (albeit through trial and error rather than formal means) that is not unlike that which preservice and in-service school teachers go through in learning to reflect on their practice in structured ways, in consciously considering and reconsidering how specific pedagogical approaches may be enacted in the classroom, and how learners construct understandings of subject matter.

It should be noted that such educational training, and such epistemological development in line with constructivist principles, are largely unavailable to most practitioners in the *field* of engineering education, because most practitioners are not rewarded for, through either intrinsic or extrinsic means, valuing or investing time in teaching development in this way or to this degree. Furthermore, engineers are trained to value and operate from a positivist, objectivist and quantitative position, which makes a recognition of the interpretivist, subjective and largely qualitative nature of teaching and learning all the more difficult. The development of such a constructivist position and subsequent teaching practices therefore requires precisely the training that is unavailable within the *field*.

11.2 - Habitus

Although epistemology of teaching and learning was seen to directly influence PCK, it was *habitus* that determined how particular epistemologies were taken up and enacted by participants in their teaching practice and in their participation in the *field* as a whole. This is because the dispositions which make up *habitus* are ¨the products of opportunities and constraints framing the individual´s earlier life experiences¨(Reay, 2004, p. 433). These dispositions are ¨durably inculcated by the possibilities and impossibilities, freedoms and necessities, opportunities and prohibitions inscribed in the objective conditions¨ (Bourdieu, 1990b, p. 77). As such, a participant´s *habitus* in a *field* is not just the result of responding to immediate conditions, but rather is ¨an active residue or sediment of his past that functions within his present, shaping his perception, thought and action and thereby moulding social practice in a regular way¨ (Crossley, 2001, p. 83). As a result, each participant´s dispositions to practice took the shape of a ¨matrix of perceptions, appreciations and actions¨ (Bourdieu, 1971, p. 83) and was visible through their purposes, goals and focus in their role.

For example, because Participant A´s reasons for participation in the *field* related to an interest in teaching skills and processes to ¨the next generation of engineers,¨ this (along with her relative independence in the *field*) prompted her to ignore the need to accrue dominant forms of *capital* and focus instead on her own teaching development. Participant B, on the other hand, valued and defended traditional views of teaching and learning of engineering in order to avoid changing his teaching practices and to focus exclusively on students learning the theoretical bases of the discipline. Although there was a discourse of educational innovation present at his site in the *field*, his reliance on the dominant forms of *capital* of the *field* (especially those concerned with the value and sanctity of theoretical knowledge) allowed him to maintain this focus and a didactic approach to his teaching unchallenged.

It was not just in response to the immediate conditions in which these participants were working (for example their immediate goals and purposes for participation) that these variations in *habitus* occurred. Whilst both participants A and B had broadly similar backgrounds working in industry as structural engineers, they had subtly different ways of embodying their previous experience in their current practice in the engineering education *field*. Participant A discussed at length the ethical responsibilities of structural engineers both in interviews with me and with her students, and made specific reference to her experience of living with that responsibility in her professional capacity. To *be* a structural engineer, therefore, was to work in ways that allowed her to live up to this responsibility, rather than just dealing with liability. This identification with *being* a structural engineer by dealing with responsibility continued to shape her practice, even in the classroom. For example, she discussed with students an instance which she received a call that a retaining wall on her site had collapsed, which as it happened was not her fault, but she emphasised to students that “you never want to receive that call” and therefore they would need to learn to work in ways that would allow them to avoid making mistakes. As a result, her sense of identification with the responsibility of being an engineer translated to her current practice in the form of needing to pass on that sense of responsibility to her students. Furthermore, her sense of professional responsibility had translated from client to student.

Participant B had worked on a panel of professional engineers tasked with developing the Australian Code for reinforced concrete and this experience was similarly embodied in his practice in the classroom. He made reference to “the Code” at various times during interviews and during class as a means of invoking the primacy of theoretical knowledge in the *doing* of engineering. Instead of focussing on developing students’ ability to identify with the ontological dimension of engineering; of *being* an engineer, he rather emphasised the need to *do* engineering by meeting the requirements of the Code. Decisions about the design of a reinforced slab, for example were discussed in class not in reference to judgments about context or ethical responsibility but in terms of “the Australian Code says that…” His practices for teaching engineering therefore sought to uphold and teach reverence for the Australian Code as the theoretical foundation, the basis on which engineering practice should be performed. Rather than him being responsible to students, they were responsible for learning to meet the Code.

The *habitus* of Participant C was characterised by reactive strategies in response to his perceptions of local expectations about performance and promotion. As a result of this reactivity, the participant shifted his focus and efforts within his role according to perceived opportunities within the site in the *field*, such as the opportunity to provide leadership on a large, funded research project, and to accept institutional notions of teaching quality. As a result, his own epistemology of teaching and learning in the discipline was seen to take a backseat to institutionally advocated views of quality in teaching and the performance of research activities.

This *habitus* was also affected by the ways in which his prior experiences were brought to bear on his current practice. Although he had developed opinions about the nature of engineering (for example about how students should be prepared to solve problems in industry) based on his own professional experience, these beliefs were often dissociated from his practice in the education *field*. For example, in teaching a class about professional standards of presentation he focussed exclusively on the assessment requirements of the course, rather than the presentation skills required for practice in industry. Perhaps as a result of this dissociation between his prior experience as a professional and his current approaches to participation in the *field*, the participant experienced difficulties identifying with his current role and forming future goals and strategies to pursue within that role. Whilst he was very keen to achieve recognition for his work, he was not clear about how he might best achieve this and did not see a link between his own interests in the *field* and any measure of success or satisfaction. As a result, despite an inclination towards student-centred teaching practice, he did not recognise pedagogical development as a valid part of his role. He discussed his interests in teaching and in educational research, but did not pursue these interests in the face of the lack of reward that the *field* would offer for them. Thus Participant C's sense of responsibility was primarily to the institution.

The research showed that for a *habitus* to be supportive of the development of effective PCK in engineering education, the matrix of perception, appreciation and action that an agent is disposed to must contest the status quo concerning the importance of research relative to teaching. In the case of Participant A, this involved the development of a unorthodox position within a heteronomous pole of the *field*, drawing on the specific skills and practices required in industry to support her focus on producing high quality professional engineers, and to authenticate her alternative epistemology of teaching the discipline. Thus, the *habitus* that is productive of PCK that is appropriate for teaching engineering is also one in which learning to *be* an engineer is a central concern. Crucially, it was *habitus*, rather than (and, in fact, despite) the objective conditions of the *field*, which created the conditions that led to the development of PCK in this case. Nothing about the *field* resulted in PCK development in any of the cases that were observed: quite the opposite.

Of the three case studies, only Participant A showed strategies for participation that were different to the standard trajectory in the *field* that was theorised in Chapter 6 (Figure 21). Instead of supporting her values and actions in the *field* in reference to the orthodoxy of the higher education node, she relied instead on the values of industry to authenticate her teaching-focused practice, and on recognition of this as a form of *capital* by her immediate supervisor. Whilst Participant B also made reference to the values of industry, through invoking the standards of the Australian Code, this was implicitly supported by the doxa of Higher Education; that disciplinary knowledge constitutes the ultimate expertise of the *field*. In this respect his strategy depended on Higher Education´s recognition of the importance of content and theoretical rules, over and above any kind of relational, contextually bound or processual focus that industry may value. Therefore, although his practice was referent to industry, strategically it fell within the Higher Education node.

For Participant A, it was not clear that her strategy for participation in the *field* would be extrinsically rewarded or sustainable. Whilst this participant has not been promoted since the time of the case (almost two years) it is unlikely that she herself would count ¨success¨ in the *field* only in terms of promotion. Rather, she stated her goal was to ¨teach a course where no one failed¨ and as such her measures of success are much more concerned with quality of teaching and learning in her courses. Nevertheless, it is unlikely that other participants in the *field* could or would take up similar strategies for participation given the level of risk of sanction and lack of promotion that they carry. Participant C´s strategy of reactivity to local opportunities has shown itself to be successful given his recent promotion, in particular his decision to ignore his own educational research interests while working on a large funded project for the university. It is questionable if Participant B had conceived of any possibilities for participation in the *field* other than the standard trajectory involving strategies of ¨runs on the board¨ and ¨research funding¨ (Figure 21). He commented that he believed it was essential to continue to publish research in order to be promoted, and his publication record shows an exclusive focus on theoretical research topics. At the time of the case his approach to teaching was yet to be challenged, suggesting that his overall strategy for participation in the *field* was acceptable.

11.3 - Field

Each stage of the research demonstrated that only one significant trajectory exists for academics to pursue in order to gain *capital* and advance in the *field*, and that the strategies along this trajectory are always associated with research activities and developing theoretical expertise, particularly those that lead to development of prestige for participants´ universities. This structure of relations assumes and promotes a strictly orthodox *habitus*, in which the doxa of the *field* about the value of theoretical disciplinary knowledge and the production of that knowledge through research is not questioned or contested. It is for this reason that the more teaching-focussed a participant is within their *habitus*, the less likely they are to have access to and use dominant forms of *capital* in the *field*. Thus, the *field* systematically discourages PCK development.

Case Study A demonstrated that there are possibilities for working with alternative forms of *capital* in the *field*, however this was achieved by developing an unorthodox and relatively low-status position within a heteronomous pole of the *field*, using values for learning engineering derived from outside the Higher Education node. In other words, it requires a *habitus* of non-conformance with the status quo in order to develop strategies that can result in the development of teaching expertise. These strategies came with a significant level of risk for the individual participant, a fact which would make access to alternative *capital* unavailable to many participants in the *field*.

Although four *field* nodes were originally theorised as being relevant to the engineering education *field* as a whole, only two of these nodes were observed to have a direct effect on the *field*. These were the Higher Education node and the Engineering Industry node. The other two *field* nodes (Engineering Education Research and Regulatory/Accreditation bodies) were not observed to have any structuring effect on the *field* during data collection for this study, however it is likely that they do carry influence at selected points in the *field*, for example via the individuals and institutional bodies involved in accreditation review processes with Engineers Australia, or for academics who publish actively and contribute to the engineering education research community. Despite this, through their absence during the cases, it was seen that the influence of these nodes is not uniformly felt throughout the *field* and therefore does not have an overall structuring effect on systems of relations within the *field*. This is because it is the Higher Education node *only* that contributes and controls the most dominant forms of *capital* that structure the *field*, as well as the underlying doxa from which they draw their values and discourses (Webb et al., 2002). Where the other three nodes of the *field* do contribute forms of *capital*, these forms are expected to be isolated or indirect in their effect and limited in their direct reach into the day to day participation in the *field* by most engineering academics. Hence, for most engineering educators, they are not likely to significantly affect the opportunities and strategies for participation in the *field*. For example, because Higher Education rewards research, but rewards funded and discipline-specific research better than hybrid and cheaply-performed forms such as engineering education research, this reduces the effect of the Engineering Education node. This was seen to be true for Participant C, who despite having published in engineering education and having received an award from the national association of engineering education, chose to strategise by reducing his amount of research in engineering education in order to accrue *capital* for research in other ways.

