Troublesome or Threshold?

The experience of difficult concepts in prosthetics

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Abstract

This thesis explores what is experienced as difficult, and potentially threshold, concepts in prosthetics. Prosthetics and orthotics education is an under-researched area and this research assists in filling this gap. Consideration is given to the reasons why students have difficulties in learning certain concepts. Attention is also given to why every student does not experience the same concepts as difficult, another under-researched area.

Using Interpretative Phenomenological Analysis as both methodology and data analyisis method, with interviews and questionnaires with staff and students for data collection, five difficult concepts were identified in prosthetics. Two concepts are suggested as troublesome but not threshold and three suggested as threshold concepts.

Curriculum design is suggested as an additional form of troublesome knowledge affecting students' engagement with, and their perception of the relevance of a concept to their discipline. Tacit troublesome knowledge is much broader than the episteme of a discipline including mental images, memories, and shortcuts taken by experts. The variation in what is found difficult and by whom is suggested as being due to differences in the prior experience of students. In order to differentiate threshold concepts from other concepts it is suggested that they require both integration and ontological transformation together with procedural concepts and associated contextualised memories, and disciplinary concepts.

Several implications for practice are suggested. Curriculum design should be considered, especially for supporting concepts, with learning experiences contextually appropriate for the students' discipline, an important consideration for multi-disciplinary modules. Due to differences in prior experience, learning activities should be created which both enable students to get to the starting point for the acquisition of, and then further develop their understanding of the threshold concept. Finally further research into threshold concepts should consider a whole programme approach including both staff and students.

Declaration

This thesis results entirely from my own work and has not been offered previously for any other degree or diploma.

Sophie Hill Date

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Whilst I was at school my dad taught me the importance of referencing and my mum sat me in front of a typewriter with a teach yourself to touch type book. Perhaps they saw something in my future that I did not. I am grateful for these very useful skills they instilled in me and their support.

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Publications and presentations derived from work on the Doctoral Programme

Hill, S. (2006). “Knocking at the door: how students enter a professional community of practice”, *Society for Research into Higher Education Postgraduate Conference*, December 2006, Brighton

Hill, S. (2009). “Theories of difficulty: can they help explain the areas that students find problematic*?”, Education in a Changing Environment Conference*, University of Salford, 15th & 16th September 2009

Hill, S. (2009). “Knocking on the door: how do students enter the disciplinary community of practice?”, *Education in a Changing Environment Conference*, University of Salford, 15th & 16th September 2009

Hill, S. (2010). “Troublesome knowledge: why don’t they understand?”, *Health and Libraries Information Journal*, 27, 80 - 83

Hill, S. (2010). “Learning to talk: A threshold concept?”, *Third Biennial Threshold Concepts Symposium; Exploring transformative dimensions of threshold concepts*, The University of New South Wales in collaboration with the University of Sydney, Sydney, Australia, 1 - 2 July 2010

Hill, S. (2010). “What do prosthetics and orthotics students find difficult?”, *Norsk Ortopediingeniørers Forening Høstmøte,* Stavanger, Norway, 6 – 7 November 2010

Hill, S. (2011). "Knocking on the door: how do students enter the disciplinary community of practice?", in E. O'Doherty, (ed.), *The fifth education in a changing environment conference book 2009: Critical voices, critical times*. Santa Rosa, CA: Informing Science Press

Table of contents

List of Tables

1. Introduction

1.1 Introduction

This piece of research arose from a discussion with another PhD student who was aware of initial threshold concepts research, and the fairly regular conversations between colleagues and myself about students who misunderstood concepts that seemed obvious to us. This thesis is a continuation of these conversations. I wanted to explore why these misunderstandings occurred. Were the things which students found difficult the same as those which lecturers thought they found difficult and why did these difficulties arise? Why did some students struggle with a concept which others found easy? What were the consequences of these misunderstandings? Could the notion of threshold concepts explain why such difficulties occur?

1.2 Context of the study

Prosthetics and orthotics is an allied health profession. Originally two separate professions in the UK, they have, since the development of diploma/degree courses come together as one profession. However in practice due to historical and contractural arrangements within the National Health Service (NHS) clinicians generally work in either prosthetics or orthotics. Prosthetists work with people who require a prosthesis (artificial limb) due to being born without a limb or having an amputation due to disease or trauma. Orthotists work with people who need part of their body protected, supported or

corrected using an orthosis (splint, brace) due to trauma, disease, or a medical condition. Prosthetists/orthotists assess the person, diagnose their funtional requirements and prescribe the appropriate prosthesis or orthosis. They then provide prosthetic or orthotic management for the person involving measurements, taking a mould of the appropriate body part, and fitting and adjusting the prosthesis/orthosis once manufactured.

Today a Bachelor of Science degree with Honours in prosthetics and orthotics is required for someone to be eligible to register with the Health Professions Council (HPC) and therefore to practice in the UK. The first combined course for prosthetists and orthotists in the UK began in 1973 as a Higher National Diploma at the Univerisity of Strathclyde. In 1986 this was replaced by a Bachelor of Science Honours Degree. In 1992 a Bachelor of Science Honours Degree was set up at the University of Salford, replacing separate prosthetics and orthotics higher national diploma level courses run at the City of Westminster College and the diploma for clinical practice from the Orthotics and Prosthetics Training and Education Council. Both degree courses were until recently four years in length, with three years based at the university spending time on theory and supervised clinical practice with volunteer service users. In the final fourth year of both programmes students enaged in clinical practice within a hospital setting with “real” service users. Two placements were undertaken in the fourth year, one in prosthetics and the other in orthotics, both six months in length.

The old four year courses are in the process of being run out at both universities. They have been replaced by a shorter four year programme at the University of Strathclyde (four academic years) with two four-month placements, one in the third year and one in the fourth year, though both are at level 10 on the Scottish Credit and Qualifications Framework. At the University of Salford, the four year programme has been replaced by a three year programme with two two-week placements in year one, two seven-week placements in year two and in third year there are two eight-week placements. There are also other changes that have been made to both courses in terms of the modular structure and some changes to the content related to practice in the 21st centuary. Both universities have some teaching led by non-prosthetists/orthotists. In addition at one university some modules are service taught at another institution.

Across the world there are a variety of entry level courses to become a prosthetist/orthotist. These include undergraduate degrees, post-graduate diplomas and masters degrees. The International Society of Prosthetics and Orthotics (ISPO) specifies that there are three levels of education and practice within the field. These are prosthetist/orthotist (category one), orthopaedic technologist (category two) and prosthetic/orthotic technician (category three). According to ISPO (2010) the attainment of prosthetist/orthotist as the level of education and training is the ultimate goal to be achieved in all countries across the world. However orthopaedic technologist is an acceptable step towards this goal in developing countries. Prosthetic/orthotic technicians work manufacturing the prostheses and the orthoses that the prosthetists and

orthotists prescribe, but unlike prosthetists/orthotists have no patient contact. Orthopaedic technologists fall somewhere between the two other categories, working with patients. Within the context of this study the level of education and practice is prosthetist/orthotist (category one).

1.3 Description of the study

In this study I explore people's experience of difficult concepts within prosthetics. I explore both the students' experience of what is difficult and what staff experience that students find difficult. This study does not seek to investigate whether conceptions or approaches to learning or teaching play a role in whether concepts are difficult. Nor does it seek to identify ways of making specific difficult concepts easier. It does seek to explore some of the reasons behind the difficulties and why not all students find the same concepts difficult.

Prosthetics and orthotics is a hard/applied discipline (Biglan 1973). Most of its research is based in the science and engineering traditions, with little qualitative research conducted. Within this thesis I take a qualitative Interpretive Phenomenological Analysis (IPA) approach (Smith and Osborn 2003). Therefore this piece of research in the context of prosthetics steps outside its traditional, disciplinary boundary and expands the limited research base of prosthetics education. IPA allows exploration of people's experiences of a phenomenon, and also acknowledges that both the participants and the researcher interpret the experiences. This methodological approach shapes

my exploration of the difficulties in prosthetics and also my approach to data analysis.

There are only two courses in prosthetics and orthotics in the UK, with participants recruited from both courses, effectively targeting the whole population. Initially I had hoped to consider difficulties in both prosthetics and orthotics. However, this would have become unmanageable in terms of size for this piece of research. This meant that I limited the staff interviewed to those who taught prosthetics, excluding those teaching orthotics. Student participants came from all four years of each programme. They were asked to focus on their experiences of difficulties in learning prosthetics. Data was collected using semi-structured interview and emailed questionnaires. It was then analysed using guidance from IPA literature. I did not adopt an action research approach as this requires practice to be evaluated, changes implemented and then evaluated again. This would have been difficult to do as I have no control over the individual practices of colleagues. Due to the time frame longitudinal research with a group of students as they progress through the courses was not possible, but provides opportunities for further research.

The overarching aim of the study is to explore difficulties in studying prosthetics and asks three research questions:

1. What is experienced as difficult, and potentially threshold, concepts in prosthetics?

2. What can help explain the possible reasons for the difficulties which students have with these concepts?
3. Is there variation in student's perception of what is difficult? If so why?

1.4 Significance of this study

Unlike other health care profession education there is very little research evidence available with regards to prosthetics and orthotics education. Therefore this study starts to fill a large gap in the research. There is also very little exploration within the literature on why difficulties in learning concepts occur and why they are not experienced by all students. Here I explore additional types of troublesome knowledge to those already suggested. My research also contributes to the growing research on threshold concepts and how they differ and can be differentiated from other concepts.

1.5 An "insider"

Making your perspective and prejudices as a researcher explicit is recommended (Patton 2002), though there may be some that remain unconscious. The role of the researcher within the interpretation of the data is recognised within IPA (Reid et al. 2005; Smith and Eatough 2007), so in order to acknowledge my perspective and its' possible influence I have tried to summarise my perspective as truthfully as I can.

I was a student at the University of Strathclyde. As a student there were some elements of the prosthetics and orthotics programme that I found difficult. I remember specifically struggling with beams and springs in mechanics and biomechanics. I remember that whilst I did pass the January examination for this module in year one, I did not pass well, and this was probably the subject that I found most difficult. Otherwise I found that I picked up concepts fairly easily, though sometimes I needed time to assimilate the information and form my perspective.

I am naturally quite quiet but I have learnt to talk to people who I do not know and perhaps now this quietness does not often come across. During the first summer term (at the time I was a student the P&O course had four terms) my non-P&O friends were away from the university, and during this period we had to meet and deal with people with amputations for the first time. Through having to ask people with amputations questions to obtain information and build up a relationship with them and also living in halls with a variety of different people over the summer I learnt to talk with people.