The strength of the Higher Education node, seen through the strength of the orthodoxy it produces, drives the tendency of the *field* as a whole towards reproduction, rather than transformation. (Bourdieu & Passeron, 1990) The fact that this research found only one significant trajectory for participants to pursue through the *field* demonstrates the highly autonomous (rather than heteronomous) structure of relations therein. The circumstances of case A demonstrated the level of risk for participants involved in going ¨off the beaten track¨ of conformity with the status quo.

Case studies B and C demonstrated the strength of *misrecognition* and *illusio* that participants in such a highly autonomous *field* are subject to. Bourdieu describes misrecognition as the ¨form of forgetting¨ by which participants in a *field* lose sight of the fact that the structure of relations they are participating in is constructed rather than natural or inevitable. ¨The agent engaged in practice knows the world…too well, without objectifying distance, takes it for granted, precisely because he is caught up in it, bound up with it; he inhabits it like a garment¨ (Bourdieu, 2000, pp. 142-143). Similarly, *illusio* is ¨the more or less unthinking commitment to the logic, values and capital of a field¨ (Webb et al., 2002, p.26). Such a state of *misrecognition* and *illusio* was captured perfectly by the Head of School in Case C when he stated ¨We either play the game or we change the game and we can´t change the game. It´s the only game to play. Once you call yourself a university you are in that game.¨ Thus, for many participants, any other possibilities for strategies for participation in the *field* are simply inconceivable, and conformity with the status quo both produces and is produced by the strength of reproduction of the *field*.

Whilst the possibilities for *habitus* in any *field* can never be entirely defined or restricted, the engineering education *field* can be said to promote forms of *habitus* that reproduce rather than challenge or transform the status quo. Although many participants who follow the dominant trajectory of the *field* may never achieve the degree of success or position epitomised by Participant D in the pilot study (see Figure 21, Chapter 6) it is the function of ¨illusio¨ that ¨the fact that being caught up in and by the game, of believing that playing is worth the effort…[is] to admit that the game is worth playing and that the stakes created in and through the fact of playing are worth pursuing¨ (Bourdieu, 1998, pp. 76-77). This in itself becomes a barrier to the development of PCK, because the kind of teaching-focussed *habitus* that was seen to be productive for effective PCK requires an almost radical deviation from the rules and stakes of the game.

11.4 - Implications and Future Work

The dominating strength of the Higher Education node, and its tendency towards reproduction, has one clear and specific implication for engineering education as a whole. That is; the *field* of engineering education is not sufficiently differentiated from the *field* of Higher Education to be able to pursue its own distinct goals and purposes. Whilst it is so clearly dominated by the structuring effect of the Higher Education node, the *field* is prevented from genuinely pursuing such purposes as the need to produce high quality, industry ready engineering graduates, through teaching that emphasises the Mode 2 knowledge of the Engineers Australia Stage One Competencies (EA, n.d.). Rather, the purpose that the *field* as a whole performs is to support the interests and strength of universities as institutions, through the mechanism of prestige. In trading on prestige as a form of *capital*, to be accrued and transacted through the production of disciplinary knowledge via research, the engineering education *field* functions in precisely the same manner as any other discipline within the academy, despite the different nature and needs of engineering as an applied discipline.

The most obvious remedy for this is in the reward structures through which strategies for participation in the *field* are encouraged or sanctioned. Undoubtedly, if some reward or recognition was available for the development of teaching, especially with a specific focus on the applied nature of the discipline, increased interest in teaching and PCK development would result among participants in the *field*. As a result, students in the discipline would be better able to learn about what it is to be an engineer, rather than simply acquiring the theoretical knowledge that goes into engineering. Over time, the make-up of groups of participants in the *field* would change, such that those participants with an exclusively positivist and instrumentalist *habitus* would be marginalised or encouraged to change.

At the core of much of this discussion is the issue of epistemology and its durability. It is precisely the durable nature of epistemology; the strength of traditions surrounding teaching and learning, of received wisdom and incumbent curricular ideologies, which result in the slow pace of change in engineering education and higher education generally, despite longstanding discussion about the need for innovation. However, this research highlights some fruitful lines of enquiry through which epistemological change could be pursued. As Shreeve (2010) reflected, engagement with ¨the experience of being a teacher¨ is a useful ingredient in any efforts at teacher development and this simple idea is a good place to start.

As Participant A demonstrated in her approach to teaching-for-practice, teaching in applied disciplines has an ontological dimension that requires some serious and conscious examination, both for the purposes of being a teacher, and for improving the learning of students about the nature of their discipline. Her knowledge of teaching-for-practice constituted an embodiment of practice in the classroom which had a number of effects. First, it gave ontological meaning to her role as a teacher, in that her identity as a teacher was an extension of her identity as an engineer, and in linking the two, the practice of teaching was necessarily referential to both the practice and experience of *being* an engineer. As such, her teaching developed out of and because of her experience as an engineer, and did so in ways that gave students access to that experience. The secondary effect of this is that in embodying practice through her teaching, students themselves could take on an engineering identity and practice the skills and processes to be put to use as professionals in industry.

Such an ´embodiment of practice´ is not unique to engineering and is certainly not unheard of in other applied disciplines. A cornerstone of teacher education, for example, is the practicum placements through which student teachers become bona fide teachers. It is the effectiveness of skills and practices that student teachers develop through such experiences that will determine what kind of teachers they become. Teacher education therefore focuses attention on supporting the kinds of skills and processes that are seen as useful to being a teacher. This may include requiring student teachers to practice lesson planning, to conduct formal observations and reflections, and to adjust planning according to the conclusions of reflections.

Similarly, the ¨clinical reasoning¨ approach of nursing education, in which students role-play acts of decision making in a simulated clinical context constitutes an ´embodiment of practice.´ Students don´t simply learn all of the decisions that they might have to make in a clinical setting. Rather, they learn what it is like to be the professional in this setting, and what it is like to make decisions *in situ,* that will be beneficial to the patient. The Problem-based Learning approach of medical education is another example, epitomised by presenting student an ill-structured problem along the lines of ¨a patient comes in with a lump on their neck – what do you do?¨ as a means of examining diagnosis as a professional task of doctors. By living through the task and negotiating the vagaries of context in a *simulation of how a real doctor would,* students have an experience of being a doctor. This approach has been argued to yield considerably better outcomes in terms of learning than spending the equivalent amount of time on content acquisition and memorisation (Barrows & Tamblyn, 1980).

As such, the obsession in engineering education with not being able to sacrifice time spent on content (Mode 1 knowledge) in the curriculum in order to pursue experiential objectives (Mode 2 knowledge), because of the idea that engineers must ´know a lot of stuff,´ is spurious and counterproductive. In answer to this preoccupation, instead of conceiving of teaching development as the addition of some inert level of ´pedagogy´ on top of a crowded and content-oriented curriculum, teaching programs for applied disciplines must give some attention to the experience of teaching as a practitioner, and the role and function of practice knowledge in teaching activities, especially how those teaching activities produce Mode 2 outcomes. With better definition and explanation of the qualitatively different means by which teachers may experience and perform this knowledge area in their teaching practice, we would be better prepared to improve teaching in engineering and other applied disciplines.

The work of Shreeve (2010) is a starting point for considering this task, however it does not fully answer this purpose. For example, her proposed categories arose out of a focus on applied disciplines which generate artefacts, such as art and design, and therefore did not fit exactly with the teaching that was seen within the case studies of this project. Future research would need to examine and expand her categories to better fit with a broader range of applied disciplines, in which the focus and purpose is not on the production of artefacts, but on services, or in the case of engineering, problem-solving designs. The adapted PCK model, including a specific category of knowledge of teaching-for-practice provides an empirically-based and explanatory framework through which such research could be pursued. This construct also allows research to go beyond the proposition of categories for experiencing teaching, to develop an understanding of how teaching knowledge is developed in and out of the contexts in which teachers work.

Looking further afield to the teaching in other professional disciplines could also help in the development of a more distinct identity for the engineering education *field*, beyond higher education generally, by generating comparisons between disciplines about how ways of experiencing teaching relate to the ontological and epistemological bases of a discipline, and how these are enacted through the *habitus* of the teacher. In generating data and discussion about the ontological and epistemological bases of engineering, how these are contested and why, and how they may be subtly embodied and enacted in teaching practice, such research has the capacity to add significantly to knowledge about the development of teaching. Furthermore, it would result in a much better foundation from which engineering education can understand itself, and begin to pursue more specific and appropriate values, goals and purposes.

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Appendix A – Instruments used in the pilot study - semi-structured Interviews with pilot participants

Stage 1 – preliminary information from participant

The purpose of this stage is to talk to the participant in order to elicit some basic information about their role in the faculty at their university. For example, I will ask them

- *what their position is called and what it involves,*
- *how much teaching they do and for what kinds of courses*
- *what their research interests are (e.g. technical and/or education and in what specific areas),*
- *how long they have been in the faculty, if they serve on any committees, etc.*
- *if they have had any time working in industry or working in partnerships with industry, when this was and how long for, etc.*
- *their background before taking an academic position, such as prior career and education*

Stage 2 – Free listing exercise

The purpose of this stage of the interview is to prompt participants to define the items that belong in their cultural domain (working in engineering education)

I am interested. In order to get starting thinking about this, I am going to ask you to simply list some items for me.

First, can you list:

- all of the **activities** that you know of that apply to working in engineering education.

By activities I mean any tasks or actions that are undertaken regularly in engineering education.

Second, can you list:

- all of the **participants or stakeholders** that you know of who have an interest in what goes on in engineering education.

These could be individuals, or groups, institutions, or any kind of entity.

Now we are going to move to thinking more specifically about working in engineering education.

Can you please list:

- all of the **rewards** that you know of that are available in working in engineering education.

These could be extrinsic or intrinsic rewards, and it doesn't matter if they are tangible or not, so long as you recognise them.

Finally, I want you to think of and list:

- all of the **goals** that you know of that can be worked towards in engineering education.

Again, it doesn't matter what the nature of these goals are, so long as you recognise them as existing.

The contents of each list will be recorded. Where the terms used are general or ambiguous, participants will be asked to explain what they mean, or to expand an item into its subparts (e.g. if participant lists "teaching" as an activity, they will be asked to explain what activities teaching involves, and these subsequent items will be included in the list).

If at the end of the exercise the meaning or inclusion of any items is not clear, participants will be prompted to explain (e.g. "I am interested to see that you include X in your list of goals. Can you tell me more about that?"). It is expected that participants will digress somewhat from the exact task, but that this will be revealing of their perspectives on the nature of the domain. This will therefore be a secondary means of eliciting data in this stage.

Stage 3 – rank ordering of lists

In this stage, the lists from each participant (activities, participants/stakeholders, rewards and goals) will have been compiled into one common list for each category. These lists will contain the most significant and common responses from the pool of participants in the pilot. Participants will now be asked to rank the items on each list according to three different dimensions of value; importance to them in their role, interest to them in their role, and time spent by them (on this item) in their role.

In the first session, I asked you to come up with four lists of categories of items: activities, participants/stakeholders, rewards and goals. I'm now going to show you four similar lists, but they won't be the same as your own lists that you created. There are ten items on each list. For each of these lists, I would like you to rank each item according to three different dimensions.