As a lecturer I identify that there are some concepts that I find easy to understand but which some students find difficult. Sometimes when reading exam answers I wonder if they had been in the same class that I taught, especially when they come out with weird and wonderful answers. I have discussed with colleagues why students muddle up weight bearing and suspension concepts and when and why this misunderstanding occurs. I have noted that students find that developing a rationale behind a prosthetic

prescription problematic and it is, perhaps, interesting to note, that whilst this is an everyday aspect of clinical practice, it was not one that I was taught. I have therefore tried to find ways for students to explore prescriptions with a focus on the person rather than on the components of the prosthesis, which is their tendency. My perspective on this problematic area certainly influenced one of my interview questions as I wanted to explore how a prescription scenario was solved by students and staff.

Although I did not have a pre-conceived hypothesis, I did "wonder if?" For instance I did wonder if the students identified weight bearing and suspension as difficult. Was it just theoretical aspects of the course that they found problematic or were there also practical aspects that caused difficulties? I also wondered if the different and varied backgrounds of the students influenced what they might identify as problematic. I concur that some of these perspectives may have an influence on how I interpret participant's experiences, however IPA acknowledges that influence. Without these perspectives I might never have considered this area for my thesis.

1.6 Structure of the thesis

In this chapter I have outlined the scope and focus of this thesis. I have indicated the contribution to prosthetic and orthotic and educational research that I make, the need to look further into why difficulties occur in learning concepts and why they are not experienced by everyone. My perspective as

an insider has also been considered, reflecting on my experience of difficult concepts both as a student and a lecturer.

In the second chapter I begin by exploring the literature on prosthetic and orthotic education. I continue drawing upon literature on professional socialisation, moving on to the literature surrounding troublesome knowledge and threshold concepts. In exploring the idea of liminality I consider how a concept can be understood in different ways.

In the third chapter I explore the methods and methodological approaches used in threshold concepts research. I discuss my methodological approach of Interpretive Phenomenological Analysis and why I feel it is suitable for researching difficulties in prosthetics. I describe the data collection methods used and the analytical approach based on guidance from Interpretive Phenomenological Analysis, before considering some issues relating to my research approach.

I present my findings within the fourth chapter. Here I suggest that there are five difficult concepts within prosthetics and that three of them are possibly threshold. I consider each difficult concept under the same headings, exploring why these aspects may cause difficulty for students and whether the concept is threshold or only troublesome.

Within the fifth chapter I discuss my findings in relation to the literature. I suggest that explicit relevance and appropriate contextualised application is

essential to encourage students to engage with the concepts. The ability for this to occur may be linked to whether the lecturer is from the students' discipline or not. Whilst tacit troublesome knowledge has already been suggested I suggest that it is bigger than the episteme and includes other tacit information. Everyone has previous knowledge from various sources but the role of this in learning concepts has not been explored with a focus on difficult concepts. This variation in prior knowledge may help to explain the variation that it is suggested occurs when learning or about to learn a threshold concept.

In chapter six I explore what my findings say about how threshold concepts are different from other concepts, and how we can use the criteria model and the concept model together to explain and identify them.

Finally I conclude this thesis reiterating my aims in this research. I summarise my findings and my discussion. I explore the limitations of my research and suggest further areas of work that could be progressed before suggesting some implications for practice.

2. Difficulties, thresholds, differences and development

2.1 Introduction

Learning should challenge learners, enabling them to continually develop. Barnett states that

> *"…the student is perforce required to venture into new places, strange places, anxiety provoking places. This is part of the point of higher education. If there was no anxiety, it is difficult to believe that we could be in the presence of a higher education."*
>
> (Barnett 2007 p147)

Lecturers, by acknowledging the new, strange and anxiety producing places in learning and the associated difficulties, may be better able to support students in their passage through them. However, in order to do this the difficulties in content knowledge should be identified before moving onto consider why these concepts prove challenging for some students. Whilst some difficulties may be due to factors over which lecturers have no control, acknowledging these factors could be used to inform the support of students through problematic concepts. Other difficulties may be due to pedagogical, epistemological and ontological reasons on which lecturers may be able to have an impact. Previous research has identified that attention should be brought to the content knowledge challenges that students face (Anderson and Hounsell 2007; Lenze and Dinham 1999; Shulman 1987). Perkins (1999; 2006; 2007) has highlighted the concept of troublesome knowledge and Meyer & Land (Land et al. 2004; Land and Meyer 2010; Meyer and Land 2003; Meyer and Land 2005; Meyer and Land 2006; Meyer et al. 2008) have

drawn attention to threshold concepts. My research aims to explore difficulties in studying prosthetics and asks the following questions:

- What is experienced as difficult, and potentially threshold, concepts in prosthetics?
- What can explain the possible reasons for the difficulties students have with these concepts?
- Is there variation in students' perceptions of what is difficult? If so why?

Unlike other health care courses there has been virtually no research exploring prosthetics and orthotics education, especially for courses enabling students to become prosthetists/orthotists. Therefore this piece of research adds to a significant gap in research on prosthetics and orthotics. Threshold concepts research acknowledges that there is variation in understanding before, during and after a threshold concept has been introduced to learners. Research from other areas shows that there are different ways of understanding a concept between novices and experts. Previous research has also identified that there are different ways of understanding the same concept between experts in different disciplines. Whilst this variation in understanding is acknowledged the reasons for this variation have not been explored. My research combines these areas of literature to explore some aspects of variation amongst learners, whilst also seeking possible reasons for this variation.