First, I would like you to rank each item on each list according to:

- Its **importance** to you in your role

Give a ten to the item with the most importance and a one to the item of least importance to you. It is up to you to decide on what basis something is important to you. I will ask you to tell me about what decisions you made in ranking these items in this way.

Second, I would like you to rank each item on each list according to:

- Its **interest** to you in your role

Give a ten to the item which you find the most interesting and a one to the item you find the least interesting. It is up to you to decide on what basis something is interesting to you. I will ask you to tell me about what decisions you made in ranking these items in this way.

Finally, I would like you to rank each item on each list according to:

- The **time** you spend on this item in your role

Give a ten to the item that you spend the most time on and a one to the item you spend the least time on. I will ask you to tell me about what decisions you made in ranking these items in this way.

Stage 4 – Discussion and debrief

The purpose of this stage is to ask the participant to explore more specifically the strategies they use in undertaking their role. For instance, to talk about how they go about pursuing the rewards and goals they have identified as important to them, and how this connects with the activities they undertake in their role, how their time is distributed etc. This is expected to yield opportunities to uncover underlying beliefs about the nature of engineering as a discipline, and their conceptions of teaching and learning.

Appendix B – The questionnaire instrument

Understanding Engineering Education Teaching Practice in Context

Introduction to the Survey

This survey forms part of the data collection for a doctoral research project entitled *Understanding Pedagogical Content Knowledge for Engineering Education: The effect of field and habitus on engineering teaching practice*. The survey is designed to collect a broad section of baseline data from the community of engineering educators in AaEe about their perspectives on their roles as engineering educators.

This research will contribute to a better understanding of how engineering teaching is responsive to and dependent on the contexts in which it occurs. It is envisaged that ultimately the results of the research will contribute to clarification of the role of engineering educators and increased support for this role. Accordingly, you will be asked questions about your background in engineering, the nature of your role and your institution, and the tasks, goals and strategies that are involved in your role as an engineering educator.

This survey has received ethical clearance from the University of Southern Queensland's Human Research Ethics Committee (HREC Approval Number: H13REA191) and approval for dissemination by the Australasian Association for Engineering Education. The research is being conducted under the supervision of Associate Professor Lyn Brodie and Dr Warren Midgley from the University of Southern Queensland.

Participant Information

Participation in this project will involve the completion of an anonymous online survey. This is expected to take around 15 minutes or less, but you can spend more time on it if you wish. There are minimal risks associated with participation in this project because although you will be asked to comment on views, conditions and practices that are associated with your academic role, the issues discussed are not expected to be sensitive in nature or damaging to the conditions of your employment. Neither your institution nor your personal identity will be named or identifiable from your answers.

You may decline to answer questions or comment on particular issues if you would prefer not to.

Consent to Participate

By continuing to the next section of this survey, you are consenting to participate and acknowledging the below terms and conditions: ·

- I have read and understand the above Participant Information
- I understand the purpose of the research project and my involvement in it
- I understand that because this survey is anonymous, once I submit the completed form, it cannot be retrieved and withdrawn from the study because it will not be identifiable in the pool of responses.

- I confirm that I am over 18 years of age
- I understand that while information gained during the study may be published, neither myself nor my institution will be identified and my personal results will remain anonymous.

Should you have any queries regarding the progress or conduct of this research, you can contact the principal researcher:

Hannah Jolly
Faculty of Education
University of Southern Queensland
West St, Toowoomba
0439 864 348

If you have any ethical concerns with how the research is being conducted or any queries about your rights as a participant please feel free to contact the University of Southern Queensland Ethics Officer on the following details.

Ethics and Research Integrity Officer
Office of Research and Higher Degrees
University of Southern Queensland
West Street, Toowoomba 4350
Ph: +61 7 4631 2690
Email: ethics@usq.edu.au

- ❍ I consent and wish to proceed with the survey
- ❍ I decline and wish to exit the survey
- ❍ This research does not apply to me, as I am not an engineering educator, and I wish to exit the survey

Q2 How long have you worked as an engineering educator in academia?

- ❍ 1-2 years
- ❍ 3-5 years
- ❍ 6-10 years
- ❍ 11-20 years
- ❍ 20+ years

Q3 Prior to entering academia did you work in a professional capacity in an industry related to engineering?

- ❍ Yes
- ❍ No

Q4 If you answered yes to the previous question, how long was this industry employment for?

- ❍ 1-2 years
- ❍ 3-5 years
- ❍ 6-10 years
- ❍ 11-20 years
- ❍ 20+ years

Q5 What were your reasons for entering academia as an engineering educator?

Q6 Do you have any ongoing links with engineering industry in your current position? (For example, do you use guest lecturers from industry in your teaching, do you have research partnerships with engineering industry, or do any consulting with industry?)

- ❍ Yes
- ❍ No

Q7 If you answered yes to the previous question, please describe the nature of these links with industry:

Q8 Please indicate which of the following best describes your current position within your faculty and institution:

- ❍ Primarily teaching focused with some research duties
- ❍ Primarily research focused with some teaching duties
- ❍ Research only
- ❍ Primarily administrative/service focused with some research/teaching duties
- ❍ Other (please give description): _____________________

Q9 Which of the following categories best describes the institution that you work in:

- ❍ One of the Group of Eight (Go8) universities (such as ANU, UNSW, or UQ)
- ❍ An Australian Technology Network (ATN) university (such as QUT, RMIT or Curtin)
- ❍ An Innovative Research University (IRU) (such as Flinders, Griffith, James Cook, Charles Darwin)
- ❍ A regional university (such as CQU, USQ, UNE or SCU)
- ❍ None of the above – my institution does not fit into any of these categories. Instead I would describe it as: ____________________
- ❍ I am not sure which category my university would belong to

Q10 In your opinion, your faculty/school thinks that the most important aspect of staff performance is:

- ❍ The quality of teaching
- ❍ The quantity of teaching
- ❍ The quality of research
- ❍ The quantity of research
- ❍ The amount of service/administrative duties performed
- ❍ All of these things are somewhat equal
- ❍ Another aspect of performance (please describe): ____________________

Q11 In your opinion, your faculty/school thinks that the most important outcome of the engineering program is:

- ❍ The theoretical competence of graduates
- ❍ The practical/application competence of graduates
- ❍ The project skills competence of graduates
- ❍ The broader, generic skills competence (e.g communication, teamwork, etc) of graduates
- ❍ All of these are somewhat equal
- ❍ Another aspect of graduate competence, (please describe): ____________________

Q12 Which of the following options best describe your research interests (you can choose as many options as apply to you):

- ❑ I am interested in technical or theoretical research topics, which add to engineering theory/knowledge
- ❑ I am interested in practical research topics, which have applications in engineering industry
- ❑ I am interesting in educational research topics, to do with the teaching and learning of engineering
- ❑ I have a significant interest in research and spend lots of time on it
- ❑ I used to do lots of research but don't spend that much time on it at the moment
- ❑ I am not really interested in research and don't spend much time on it
- ❑ I would like to be doing more research but don't have time
- ❑ Other comments about research interests: ____________________

Q13 If you would like to make any extra comments about the above questions or responses, please do so here:

Q14 Please indicate the number of courses that you teach (a course being a semester unit of study) in an average semester:

Q15 Please indicate the number of students for whom you have a supervisory role (e.g. for Honours, Masters, PhD, or final year project students) in an average semester:

Q16 Which of the following options best describe the courses that you teach (select as many options as apply to you):

- ❑ I teach theoretical course/s
- ❑ I teach technical course/s
- ❑ I teach practical/industry-focused course/s
- ❑ I teach project based course/s
- ❑ I teach first year course/s
- ❑ I teach second year course/s
- ❑ I teach third and fourth year course/s
- ❑ I teach postgraduate course/s

- ❑ I teach to very large class sizes (more than 500 students)
- ❑ I teach to large class sizes (more than 200 students)
- ❑ I teach to medium class sizes (50-100 students)
- ❑ I teach to small class sizes (less than 50 students)
- ❑ I teach to primarily on-campus classes
- ❑ I teach to primarily online classes
- ❑ I teach to classes that are a mix of on-campus and online modes

Q17 On average, how many hours per week would you spend teaching (giving lectures/ tutorials/ labs/ workshops/ consultation sessions)?:

Q18 On average, how many hours per week would you spend preparing materials for teaching (e.g. lectures, resources, notes, practice problems)?:

Q19 On average, how many hours per semester would you spend revising your teaching activities and/or investigating new ways to conduct your teaching activities?:

Q20 Prior to entering academia as an engineering educator, how many years of experience with teaching did you have?

- ❍ 1-2 years
- ❍ 3-5 years
- ❍ 6-10 years
- ❍ 11-20 years
- ❍ 20+ years

Q21 Do you have any formal training or qualifications in teaching?

- ❍ Yes
- ❍ No

Q22 If you answered yes to the above question, please give details of this training/qualification:

Q23 If you would like to make any extra comments about the above questions or responses, please do so here:

Q24 In the following table appears a list of possible **tasks or activities** that you *may undertake* in your role as an engineering educator. Please rank them as best you can.

There will be three different measures to rank each item against.

First, please rank the TASKS in this list for their **level of interest for you**.

Rank each item from 10 to 1. A score of 1 indicates the most interest to you. A score of 10 indicates the least interest to you.

______ Preparing and revising lectures/teaching activities
______ Lecturing/tutorials
______ Writing proposals for grants
______ Writing papers for publication
______ Reviewing and improving existing courses
______ Designing and developing new courses
______ Conducting research (e.g: research design, data gathering, analysis):
______ Service to the faculty/school (e.g: committees, administrative duties, etc):
______ Eliciting and evaluating feedback from students
______ Training tutors or teaching staff

Q25 Second, please rank the TASKS in this list for how **important they are for you to be able to do well in your role:**

A score of 1 indicates the most importance. A score of 10 indicates the least importance.

______ Preparing and revising lectures/teaching activities
______ Lecturing/tutorials
______ Writing proposals for grants
______ Writing papers for publication
______ Reviewing and improving existing courses
______ Designing and developing new courses
______ Conducting research (e.g: research design, data gathering, analysis):
______ Service to the faculty/school (e.g: committees, administrative duties, etc):
______ Eliciting and evaluating feedback from students
______ Training tutors or teaching staff

Q26 Finally, please rank the TASKS in this list for **how much time you spend on them**:

A score of 1 indicates the most time spent. A score of 10 indicates the least time spent.

______ Preparing and revising lectures/teaching activities
______ Lecturing/tutorials
______ Writing proposals for grants
______ Writing papers for publication
______ Reviewing and improving existing courses
______ Designing and developing new courses

______ Conducting research (e.g: research design, data gathering, analysis):
______ Service to the faculty/school (e.g: committees, administrative duties, etc):
______ Eliciting and evaluating feedback from students
______ Training tutors or teaching staff

Q27 The above list of activities/tasks has been derived from a previous stage of data collection with engineering academics, but it may not fit your circumstances. Please comment:

Q28 In the following table appears a list of **goals** that it is possible to pursue in engineering education. Please rank them as best you can.

There will be three different measures to rank each item against.

First, please rank the GOALS in this list for their **level of interest for you**.

Rank each item from 10 to 1. A score of 1 indicates the most interest to you. A score of 10 indicates the least interest to you.

______ Ensuring my own relevance and currency within the discipline
______ Achieving promotion
______ Improving my rate of publication
______ Educating the next generation of engineers
______ Improving student feedback on my teaching
______ Developing a good research record and reputation
______ Improving the learning outcomes of students
______ Increasing the amount of funding I have for my research
______ Enabling young staff to learn how to do research
______ Doing a better job of teaching

Q29 Second, please rank the GOALS in this list for **how important they are for you to be able to do well in your role:**

A score of 1 indicates the most importance. A score of 10 indicates the least importance.

______ Ensuring my own relevance and currency within the discipline
______ Achieving promotion
______ Improving my rate of publication
______ Educating the next generation of engineers
______ Improving student feedback on my teaching
______ Developing a good research record and reputation
______ Improving the learning outcomes of students
______ Increasing the amount of funding I have for my research
______ Enabling young staff to learn how to do research
______ Doing a better job of teaching

Q30 Finally, please rank the GOALS in this list for **how much time you spend on them**:

A score of 1 indicates the most time spent. A score of 10 indicates the least time spent.

______ Ensuring my own relevance and currency within the discipline
______ Achieving promotion
______ Improving my rate of publication/research output/funding awarded, etc
______ Educating the next generation of engineers
______ Improving student feedback on my teaching
______ Developing a good research record and reputation
______ Improving the learning outcomes of students
______ Increasing the amount of funding I have for my research
______ Enabling young staff to learn how to do research
______ Doing a better job of teaching

Q31 The above list of goals has been derived from a previous stage of data collection with engineering academics, but it may not fit your circumstances. Please comment:

Q32 In the following table appears a list of **indicators of success** that may be relevant to doing well in your position as an engineering educator. Please rank them as best you can.

There will be two different measures to rank each item against.

First, please rank the INDICATORS OF SUCCESS in this list for their **level of interest for you.**

Rank each item from 10 to 1. A score of 1 indicates the most interest to you. A score of 10 indicates the least interest to you.

______ Having research published
______ Winning citations/ awards
______ Achieving promotion
______ Being asked to collaborate on research projects or publications
______ Having my teaching innovations or pedagogies taken up elsewhere
______ Seeing the outcomes/findings of technical research being used for industrial applications
______ High levels of attendance at lectures/ teaching sessions
______ Positive feedback from students on my teaching
______ Being able to use research activities to inform teaching activities and vice versa (e.g. first-hand knowledge of recent developments in research field being passed on to students)
______ Getting recognition by professional engineering societies (e.g. demand for consultancy services, fellowships, etc)

Q33 Second, please rank the INDICATORS OF SUCCESS in this list for **how important they are for you to be able to do well in your role:**

A score of 1 indicates the most importance. A score of 10 indicates the least importance.

______ Having research published
______ Winning citations/ awards
______ Achieving promotion
______ Being asked to collaborate on research projects or publications
______ Having my teaching innovations or pedagogies taken up elsewhere
______ Seeing the outcomes/findings of technical research being used for industrial applications
______ High levels of attendance at lectures/ teaching sessions
______ Positive feedback from students on my teaching
______ Being able to use research activities to inform teaching activities and vice versa (e.g. first-hand knowledge of recent developments in research field being passed on to students)
______ Getting recognition by professional engineering societies (e.g. demand for consultancy services, fellowships, etc)

Q34 The above list of indicators of success has been derived from a previous stage of data collection with engineering academics, but it may not fit your circumstances. Please comment:

Q35 If you would like to make any extra comments about this survey or your responses, please do so here:

Appendix C – The case study interview protocols

Pre-observation Interview

Your academic role

- What is the nature of your role here at the uni (e.g. title, how long have you been here)?
- What does this role involve (how much teaching, research, admin duties)?
- How many courses do you teach (and how many are being taught this semester)?
- What is the nature of those courses (subject matter, year level, number of students, etc)?
- What is your contact with the students for those courses (e.g. lectures, tutes, labs)?
- Where do these courses fit in the overall engineering program here?
- Can you tell me about the nature of the engineering program here? What kinds of things do you think the program emphasises/tries to emphasise (e.g. work placements, theoretical knowledge, skills development, etc)?
- What kinds of priorities are there in the faculty (e.g. quality of teaching, quality of research, etc)? If the faculty had one or two key goals, what do you think they would be?
- What do you think the overall aim of the institution is? What does the uni think is important?

The week ahead

- What is on the agenda for this week? Are there any particular goals or priorities for you?
- What kinds of classes can I expect to see this week (e.g types of sessions, topics to be covered, where the students are up to with everything)?
- What do you expect will be going on in the classes (e.g. students beginning to consider new material, practicing learned concepts , etc)?
- What topics or concepts are going to be most important for the students this week? Why?
- What are your expectations about how the students will handle these topics/concepts (e.g. will they struggle with them, do they usually respond a particular way, are there any misconceptions that they tend to have?
- What do you think it will be important to focus on in these sessions? Why?
- How do you think you will know if your students are understanding or not?
- Are there any particularly interesting or important moments I should look out for?

Additional events/duties

- Is there anything else that will be going on this week (other than teaching sessions) that is of significance for your role (e.g. meetings, committees)? Why is it significant?
- Is there anything in particular (other than teaching) that will take up a lot of your time? Why? How do you feel about this task?

Background

- How did you come in to working as an engineering academic (e.g. via postgraduate study/ industry)?
- What were your reasons for becoming an engineering academic?
- What kind of experience did you have with teaching before entering academia?
- What kinds of research are you undertaking?

Beliefs about the nature of teaching and learning and engineering as a discipline

- Can you tell me about engineering as a discipline? What is it like? What kinds of skills and aptitudes does it involve? What are the most important things that students have to learn to become an engineer?
- What kinds of things make students good learners in engineering?
- What kinds of things can teachers do to help students to learn like this? What kinds of teaching activities/events make the most difference for helping students?
- Do you use any particular approaches or activities that are relevant to this?
- Do you think you have any particular strengths or weaknesses in your teaching?

Post-observation interview

Interesting events

- How did you feel about the teaching sessions this week?
- Could you describe any events from the teaching sessions I saw this week that you thought were particularly interesting or significant?
- What were your most effective teaching moments? Why? How did you achieve it? Why did it work?
- Were there any student misconceptions during teaching this week that you picked up on? What were they? How did you address them?
- Did you make any changes to what you had planned to do this week?
- If you could make any changes to what went on in class this week, what would they be? Why?
- I would like to ask you about a couple of things that I saw…. Can you tell me what about [certain event]? What is your understanding of that moment? Why did that occur? How do you feel about it?

Time allocation

- At the start of the week we talked about your goals and priorities for the week – how do you feel about these now? How well were you able to manage or achieve them? Why?
- Thinking back to how your time was taken up this week, if you could make any changes to this, what would they be (e.g. more time on research, less time in meetings, etc)?
- What were some of the rewarding moments for you this week? Why?
- What were the more frustrating moments? Why?
- How typical was this week for you? Why? How would this week compare to the ideal week in your job?

Appendix D – Example of notes taken during observation

Tuesday 8/4/14

7.45

Walking to fourth year project design course lecture to be taken by HOS as guest lecturer on fire safety. L discussing project options for students - options to be submitted. Wants students to ¨surprise us.¨

HOS: ¨Does the third option have to be concrete?¨

L: ¨we leave it up to them becuase it is more important at this stage to be focussing on professional skills. Later on it is more about concrete.

Tutors are attending the lecture.

7.55

Some students aer discussing their submission before the lecture. One student approaches a tutor to ask a question about the submission. (Whether to submit on grid paper or not)

Students appear to be seated in their project teams.

8.00

Lecture by HOS begins: ¨most engineers see fire safety as an afterthought (regardless of the type of engineer).¨ Talks about the practical issues with this in terms of the optimisation of design.

Some students walk in late. Makes no comment but looks at watch.

Asks why it is that fire safety is an afterthought, after discussing all of the problems with this. Asks students who has thougth about fire safety. Students are unresponsive.

¨You have been working on your designs for five weeks. What have you thought about?¨

Student replies yes they have thougth about fire safey but only in terms of what they have read in the brief.

Lecturer is constantly asking, of what, why, etc. Lecturer begins to draw concrete beam with reinforcements.

L comments to me that she loves this lecture because the questions put the students on the spot.

Lecturer continues to interrogate students´understandings in terms of the diagram just drawn: ¨why is the cover appropriate to help you with the expansion?¨

He is moving between using diagrams and graphs. Expects students to be able to follow. Continues to question. ¨Why is the cover helpful?¨

Students begin to develop hypotheses and he begins to test these through ongoing questions: ¨ok, so you are saying it is not about expansion it is about strength?¨

Alternates between questions and explanations using diagrams, then developing more questions to force students to rehypothesise.

Comments: ¨come on, this is a servicability problem.¨

Continues working and uncovering issues with students understandings about what part of the structure takes the load

¨why is concrete used as insulation when it gives a lot of weight?

8.17

Students are now giving more responses and more students are responding.

Lecturer is linking concepts back to professional responsibility, for example doing a cost benefit analysis to be able to offer the best design. Comments about being stuck between different professional responsibilities, such as to be safe for the public or cost effective for the clients.

Poses question about how to use the building code to determine the design. Explains the need for questioning in the design process in order to achieve optimisation. Goes back to student point at the beginning of the lecture who said that they have thought about safety only in terms of what is in the brief.

Lecturer is using chalk and talk only, but with a very socratic style

¨What do I need to know to be able to understand which of the two options is best?¨

Student asks ¨fire rating?¨

Lecturer: ¨how much of that is for a parking structure?

Liza: ¨60¨

Lecturer: ¨now that you have been given the answer of how much it is, what does that mean?

Gives content/theory

Ï have used my words very carefully, what does that mean?¨

Students hypothesise again and lecturer asks further questions. He points out that it is not helpful to understand requirements in terms of standards.

¨What is a fire rating?¨

Lecturer is being very clear about what students need to know, that is, meaning not memorisation of content.

Students are becoming more and more focussed and responsive.

There is a quesrtion about fire rating already in the notes but students have read them or the relevant fire codes.