Only some of the existing research on threshold concepts has explored both staff and student perspectives and my research seeks to explore both staffs'

and students' experience of difficult concept in prosthetics. There is literature on conceptions of learning (Marton and Säljö 1984; Säljö 1979) and teaching (Dall'Alba 1990; Kember and Gow 1994), and approaches to learning (Entwistle and Ramsden 1983; Marton and Säljö 1976a; Marton and Säljö 1976b) and teaching (Trigwell and Prosser 1996) and the approaches and conceptions of individuals may affect whether a concept is difficult or not. However this is not the focus of my research.

In this chapter I first consider the literature on prosthetics and orthotics education. Secondly I explore professional socialisation and its impact on teachers and learners. Thirdly I consider troublesome knowledge. I then finish by exploring threshold concepts including the notion of liminality and variation in ways of understanding a concept.

2.2 Prosthetics and orthotics education

In relation to pedagogical theory the discipline of prosthetics and orthotics is virtually untheorised and there is a lack of educational research. The literature is historical (Hovorka et al. 2002a; Hughes 1992), describes courses, syllabus requirements or revisions (Barringer et al. 1993; Fishman 1977; Hovorka et al. 2002b; Hughes 1978; International Society of Prosthetics and Orthotics 2001; International Society of Prosthetics and Orthotics 2002; International Society of Prosthetics and Orthotics 2004a; International Society of Prosthetics and Orthotics 2004b; International Society of Prosthetics and Orthotics 2010; Nielsen et al. 1987; Quality Assurance Agency for Higher Education 2001b;

Raschke and Ford 2002; Retzlaff 1992), focuses on prosthetics and orthotics education in the developing world (Heim 1995; Kheng 2008; Magnusson and Ramstrand 2009; Raab 1992), discusses the creation of an accessible curriculum (McMonagle et al. 2009), describes the inclusion of specific concepts and skills within the syllabus (Malas 2002; Ramstrand and Brodtkorb 2008; Wong 2007), describes the development of distance and open learning programmes (Lemaire 1993; Lin 2002; Simpson 2002; Wong et al. 2004) and describes other learning and teaching approaches (Kapp and Fergason 2002; Lusardi and Levangie 2002).

In addition there have been three conferences/meetings on prosthetic and orthotic education which have focused on syllabus content, delivery methods, entry level qualifications, the Bologna process, and continuing professional development (International Society of Prosthetics and Orthotics 2004a; International Society of Prosthetics and Orthotics 2004b; International Society of Prosthetics and Orthotics & Interbor 2007; Prosthetic and Orthotic Educators Meeting 2002). Legitimate peripheral participation in the prosthetics and orthotics community of practice (Lave and Wenger 1991) is explored by Hill (2011), demonstrating that students engage with the prosthetic and orthotic community of practice throughout a degree course. This previous literature is predominantly descriptive in nature and there is little empirical research into prosthetic and orthotic education. Little of the research focuses on student learning and the experiences of staff and students. In this research I focus on staff and students' experience of difficult concepts in learning prosthetics.

Bache (2008), whilst not focused on education, does explore an aspect of how prosthetists/orthotists practice, another under-researched area. Bache states that within the field of prosthetics and orthotics the human body and the prosthesis or orthosis are seen as separate entities as opposed to one system. Accordingly this means, he states, that the prosthesis or orthosis is the focus of the prosthetist/orthotist rather than the person's needs, the barriers to meeting these needs and how best to meet them. Bache has come to this conclusion because the literature on prosthetics and orthotics is focused on the replacement or correction of a body part and focuses on the biomechanics and technical aspects of prosthetics and orthotics e.g. different prosthetic feet, or the properties of different materials used and mainly ignores the person. Indeed the International Standards Organisation's definitions of prosthesis – *"an externally applied device used to replace wholly, or in part, an absent or deficient limb segment"* and of orthosis – *"an externally applied device used to modify the structural and functional characteristics of the neuromuscular and skeletal systems"* (International Standards Organisation 1989) define a prosthesis and an orthosis as separate to the person. What is not espoused in the literature is how prosthetists and orthotists think, how they focus on the person and what they consider when identifying a person's needs and considering how best to meet these needs. These are developed through the knowledge available within the literature and through personal, experiential knowledge developed through discussion and practice. Bache tries to verbalise this process through a conceptual framework he calls "prosthotology" based on goals and goal systems. It may be more easily

explored and explained through considering the “ways of thinking and practising” in prosthetics and orthotics. Overall there needs to be further research into how prosthetists and orthotists think and practice and in how we socialise students into the discipline.