¨What does it mean to be fire rated?¨

Student: ¨structural integrity, structural stability, etc.¨

Appendix E – Free lists completed by pilot participants

Free list of Tasks by pilot participants

Participant A	Participant B	Participant C	Participant D
Workshops, mentoring, networking, forums, training and dissemination for teaching and learning development program	Keeping up to date with technical knowledge	Preparing and revising lectures	Revising and bringing up to date course documents
Evaluation of own teaching	Running courses	Marking	Mapping graduate attributes to course objectives
Lecturing	Preparation of teaching activities	Service activities	Preparing teaching materials and how you are going to teach
Consultations	Reviewing and improving courses – course renewal	Assessment design	Selecting and preparing tutors for teaching in courses
Preparation for teaching	(Re)evaluation of and reflection on courses and teaching	Research in field related to (content of) teaching	Conducting lectures
Developing new courses, including learning objectives, setting assessment, making sure there is communication and feedback	Eliciting feedback from students	Writing proposals for grants	Setting exam questions and checking that the assessment documents work against the marking scheme
Reviewing formal and informal feedback from students	Training tutors (pedagogically)	Simulations/ experiments	Sending students their own exams to compare to ideal solutions as feedback
Tutor consultation and debrief	Giving feedback on assessment to students	Analysis	Time management/planning activities – worked out against short, medium and long term goals
Replanning/improving courses		Publication	
Resourcing – people, computers, materials, handouts		Running through simulations and developing practice problems for students	
Evaluation from teaching literature		Working on Grad Cert in Higher Ed	
Collaborating with colleagues at every part of the research process		Keeping abreast of activities in the school/faculty such as teacher training	
Supervising PhDs		Supervising PhD and final year project students	
Getting funding – writing proposals, getting partners, writing papers, conference attendance and organising			
Dissemination of findings to other organisations			
Administrative tasks – travel forms, appraisal forms, putting papers on research			

gate, maintaining websites, course profiles			
Moderation of assessment			
Service on committees			

Free list of Goals by pilot participants

Participant A	Participant B	Participant C	Participant D
Ensuring own relevance in department with technical focus	Educate the next generation	Publish more	To teach well
Promotion	Reengaging student cohort	Improve research output	To get >/4 CVAL results in first year courses
Challenge the system when not valued	Improve learning outcomes	Develop technical research reputation and world class research record	To do research that has a purpose that is seen by society, or a product that you can see in the marketplace
More papers and writing		Shift student focus from marks to engineering skills	Put a patent out
Improve student feedback on teaching – both for the faculty and for own teaching		Reduce time spent on teaching	Delegating research tasks to research fellows
Do a better job of teaching international students (faculty and own)		Encourage more appreciation of hands-on skills as well as theoretical skills within the discipline	Teaching research fellows how to write grants, research tips for preparing proposals, enabling young staff to learn how to do research/ get grants, older staff to get more money
Better/more dissemination of research projects		Run smaller courses	Training the next generation of people to continue the work
Better/more dissemination of teaching and learning development program			
Help and support the progress of PhD students			

Free list of Indicators of Success by participants

Participant A	Participant B	Participant C	Participant D
Getting papers published	Feedback from students (not formal evaluations)	Getting papers published in refereed journals	Being an engineering education all-rounder
Getting promoted	Rewarded for building rapport with students	Getting recognition in the industry through demand for consultancy services, etc	To do great research
Improved teaching evaluations from students (formal generic ones run by university)	Promotion for research but not teaching	Own cohort of successful students (such as PhD and final year project students)	To translate research to students
PhD students graduating	Publication	Professorship	Helping (future) graduates to become good engineers in industry

Invitations to speak at other institutions	Citations	Pay raise/promotion	Empathy/connections with students
Citations		Teaching and learning awards/citations	High scores in measures of quality of teaching and quality of research (from university)
Being asked to be in on research proposals or publications		Recommendation by professional Engineering societies/ fellowship in engineering societies	Having research inform teaching and teaching inform research
Having innovations or pedagogies taken up and used elsewhere		Seeing the outcomes/findings of technical research be taken up and used in industrial applications	Students/researchers coming back to work with you
People calling you up for advice and actually being able to help them			Influencing the whole instead of just part (of curriculum)
Expressions of gratitude (from colleagues or students)			
High levels of attendance at lectures and teaching sessions			

Appendix F – Data from questionnaire

Number of respondents: 80

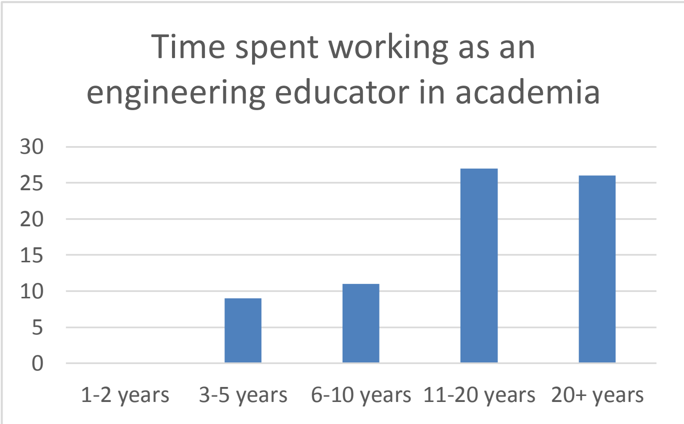
Number of complete responses: 40

Number of partial responses: 40

Q2 How long have you worked as an engineering educator in academia?

Number of complete responses: 73

How long have you worked as an engineering educator in academia		
1-2 years	0	0%
3-5 years	9	12.3%
6-10 years	11	15%
11-20 years	27	37%
20+ years	26	35.7%



Q3 Prior to entering academia did you work in a professional capacity in an industry related to engineering?

Q4 If you answered yes to the previous question, how long was this industry employment for?

Number of complete responses: 71

Time in industry prior to entering academia		
No time in industry prior to academia	15	21.1%
1-2 years	8	11.3%
3-5 years	9	12.7%
6-10 years	15	21.1%
11-20 years	15	21.1%
20+ years	9	12.7%

Q5 What were your reasons for entering academia as an engineering educator?

Reasons for entering academia	
Teaching focus	14
Teaching research nexus	2
Research focus	3
Both teaching and research	12
Industry interface focus	4
Job conditions flexibility	9
Job conditions security and opportunity	7
Intrinsic or personal reasons (such as to pursue a higher degree)	23

Number of complete responses: 74

Q6 Do you have any ongoing links with engineering industry in your current position?

(For example, do you use guest lecturers from industry in your teaching, do you have research partnerships with engineering industry, or do any consulting with industry?)

Number of complete responses: 70

Q7 If you answered yes to the previous question, please describe the nature of these links with industry:

Nature of ongoing links with industry	
Use of guest lecturers in class	28
Research partnerships	13
Consultancy	27
Research supervision	5
Providing research projects and advice for coursework	19
Facilitating with students visiting industry for site visits, internships, as graduate hires, etc	18
Sharing resources and equipment	2
Maintaining industry contacts or participation on boards/industry bodies, etc	12
¨Collaboration¨	3
Working on university boards for consulting with industry (e.g uni advisory council)	2
No ongoing links with industry	10

Q8 Please indicate which of the following best describes your current position within your faculty and institution:

Number of complete responses: 69

Nature of current position	
Primarily teaching focused with some research duties	20
Primarily research focused with some teaching duties	6
Research only	1
Primarily administrative/service focused with some research/teaching duties	14
Other (please give description	9
- equal teaching and research	8
- normal academic load, teaching research and admin	8
- management/executive	3

Q9 Which of the following categories best describes the institution that you work in:

Number of complete responses: 66

Category of institution	
One of the Group of Eight (Go8) universities (such as ANU, UNSW, or UQ)	18
An Australian Technology Network (ATN) university (such as QUT, RMIT or Curtin)	14
An Innovative Research University (IRU) (such as Flinders, Griffith, James Cook, Charles Darwin)	6
A regional university (such as CQU, USQ, UNE or SCU)	12
None of the above – my institution does not fit into any of these categories. Instead I would describe it as	
Monash	1
TAFE	1
Macquarie	1

Like an ATN but not in that category	1
ADFA	1
An institution in New Zealand	4
No explanation given	4
I am not sure which category my university would belong to	3

Q10 In your opinion, your faculty/school thinks that the most important aspect of staff performance is:

Number of complete responses: 67

Most important aspect of staff performance	
The quality of teaching	10
The quantity of teaching	2
The quality of research	18
The quantity of research	16
The amount of service/administrative duties performed	0
All of these things are somewhat equal	18
Another aspect of performance (please describe):	
¨Funded research¨	1
¨I'm not sure - it seems to vary with the person/Dept/Faculty. My University has a PDR process for staff, but in recent years it's not been taken seriously in my Dept¨	1
¨Don't think and do what management wants without them telling us what they want...¨	1

Q11 In your opinion, your faculty/school thinks that the most important outcome of the engineering program is:

Number of complete responses: 67

Most important outcome of the engineering program	
The theoretical competence of graduates	6
The practical/application competence of graduates	14
The project skills competence of graduates	3
The broader, generic skills competence (e.g communication, teamwork, etc) of graduates	6
All of these are somewhat equal	29
Another aspect of graduate competence, (please describe):	
¨I have not heard this articulated, even though I have directly asked¨	1
¨nothing relating to graduate competence - most important outcome is funding which can be channelled into supporting researchers¨	1
¨Capability to draw on theory in previously unseen situations, cross disciplinary thinking¨	1
¨Matching graduate skills and industry needs.¨	1
¨Faculty - Completion, regardless of above; School/Department - All of these are required (somewhat equal).¨	1
¨I'm not sure what the Dept would say is the most important outcome, however in recent years there has been an increasing emphasis on project work in the engineering curriculum.¨	1
¨Student satisfaction¨	1
¨Meeting Canberra "Guidelines" (i.e. Canberra financial blackmail)¨	1
¨a foundation encompassing al of the above along with awareness of the need and ability to continue profesional development and learning¨	1

Q12 Which of the following options best describe your research interests (you can choose as many options as apply to you):

a) I am interested in technical or theoretical research topics, which add to engineering theory/knowledge
b) I am interested in practical research topics, which have applications in engineering industry
c) I am interesting in educational research topics, to do with the teaching and learning of engineering

d) I have a significant interest in research and spend lots of time on it
e) I used to do lots of research but don't spend that much time on it at the moment
f) I am not really interested in research and don't spend much time on it
g) I would like to be doing more research but don't have time

h) Other comments about research interests: ____________________

Number of complete responses: 67

Research Interests Overview by category (Q12 a-c)	
Total number interested in technical/theoretical research	24
Total number of people interested in practical research	46
Total number of people interested in educational research	44
Technical or theoretical research only (a)	2
Both technical/theoretical and practical research (a & b)	8
Practical research only (b)	11
Both practical and education research (b & c)	16
Education research only (c)	12
Both technical/theoretical and educational research (a & b)	3
All three of these research areas (a, b & c)	13

Levels of interest in research of survey participants (d –g)	
I have a significant interest in research and spend lots of time on it (d)	11
I have a significant interest in research but don´t spend much time on it (d & g)	5
I used to do lots of research but don't spend that much time on it at the moment (e)	7
I used to lots of research and would like to do more but do not have the time (e & g)	8
I am not really interested in research and don't spend much time on it (f)	2
I would like to be doing more research but don't have time (g)	11

Other comments made about research interests under Question 12 (4 Responses)

Respondent selected the following options from the list:

a) I am interested in technical or theoretical research topics, which add to engineering theory/knowledge
b) I am interested in practical research topics, which have applications in engineering industry
c) I am interesting in educational research topics, to do with the teaching and learning of engineering
d) I have a significant interest in research and spend lots of time on it
g) I would like to be doing more research but don't have time

Other comments about research interests:

¨ Funding challenged. Government is below OECD mean % investment. My children will leave this country.¨

Additionally, under the next section, the same respondent commented:

¨Stated commitment to teaching and research is not consistent with funding.¨

Respondent selected the following options from the list:

c) I am interesting in educational research topics, to do with the teaching and learning of engineering

Other comments about research interests:

¨I like to do research around my teaching to support my students' learning¨

Respondent selected the following options from the list:

a) I am interested in technical or theoretical research topics, which add to engineering theory/knowledge
b) I am interested in practical research topics, which have applications in engineering industry
c) I am interesting in educational research topics, to do with the teaching and learning of engineering

Other comments about research interests:

¨My research interests and activities are diverse - I have changed research areas a couple of times during my academic career, and in recent years have published research in four different areas, though I am mainly active in two.¨

Respondent selected the following options from the list:

Other comments about research interests:

¨I used to do some educational research but don´t spend that much time on it at the moment¨

Respondent selected the following options from the list:

c) I am interesting in educational research topics, to do with the teaching and learning of engineering

Other comments about research interests:

´My research interests lie outside traditional Engineering¨

Q13 If you would like to make any extra comments about the above questions or responses, please do so here:

Number of responses: 9

Comment by respondent	Theme/Topic
As one becomes a line manager and moves up the administrative side of tertiary education, there is less time to devote to personal research. One of the goals (hopefully) is to get one's junior colleagues on the path to developing their research area.	Time for research
There is lots of pressure to get research funds but no help in marketing for consulting type work. I think Australia would be better off with career prospects for p/g study that are good enough students will study without large scholarships because future income is sufficiently better. This would shift the emphasis for grants from paying for people to paying only for equipment, making the same budget go much further and strengthening the country. Australia: typical grants are $50-100k pa for 3 years, Taiwan $10k one off, but most staff would get 2 or 3 per year instead of our lottery for brand name professors.	Support for research
Stated commitment to teaching and research is not consistent with funding.	Value for teaching and research
Research on aspects of engineering practice, including certain technical and socio-technical aspects, human factors.	Research interests
I accept that my scene is a bit unusual. I started at 40% fraction, off-campus teaching only, then this grew into 50%, 80% and 100% and some UG subjects, and PG program leadership. After School re-org in 2003, UG at our campus was Civil Engg only, and as a Mech, my teaching grew to 3 PG units..	Nature of position
My interests are in delivering materials including associate degree level, specialising in digital electronics concepts	Teaching interests
I am not in a faculty- I am placed in a learning centre - a central unit under a dvc portfolio- and liaise with engineering and science academics and professional staff by invitation and from relationships developed over many years- I try to help students develop their comm skills (from 1st yr to phd) and study/learning skills -I give guest talks, co teach tutorials with an academic, develop and deliver credit bearing comm skills courses(with engineering theme and academic staff involvement in design , teaching and marking), train tutors in marking writing/feedback, design lms and online resouces on writing etc.. and do a bit of co authored reseach when i can find the time.. I have been slogging away for 15 yrs - I see some benefits for our students .. but our classes are getting bigger each year and its getting harder to feel that you can make real connections and really help our students .. thanks for listening.	Nature of position
there is a shift in the School's thinking about the importance of teaching (as being more important). / In theory the workload is 40% teaching 40% research 20% service, but we are in transition from a 70-20-10 model, so the 40-40-20 is aspirational at this stage	Value for teaching

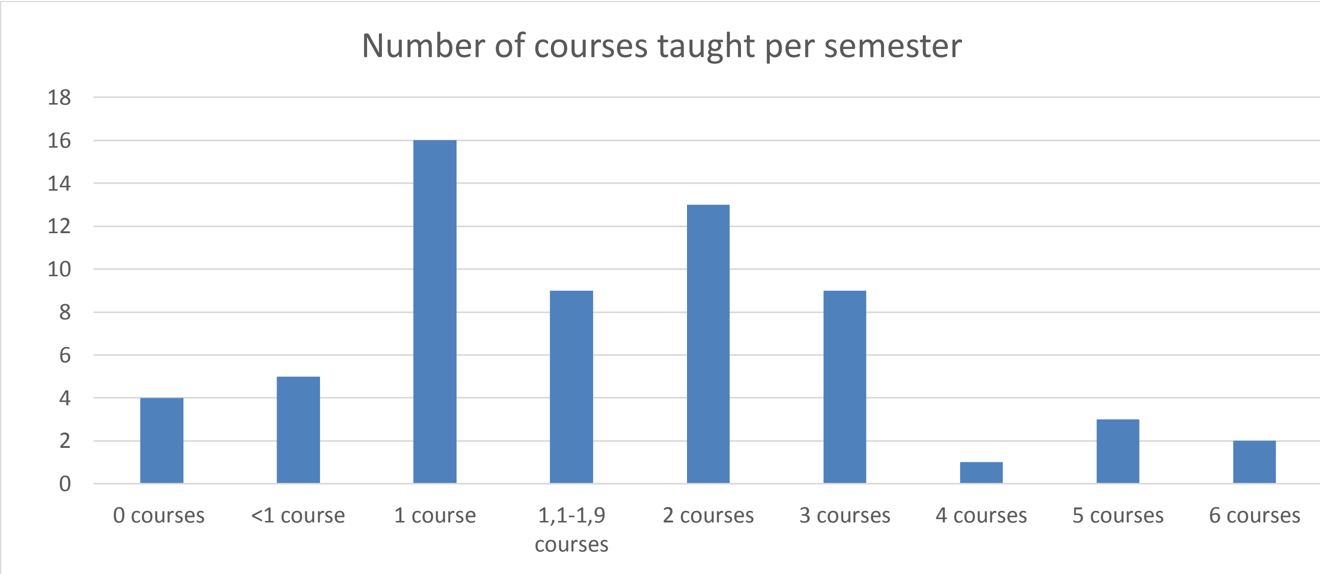
Universities in general place far to much emphasis on the PhD qualifications for lecturers and it turns out that most PhD's are the worst possible lecturers with zero to almost zero industry experience. Discipline research is much more important to students than educational research and industry experience far outweighs the outcomes achieved in a theoretical PhD.	Value for research

Q14 Please indicate the number of courses that you teach (a course being a semester unit of study) in an average semester:

Number of responses: 62

Range of responses: 0-6 (including partial numbers taken as an average, for example 1.5 when a respondent indicated they teach one course in semester 1 and 2 courses in semester 2)

Average response: 1.89 courses per semester



Q15 Please indicate the number of students for whom you have a supervisory role (e.g. for Honours, Masters, PhD, or final year project students) in an average semester:

Number of responses: 62

Range of responses: 0-20

Average response: 6.05 students

Q16 Which of the following options best describe the courses that you teach (select as many options as apply to you):

a) I teach theoretical course/s
b) I teach technical course/s
c) I teach practical/industry-focused course/s
d) I teach project based course/s

e) I teach first year course/s
f) I teach second year course/s
g) I teach third and fourth year course/s
h) I teach postgraduate course/s

i) I teach to very large class sizes (more than 500 students)
j) I teach to large class sizes (more than 200 students)
k) I teach to medium class sizes (50-100 students)
l) I teach to small class sizes (less than 50 students)

m) I teach to primarily on-campus classes
n) I teach to primarily online classes
o) I teach to classes that are a mix of on-campus and online modes

Number of responses: 57

Total numbers of each type of course			
Theoretical courses	22	Practical courses	40
Technical courses	28	Project based courses	30

Types of courses taught (a-d)	
theoretical only (a)	3
technical only (b)	3
practical only (c)	10
project based only (d)	6
theoretical and technical (a & b)	5
theoretical, tech, practical (a, b & c)	2
theoretical and practical (a & c)	3
theoretical, tech and project based (a, b & d)	2
technical, practical, project (a, c & d)	5
all four (a-d)	5
practical and project based (c & d)	7
technical and practical (b & c)	4
technical and project (b & d)	1
theoretical, practical and project (a, c & d)	1

Teaching mode (m-o)	
on-campus only (m)	35
online only (n)	4
mix only (o)	15
on-campus and online (m & n)	1

on-campus and mixed (m & o)	1

Q20 Prior to entering academia as an engineering educator, how many years of experience with teaching did you have?

Number of responses 62

Number of years of teaching experience prior to entering academia	
1-2 years	37
3-5 years	12
6-10 years	5
11-20 years	6
20+ years	2

Q21 Do you have any formal training or qualifications in teaching?

Number of completed responses: 62

Yes: 24 No: 38

Q22 If you answered yes to the above question, please give details of this training/qualification:

Type of Qualification	
Graduate or Postgraduate Certificate in Higher Education	16
¨Introduction to tertiary teaching semester long course and a variety of short courses¨	1
¨UK Fellowship of the Higher Education Academy (joined as a Member for the former Institute for Learning & Teaching in Higher Education by the experience appraisal and portfolio route).¨	1
¨Bachelor Education (4 years inservice) / certificate 4 in training and assessment¨	1
¨(dont laugh) .. PG in secondary art education , teaching English as a foreign language (cert), MA language in education¨	1
¨Dip. Ed and Master of Education¨	1
¨Undertook a PhD with a very significant component being education it's theory and application in engineering¨	1
¨A range of courses organised by Universities to upgrade/update/develop this category of qualification¨	1
¨Dip Ed¨	1

Q23 If you would like to make any extra comments about the above questions or responses, please do so here:

Comment by respondent	**Themes/Topics**
Appointments to the university are based on research publications and research area, not on teaching excellence. Teaching excellence is a personal aim, and fitted around the other responsibilities	Value for research above teaching
The biggest difficulty is the lack of clarity of what is expected of me, so I cannot end my day feeling "I have succeeded at what is expected".	Nature of position – rewards for performance
I have worked for 5 years with professional education researchers. This is unusual, and has significantly improved my teaching skills... continuing education/professional development.	Teaching experience/ expertise

Since becoming a lecturer I have attended many workshops/seminars on different aspects of teaching which has been supplemented by reading and lively discussion with colleagues (at my institution and elsewhere) on aspects of teaching.	Teaching experience/ expertise
Taught part-time for 15 years before commencing full-time academic career.	Teaching experience
/ Missing was the 100-200 class sizes.	Problem with survey
No formal quals in teaching but I did much training when as an Army Engineer officer (CMF) and also as a Leader Trainer in Scouts Australia.	Teaching experience
Bachelor in education was attained 22 years ago and I am back at university completing a grad dip in teaching to update my knowledge and skills	Teaching experience
It was difficult to answer the previous questions regarding the average number of hours spent on teaching with any precision - it varies greatly week- to-week and semester-to-semester, and some teaching-related activities were not listed and/or it was unclear where they should be grouped (e.g. exam/assessment preparation, marking, tutor supervision, etc).	Problem with the survey
my on-line course had 3 million hits last year...	Teaching experience/ expertise
I bring an understaning of language and genres and how they work and the academic brings an understanding of the field and what is essential and togetter we work out how best to explain and support out students.	Teaching experience/ expertise
It amazed me when I started teaching that I didn't need any qualifications other than a degree in the area that I would be teaching. It still baffles me that this is still the case!	Value for teaching
"Previous experience of teaching" = tutoring (high school or undergraduate students)	Teaching experience
Some of the above courses (organised by University) were of a quite poor quality.	Value for teaching