2.3 Professional socialisation

Previously I have explored professional socialisation in prosthetics and orthotics through legitimate peripheral participation in a community of practice (Hill 2011). Part of studying a discipline involves learning to think and act like a member of that discipline or profession, with learners socialised into the profession and this has been explored for many professions. Previous research into higher education has labelled professional socialisation as the *“ways of thinking and practicing”* (Entwistle 2005 p67; McCune and Hounsell 2005 p255), *“epistemes”* (Perkins 2006 p42), the *“rules of engagement”* (Shulman 2005 p6), and *“legitimate peripheral participation”* in a community of practice (Lave and Wenger 1991 p29). Ways of thinking and practising cover anything that helps students to develop a sense of what it means to be a member of a disciplinary community. This includes not just forms of knowledge and understanding but also subject specific skills, the development of familiarity with the values, beliefs and attitudes (Anderson & Hounsell, 2007) and cultural rules (Gerholm 1985) and the shared repertoire, mutual engagement and joint enterprise (Lave and Wenger 1991). Specialist language, and the ways of thinking behind the language, makes the discipline impenetrable to outsiders (Becher and Trowler 2001). Entry to a discipline

requires a "*sufficient level of technical proficiency",* loyalty to the community and conforming to their norms (Becher and Trowler 2001 p47). Disciplinary membership involves a *"sense of identity"* and *"a way of being in the world"* (Geertz 1983 p155).

However progression into the ways of thinking and practising may not be smooth. Some of this process of professional socialisation is often tacit and does not receive direct attention, thus making it difficult for the students to grasp (Clouder 2005; Meyer and Land 2005). Disciplines tend to have a generic or stereotypical description. Disciplines are considered to have *"recognizable identities and particular cultural attributes*" (Becher and Trowler 2001 p44). This generic view is partially created by disciplinary myths which form part of the philosophy (Menec and Perry 1995; Taylor 1976). Becher & Trowler (2001) consider myths as part of Bourdieu's (1979) "*cultural capital*" and that this is akin to the hidden curriculum consisting of the disciplinary stories, the codes of practice and disciplinary conventions. The issue of the generic view of a discipline is that the variety within the discipline is lost. This variety includes specialisms and individual member differences. People outwith the discipline may see or experience the thing in a different way (Bowden and Marton 1998).

2.3.1 Professional socialisation and teaching

Clark (1987) found that academics identify most with their discipline, with their academic identity coming second. Disiciplinary ways of thinking and practicing

affect which features of a situation we see as critical to our field (Marton et al. 2004). A lecturer's personal beliefs about their epistemological, and teaching and learning assumptions will influence the context of their students (Bain et al. 1998). The ways disciplines are taught in higher education may affect those who go on to teach the subject at high school, in the way they approach and view the subject (Stodolosky and Grossman 1995). Thereby exacerbating myths and stereotypes of the subject (Menec and Perry 1995), with each discipline having "*signature pedagogies*" (Shulman 2005). Various studies have explored the differences in learning and teaching approaches between disciplines (for example see Ballantyne et al. 1999; Kemp and Jones 2007; Lenze 1995; Lindblom-Ylänne et al. 2006; Smeby 1996). Although the possible impact of being taught a subject by someone outside your discipline is mentioned (Association of British Neurologists 1995; Cox 1987; Flanagan et al. 2010; LeBard et al. 2009; Mitchell 1988) it is not explored in detail within the literature.

2.3.2 Professional socialisation and learning

As well as disciplinary differences amongst lecturers, differences have been found amongst students. Students in different disciplines have different ways of perceiving what it means to study in that discipline, and if they move away from this it could affect their motivation for study and performance (Breen 1999). Therefore the disciplinary way of thinking and practising should be communicated to students early in the course. Students of different disciplines have been shown to require different skills and ways of working (Neumann

and Becher 2002; Whitmire 2002). Greed (1991) found that people self-select into a discipline according to personality and background. Ylijoki (2000) found that the moral order of disciplines creates distinctive practices across disciplines. Menec & Perry (1995) found that there are “myths” about subject matter, for example that maths is hard, or that there are stereotypes regarding the type of person likely to study a particular discipline. The myths and stereotypes about a subject may place certain students “at risk” if they believe the myth or do not fit the stereotype (Menec and Perry 1995). Another area of difficulty, noted by Anderson & Hounsell (2007), is that a student’s engagement with disciplinary ways of thinking and practising will be mediated by their individual background, life experiences, existing knowledge and their attitude towards study. However, they do not explore this potential effect on engagement further. These differences between students, particularly in their backgrounds, may affect what students find difficult but this is not addressed in the literature. My research seeks to explore possible influences of a student’s background on what may be difficult and why.

Part of studying a particular discipline involves socialisation into its epistemology and ontology and ways of practicing. This may impact on the learning and teaching approaches within different disciplines. Students’ backgrounds may also affect their engagement with the socialisation into the discipline. The socialisation process may be troublesome due to who is facilitating the learning and also a student’s prior experience. I seek to explore if and how the background of both the lecturer and the student may influence the troublesomeness of difficult concepts.

2.4 Troublesome knowledge

Whilst the effect on troublesomeness of the background of teachers and learners has not been investigated, other types of troublesomeness have been suggested. Perkins (1999; 2006; 2007) identified that there are certain kinds of knowledge that prove difficult or “troublesome” for students. They may be troublesome because they may involve ritual, inert, conceptually difficult, alien (Perkins 1999; 2006; 2007), tacit (Meyer and Land 2003) or emotionally challenging (Cousin 2006) knowledge. Knowledge that is routine and can lack meaning is described as ritual e.g. historical dates. Material which we know and understand but do not actively use or make connections with other contexts is considered to be inert. Perkins (2007) suggests that if we fail to make a positive connection with the material and its use outside the classroom this material will become inert. Therefore context is important for learning. Some knowledge is simply conceptually difficult or complex with abstract concepts requiring more time to represent and explain (Donald 2002). There is also some knowledge that is alien to our understanding, coming from a different perspective to our own. Perkins (2007) provides examples of a person’s current belief system being at odds with the belief system expressed in the apparent alien knowledge, due to a difference in context. Perkins (2007) suggests that the tacit dimension is the episteme. However Perkins fails to consider that there may be other tacit dimensions, a factor that I explore in this research.