Q24-30 Ranking lists for Tasks, Goals and Indicators of Success

Number of complete responses received: 40

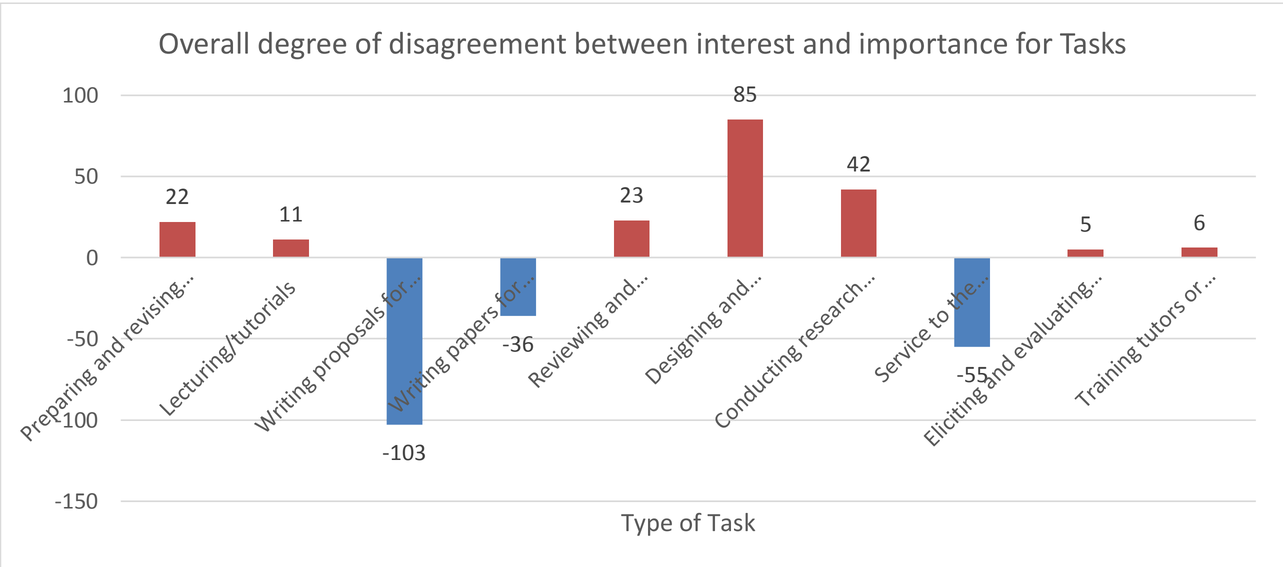
Tasks

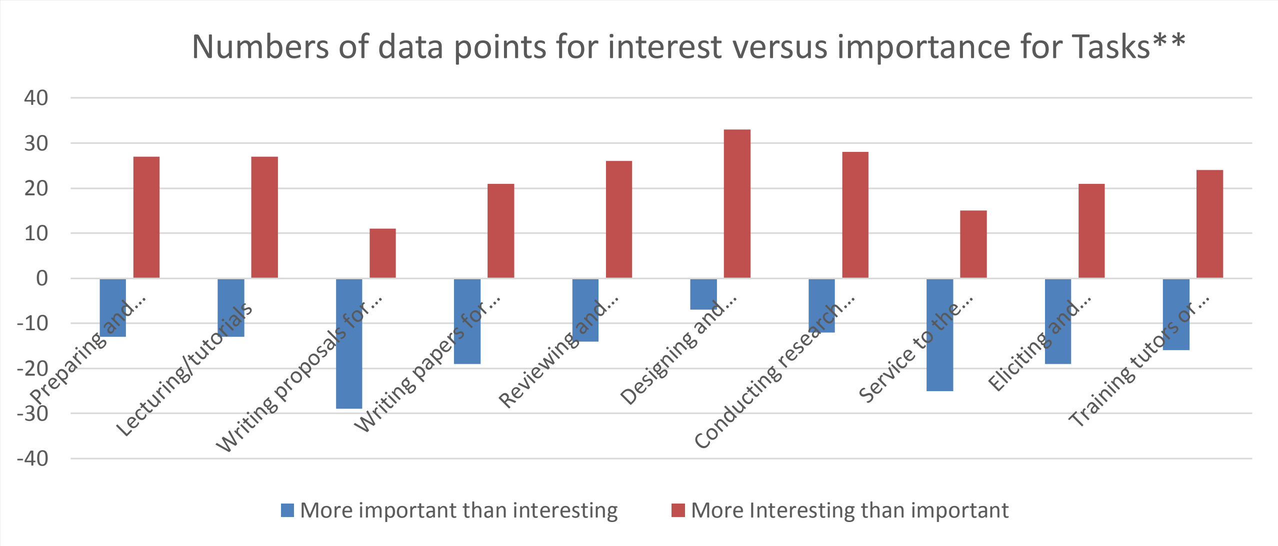
Degree of overall agreement/disagreement between interest and importance for Tasks			
Number of data points that fall on diagonal line (showing strong agreement between interest and importance)	64	16%	36.25 %
Number of data points that fall within one point of diagonal line (showing agreement between interest and importance)	92	20.25%	

Degree of agreement/disagreement between interest and importance for each Task							
Task	Disagreement score (Interest minus importance)*		Number of data points on line of agreement	Percentage of data points on line of agreement	Number of data points within one point of line of agreement	Percentage of data points within one point of agreement	Total agreement percentage
	More **interesting** than important	More **important** than interesting					

Preparing and revising lectures/teaching activities	22		3	7,5%	14	35,0%	42,5%
Lecturing/tutorials	11		11	27,5%	11	27,5%	55,0%
Writing proposals for grants		-103	5	12,5%	4	10,0%	22,5%
Writing papers for publication		-36	10	25,0%	13	32,5%	57,5%
Reviewing and improving existing courses	23		7	17,5%	9	22,5%	40,0%
Designing and developing new courses	85		5	12,5%	2	5,0%	17,5%
Conducting research	42		6	15,0%	5	12,5%	27,5%
Service to the faculty/school		-55	4	10,0%	4	10,0%	20,0%
Eliciting and evaluating feedback from students	5 (neutral)		4	10,0%	8	20,0%	30,0%
Training tutors or teaching staff	6 (neutral)		9	22,5%	12	30,0%	52,5%

* arrived at by subtracting importance score from interest score for each participant´s response to each Task on the list and adding all scores together to show overall degree of interest versus importance





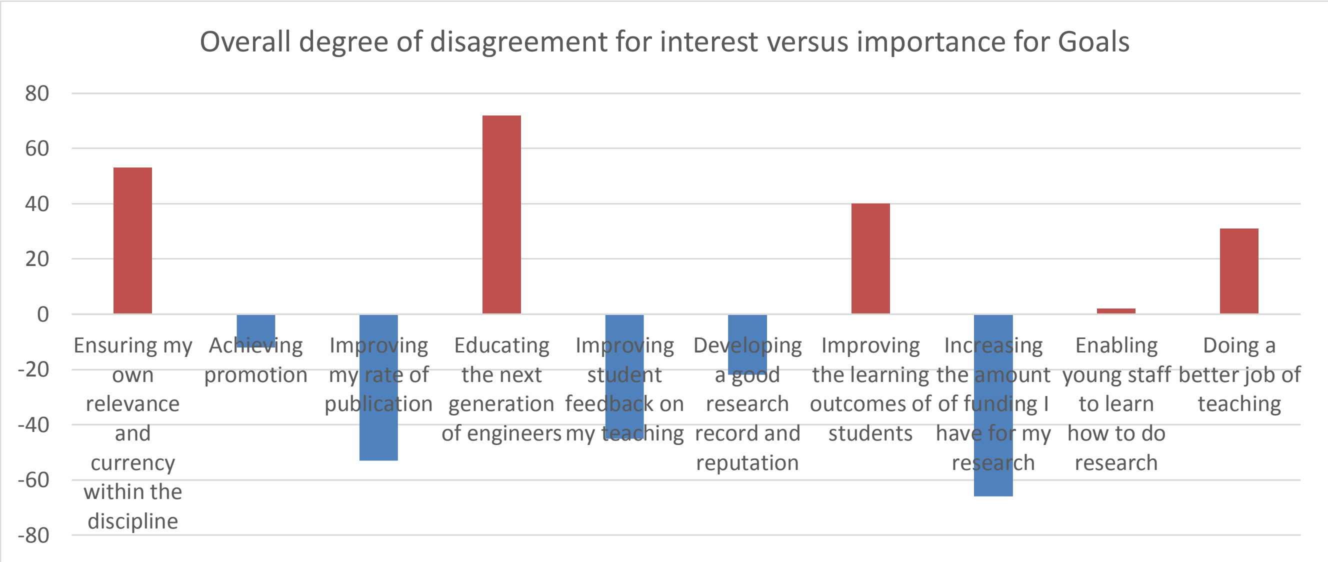
** Arrived at by adding total numbers of scores of more interesting than important, and more important than interesting for each Task on the list