Research in other areas suggests possible examples of tacit knowledge, for example sometimes written explanations of concept do not provide enough

information to gain an understanding of a concept. If an image (picture, diagram, graph) is provided then this may allow learners to grasp a concept better than through words alone as the theoretical concept can then be seen (Resnick 1989) and the image can act as a retrieval cue for a concept (Gick 1985). This research suggests that images can assist learning but simply providing an image to the learner may not be sufficient and he or she may require many images to fully understand a concept. It is known that much knowledge held by professionals becomes tacit as they progress through from novice to expert (Benner 1984; Dreyfus and Dreyfus 1986; Eraut 2000; Schön 1983). For example Kuipers & Kassierer (1984) found that experts skip steps in the reasoning process compared to novices. This tacit dimension is difficult for experts to recognise and make explicit and again this may be one of the reasons behind the troublesomeness of some concepts. The emotional capital, the emotional "assets" which students bring with them, may be another reason why knowledge may be troublesome (Cousin 2006). A student's emotional capital may be insufficient or too variable to harness and enable them to deal with the knowledge. This is part of the student's background that may affect why certain concepts may be difficult for them. Six types of troublesome knowledge have been suggested; however there may be more explanations for why certain concepts appear to be troublesome for students and in this research I explore whether there are other types or causes of troublesome knowledge.

2.5 Threshold concepts

Threshold concepts have been suggested as providing a new way of viewing a concept. In order for the idea of threshold concepts to be useful they must be different from other concepts. They have been defined using two models: the criteria model and the concept model.

The idea of concepts within a discipline is not new. All disciplines have concepts that are an essential part of the discipline's curriculum. These are often identified as basic, core, key or fundamental to that discipline. Whilst key concepts in prosthetics and orthotics have previously been identified (International Society of Prosthetics and Orthotics 2002; Quality Assurance Agency for Higher Education 2001b), no research has explored what is difficult within prosthetics and orthotics or if there are any threshold concepts within the discipline.

Threshold concepts, in order to bring something new to the idea of concepts, need to be different from other concepts. Recently threshold concepts have gained attention and extended from education to the transformation of a nation (Kutsar and Kärner 2010). It appears to have sparked interest amongst academics as an alternative way to explore the pedagogical content knowledge of their subject.

Threshold concepts may provide an alternative to way of looking at the ways of thinking and practicing in disciplines (Davies and Mangan 2005). Due to their transformative nature, they may be involved in a change in identity and

their acquisition is part of "*joining a community*" (Davies 2006 p74) and this has acknowledged links with communities of practice (Land et al. 2004; Land and Meyer 2010; Meyer and Land 2005). They may also provide "*shape and structure to the subject*" (Davies 2006 p75), an overarching idea that integrates pieces of declarative knowledge and understanding. Perkins (2006) considers that threshold concepts can be troublesome not only because they may be conceptually difficult but also because they require the student to understand the underlying episteme of that discipline. Therefore threshold concepts may enable students and lecturers to "view" the course differently, giving a more holistic approach to the discipline. I consider how threshold concepts are defined before moving on to explore liminality and the literature on different ways of understanding a concept.

2.5.1 Criteria model

Meyer & Land (2003 p412) define a threshold concept as *"akin to a portal, opening up a new and previously inaccessible way of thinking about something"*. They consider that a student must understand or view the concept before they are able to progress their understanding in that subject. The change in understanding or view may be to do with the subject matter, the overarching view of the subject, or a world view. Meyer & Land (2003) suggest that there are five characteristics of a threshold concept: transformative, probably irreversible, troublesome, integrative and bounded. I have named this the "criteria model".

The transformative nature of a threshold concept enables the person to see something in a different way. A change of this nature has however been identified in other research in relation to what learning is. Within phenomenography learning is viewed as a change in the students state of awareness or the way they experience the concept (Pong and Marton 2001). Learning has also been viewed as a way of experiencing the world *"to help students to go beyond their experience, to use it and reflect upon it, and thereby change their perspective on it, and therefore change the way they experience the world."* (Laurillard 1993 p26). Bowden & Marton's (1998 p108) view is that *"learning implies a change in our way of seeing something"*. Saljo (1979) also suggests that part of learning is seeing in a different way. All of these views of learning share a transformative notion. Threshold concepts differ because it is the acquisition of a specific concept that transforms the way of seeing rather than learning in general. Meyer & Land (2003) suggest that threshold concepts have an irreversible nature; you cannot go back through the portal. This aspect of a threshold concept may be very difficult to confirm as it may be the continued use of the concept that equates to irreversibility. Lack of use may result in the concept becoming inert or being forgotten completely. Or it may be that the original concept is superseded or replaced by another concept within the discipline. The third characteristic, troublesome knowledge, has already been discussed (section 2.4). Threshold concepts are also considered to be integrative in that they link with and expose previously held knowledge. Meyer & Land (2003) also suggest that a threshold concept is bounded by other threshold concepts.

Whilst Meyer and Land (2003) suggest that there are five criteria for a threshold concept, they do not state how many of the criteria a concept must have in order to be threshold. Within the literature there is variation about which and how many criteria must be met in order to be a threshold concept. Meyer (2010 p205) states that "*Threshold concepts cannot be described as an essentialist, definitive list of characteristics*". Cowart (2010) states that a concept must meet all five of the criteria to be considered threshold. Park and Light (2010) state that they believe that there are two essential characteristics (integrative and transformative) and three associated concepts. Integration features as a factor in most threshold concept literature and is considered by some to be essential to then enable transformation of the student's view of the concept moving them along a trajectory from novice to expert (Ross et al. 2010; Taylor and Meyer 2010). Most research states that the threshold concept meets some but not all of the criteria. However, other research on threshold concepts does not consider how the threshold concept identified matches the criteria. O'Donnell (2010) questions all the criteria for a threshold concept due to the lack of definitiveness in the description of the criteria, and Rowbottom (2007) believes that the definition is too vague.

2.5.2 Concept model

Alongside the criteria model of threshold concepts, Davies & Mangan (2007) proposed a model for threshold concepts consisting of basic, procedural and disciplinary concepts. Davies & Mangan (2007) refer to both disciplinary and procedural as threshold concepts with procedural concepts being seen as

enablers to achieving the disciplinary concept. However, Shanahan et al (2010), Flanagan et al (2010) and Ross et al (2010) perceive Davies & Mangan's (2007) model as hierarchical starting with basic, then discipline and then procedural. Davies & Mangan (2010), in reviewing their model, explore the relationship between the different types of concepts emphasising that they view procedural concepts as the means to enable conceptual change leading to full understanding of discipline threshold concepts. In their model disciplinary threshold concepts are viewed as the way of thinking and the procedural concepts as the way of practicing within a discipline.

Essentially the criteria model and the concept model both suggest ways of differentiating threshold concepts from other concepts. Whether the two models can be combined and used together to help further differentiate threshold and other concepts has had little mention within the literature.

2.5.3 Liminality

Whilst these models provide possible ways of defining and differentiating threshold concepts they fail to explain why some students have issues with certain concepts and others do not. Meyer and Land (2006) have suggested that this is to do with variation and they suggest that there are four types of variation: pre-liminal, sub-liminal, liminal and post-liminal. Pre-liminal is defined as how a concept "comes into view" (Land and Meyer 2010). Sub-liminal is considered to be the tacit understanding of a concept which may be an everyday view of a concept (Land and Meyer 2010). Liminal variation

occurs whilst students are within the liminal space, the *"betwixt and between"* (Turner 1995 p95) where students may oscillate between understanding and not understanding. Finally there is post-liminal variation where people exit the liminal space (Land and Meyer 2010). Meyer & Land (2006) suggest that the everyday use, and the definition of the words or phrases used in describing or naming a threshold concept, together with the student's experience of the threshold concept affect how a student approaches and progresses through the concept.

There are other considerations that may affect students understanding of a threshold concept such as emotional capital (Cousin 2006) and their ability to manage a feeling of uncertainty (Savin-Baden 2006). The relationship between social, economic and cultural contexts and the students' learning may also provide reasons to explain the variation in students' progression and understanding (Bloomer and Hodkinson 2000). Lecturers can identify that students have difficulties due to affective barriers e.g. shyness, and their understanding of other languages (Lenze 1995), thus providing another possible element of pre-liminal variation. Scheja (2006) found that students perceptions of the teaching and learning environment has an impact on their understanding. He found that issues of workload, time management and wanting to "stay in phase" impacted on their learning. Coping strategies, such as copying or working together on individual tasks, or prioritising, were developed to deal with heavy workloads and time issues. Students who failed to keep up with the progress of the course "fell out of phase". Scheja suggests that as a result students understanding may be delayed due to a lack of time

to reflect. This delay in understanding may account for some of the variation amongst students in their understanding. Others have also noted that students' perception of relevance has an effect on their learning (LeBard et al. 2009; Orsini-Jones 2010; Quinnell and Thompson 2010). The existing literature fails to explore whether aspects of curriculum design have an impact on whether learning is troublesome. Whilst Resnik and Jensen (2003) suggest that prior knowledge and experience gained before education accelerates knowledge acquisition and integration, the remaining literature fails to consider the influence of prior learning and experience that students bring on whether a concept is troublesome.

2.5.3.1 Ways of understanding a concept

Meyer and Land (2006) suggest that there is oscillation between different understandings of a concept (liminal variation) that occurs whilst learning a concept and also variation at the exit point of the liminal space. Previous research in other areas has identified that there are different ways of understanding a concept and has questioned whether these different ways are alternative views or misunderstandings. In addition although students may have previously studied certain concepts their understanding of these concepts from prior experience may not be the same. However the literature lacks reasons why there may be this variation in understandings and the threshold concepts literature appears to assume that lecturers all have the same understanding.