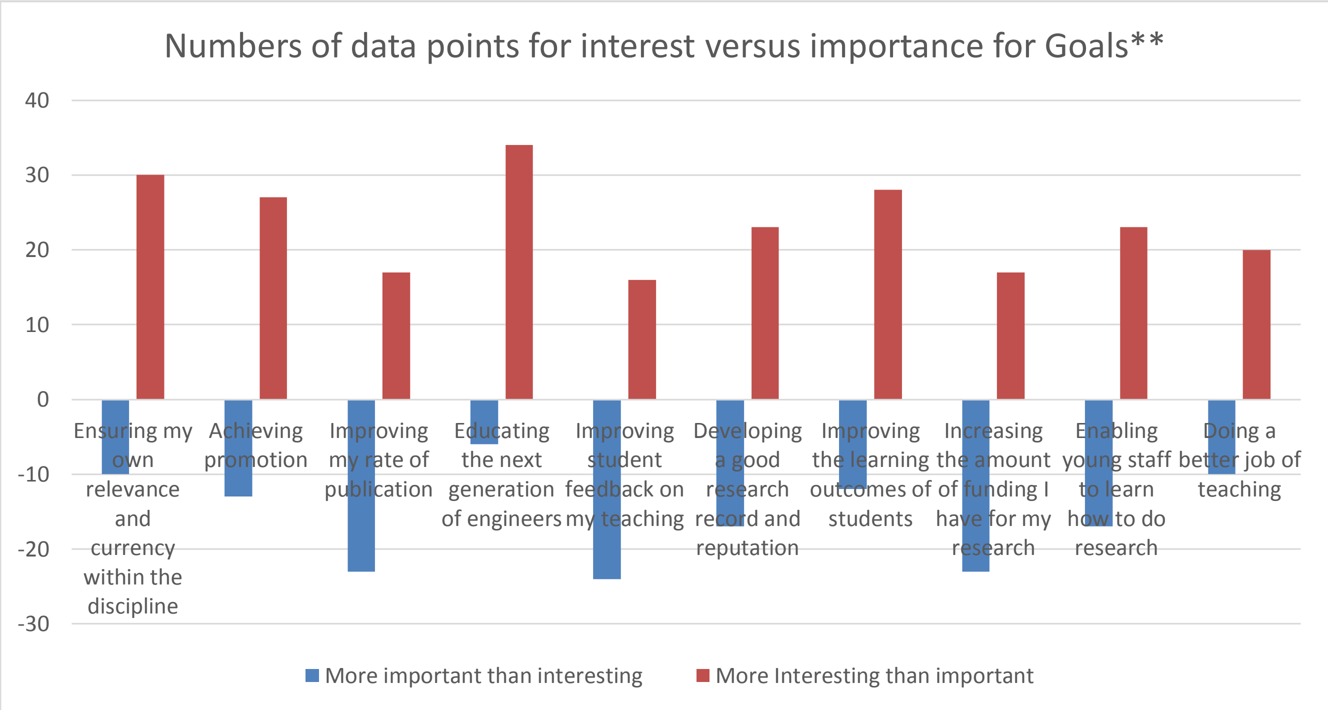
Goals

Degree of overall agreement/disagreement between interest and importance for Goals								
Number of data points that fall on diagonal line (showing strong agreement between interest and importance)			109	27,3%	46.8%			
Number of data points that fall within one point of diagonal line (showing agreement between interest and importance)			78	19,5%				
Degree of agreement/disagreement between interest and importance for each Goal								
Goal	Disagreement score (Interest minus importance)*		Number of data points on line of agreement	Percentage of data points on line of agreement	Number of data points within one point of line of agreement	Percentage of data points within one point of agreement	Total agreement percentage
	More **interesting** than important	More **important** than interesting					
Ensuring my own relevance and currency within the discipline	53		10	25,0%	6	15,0%	40,0%
Achieving promotion		-12	20	50,0%	6	15,0%	65,0%
Improving my rate of publication		-53	8	20,0%	8	20,0%	40,0%
Educating the next generation of engineers	72		11	27,5%	6	15,0%	42,5%
Improving student feedback on my teaching		-45	7	17,5%	11	27,5%	45,0%
Developing a good research record and reputation		-22	9	22,5%	12	30,0%	52,5%
Improving the learning outcomes of students	40		10	25,0%	7	17,5%	42,5%

Increasing the amount of funding I have for my research		-66	12	30,0%	3	7,5%	37,5%
Enabling young staff to learn how to do research	2 (neutral)		11		27,5%	27,5%	55,0%
Doing a better job of teaching	31		11	27,5%	8	20,0%	47,5%

* arrived at by subtracting importance score from interest score for each participant´s response to each task on the list and adding all scores together to show overall degree of interest versus importance





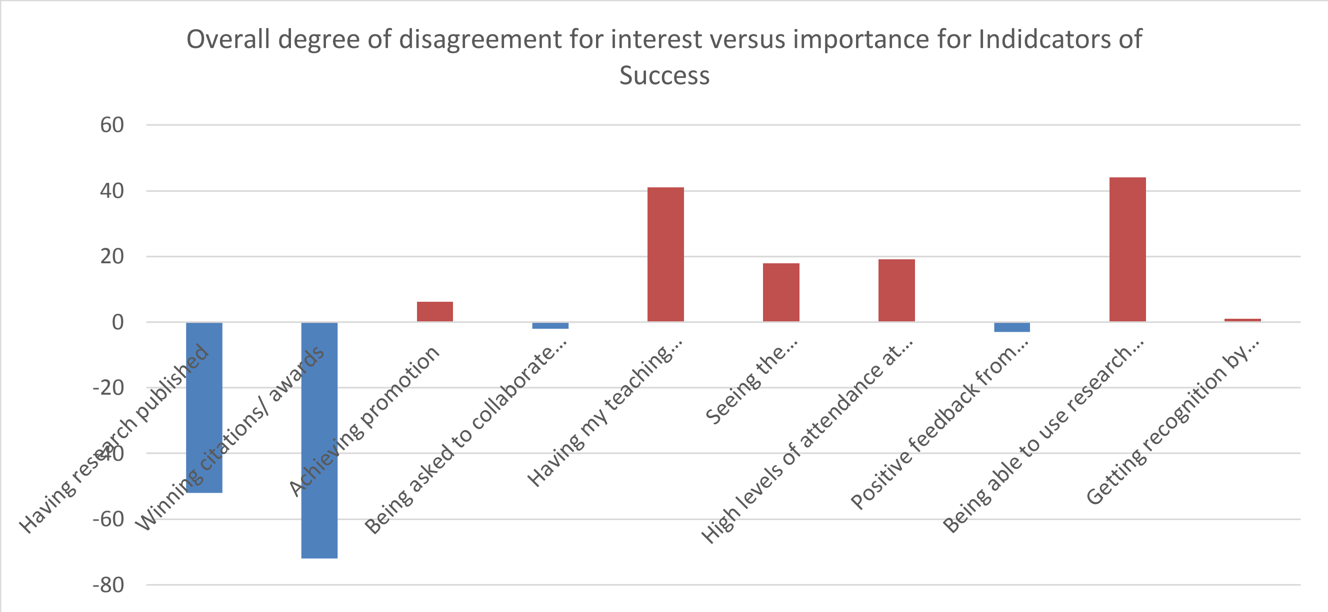
** Arrived at by adding total numbers of scores of more interesting than important, and more important than interesting for each Goal on the list

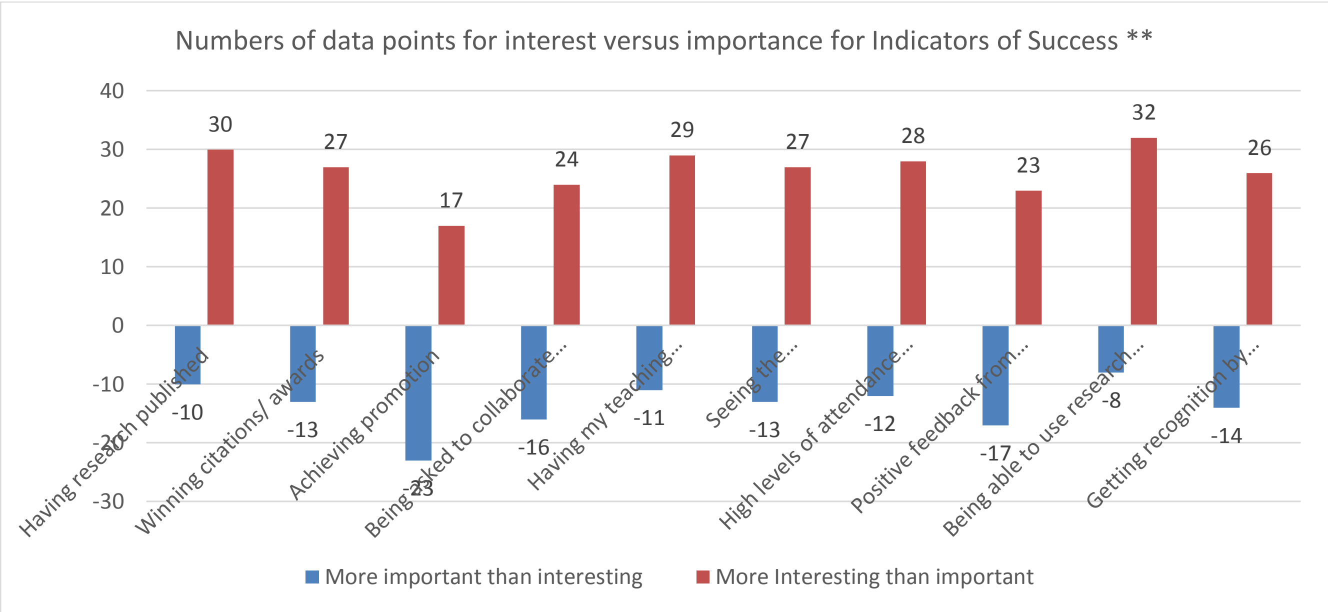
Indicators of Success

Degree of overall agreement/disagreement between interest and importance for Indicators of Success			
Number of data points that fall on diagonal line (showing strong agreement between interest and importance)	127	31,8%	47.5%
Number of data points that fall within one point of diagonal line (showing agreement between interest and importance)	63	15,8%	

Degree of agreement/disagreement between interest and importance for each Indicator of Success							
Indicator of Success	Disagreement score (Interest minus importance)*		Number of data points on line of agreement	Percentage of data points on line of agreement	Number of data points within one point of line of agreement	Percentage of data points within one point of agreement	Total agreement percentage
	More **interesting** than important	More **important** than interesting					
Having research published		-52	13	32,5%	6	15,0%	47,5%
Winning citations/ awards		-72	13	32,5%	5	12,5%	45,0%
Achieving promotion	6		20	50,0%	5	12,5%	62,5%
Being asked to collaborate on research projects or publications	-2 (neutral		11	27,5%	9	22,5%	50,0%
Having my teaching innovations or pedagogies taken up elsewhere	41		11	27,5%	10	25,0%	52,5%
Seeing the outcomes/findings of technical research being used for industrial applications	18		13	32,5%	7	17,5%	50,0%
High levels of attendance at lectures/ teaching sessions	19		14	35,0%	7	17,5%	52,5%
Positive feedback from students on my teaching	-3 (neutral)		7	17,5%	5	12,5%	30,0%
Being able to use research activities to inform teaching activities and vice versa	44		10	25,0%	5	12,5%	37,5%
Getting recognition by professional engineering societies	1 (neutral)		15	37,5%	4	10,0%	47,5%

* arrived at by subtracting importance score from interest score for each participant´s response to each task on the list and adding all scores together to show overall degree of interest versus importance





** Arrived at by adding total numbers of scores of more interesting than important, and more important than interesting for each Indicator of Success on the list

Appendix G – Summary of program of innovation at university for Case Study B

[*Name of program*]: What is it exactly?

	Earlier ways	[name of program]
[Name of Program] Curriculum Design		
Learning at [name of uni]	Practice-oriented learning	[name of uni] Model of Learning: practice-oriented, global and research-inspired
What is important	What students know	What students can do with what they know and how they do it
Subject design	Dot point list of content	Linking 'what students can do with what they know' to objectives -> learning activities and assessment
Graduate attributes	Largely not identified or included	Faculty or course-specific attributes identified, embedded and assessed
What students experience		
Learning activities	Primarily lectures, with tutorials, labs or studios, with [name of uni Blackboard page]	Best of online learning combined with best of face-to-face collaborative learning with [name of uni Blackboard page] engagement
Learning resources	Notes from class, readings from Library and textbooks	Podcasts, screencasts, YouTube, Open Education Resources, online learning resources, readings and digital resources from Library, social media and textbooks
On campus learning experience	Primarily lectures and tutorials, structured labs, individual studios	Primarily collaborative learning activities. Some lectures/ guest presentations, inquiry-based and research labs and studios
Off-campus learning experience	Assignments, studying for exams with [name of uni Blackboard page] engagement	Engaging in 'real-life' experiences including work placements, community projects, competitions. Preparing for on-campus learning including engaging with podcasts, online material, pre-readings, online tutorials, and engaging in group work, doing assignments, undertaking research.
Assessment	Exams – Focus on "What can you remember?" Assignments	Authentic activities designed to elicit "What can you do with what you have learned?"
Feedback	Lecturer and tutor feedback on completed work.	Diagnostic feedback. "Benchmarking" and discussion of criteria. Feedback on draft work. Lecturer, tutor and peer feedback. Self-assessment and reflection.
Student support		
Transition to university	Orientation before week 1, peer support	Orientation. Transition support during semester. Numerous "First Year Experience" project outcomes, Peer support