Research has shown that there are qualitatively different ways of understanding a concept (Bowden and Marton 1998). These qualitatively different ways of understanding have been shown in many subjects, for example history and physics (Patrick 1998); the mole in chemistry (Tullberg 1998); accounting (Rovio-Johansson 1998); Newton's laws of force and motion (Clement 1982; McCloskey 1983; Resnick 1983); statistics and probability (Tversky and Kahneman 1982), simple electronic circuits (Cohen et al. 1983), information systems (Cope and Prosser 2005), the human respiratory system and aquarium systems (Hmelo-Silver et al. 2007). There are also differences in how experts in similar disciplines view the same concept dependent on their relationship to the discipline e.g. aquarium hobbyists and biologists (Hmelo-Silver et al. 2007), genetic counsellors and molecular biologists (Smith 1990), different kinds of tree experts (Lynch et al. 2000; Medin et al. 1997) and Pfundt and Duit (1994) have compiled a bibliography of studies describing alternative conceptions in science. There has also been research into everyday understandings of concepts or *"folk wisdom"* (Mameli and Bateson 2006 p155) within biology (see for example Bateson and Mameli 2007; Mameli and Bateson 2006). Therefore understanding of a concept may be bounded by how it is perceived and applied both within a specific discipline or in its everyday understanding. Two disciplines may need to understand the same concept but how they understand the concept may be different. Within the threshold concepts literature there are suggestions that the same concept may be threshold within one discipline, for example economics, but not another (Cousin 2009), threshold in one disciplinary school, where a discipline has different foci, for

example microeconomics and macroeconomics, but not another (Meyer et al. 2008) or threshold across several disciplines (Ross et al. 2010).

Within threshold concepts research variation in students' understanding of a concept has been explored (Ashwin 2008; Cope and Byrne 2006; Park and Light 2010; Reimann and Jackson 2006; Shanahan and Meyer 2006; Thomas et al. 2010). Other research has shown that the way of seeing or experiencing something has been shown to vary according to the level the person is within their discipline (for example Bowden and Marton 1998; Chi et al. 1982; DeGroot 1965; DeGroot 1966; 1979; Lesgold et al. 1988), so the level of the student may need to be considered when exploring their understanding of a concept. Students may hold the same conception as the teachers who taught them (Laurillard 1993; Patrick 1998; Rovio-Johansson 1998) but the literature does not explore whether the teacher's discipline, if different from the students, affects understanding. Understanding of a concept may be affected by the person's knowledge base. These knowledge bases are individual and developed through experience (Eraut 1994; Schön 1983) and may include words, pictures and diagrams (Hong and O'Neil 1992), symbols and definitions (Laurillard 1993; Säljö 1984), models of practice (Trede and Higgs 2008) and patient stories (Benner et al. 1992; Mattingly and Fleming 1994).

Other research has explored whether different understandings are wrong or alternative ways of understandings of a concept. They use a wide variety of terms to describe the differences between understandings: preconceptions (Clement 1982; Glaser and Bassok 1989), alternative conceptions (Hewson

and Hewsen 1984), naive beliefs (McCloskey et al. 1980), alternative frameworks (Driver 1983; Driver and Easley 1978), alternative credible views (Snow 1989) and naive theories (McCloskey 1983; Resnick 1983; Snow 1989). Whether these differences are wrong or simply different from each other, some of them have durability and explanatory power. These alternative conceptions may be *"deep seated and resistant to change"* (Clement 1987 p3) and can persist despite instruction (McCloskey 1983). They may also remain unconscious, continuing to have an effect on learning new concepts (Fischbein et al. 1985). Alternative conceptions that remain may do so because they are based in effective and productive knowledge, and the context has an impact on the suitability and effectiveness of the version of the concept that is used (Smith et al. 1993). It is possible that students may fluctuate between different understandings within their learning.

During the period of liminality it is suggested that there are occasions where the learner appears to have acquired the concept but actually have not. Meyer & Land (2006 p24) termed this misunderstanding *"mimicry".* This mimicry may involve a lay view of the concept rather than a subject view. The learner may be able to recite a definition of a concept but not fully understand it. They may also be able to use the concept within their subject but not apply it to their wider world. A student's journey in the acquisition of a threshold concept may involve attempts at both understanding and misunderstanding or *"compensatory mimicry"* (Meyer and Land 2006 p24). It has been suggested that

> *"substantial conceptual change does not take place rapidly, and*

relatively stable intermediate states of understanding often precede conceptual mastery." (Smith et al. 1993 p123).

It is not simply a matter of replacing a misconception with an appropriate conception as these different conceptions can coexist and people switch between them (Clement 1982; Clement 1987; Laurillard 1993). A new concept will only be accepted if the learners are not happy with their current conception and the new conception is "*intelligible, plausible and fruitful*" (Posner et al. 1982 p214). So even after learning a disciplinary concept students may still use their everyday concept depending on the circumstances (Reimann and Jackson 2006). If lecturers know what these different ways of understanding a concept are then they can challenge the differences (Bowden and Marton 1998; Laurillard 1993; Smith et al. 1993).

Most of the threshold concepts literature explores either staff or students' perceptions. There are few articles exploring both staff and students' perceptions of possible threshold concepts. Within the threshold concepts literature it appears that whilst variation in understanding is acknowledged for students, there is an "approved" disciplinary view that is shared by lecturers. From other literature (Patrick 1998; Rovio-Johansson 1998; Tullberg 1998) it appears that this may not be the case and this may add to any troublesomeness experienced by students.

As discussed earlier (section 2.3.1) the discipline of the lecturer may influence how they present and explain information to students. In addition how

information is presented to students or how questions are asked will result in different answers according to the focus of the question (Marton et al. 2004). Lecturers should be aware of the variation in student understanding (Bowden and Marton 1998; Laurillard 1993; Marton et al. 2004). Courses build upon assumptions that students understand certain concepts and then build upon these assumptions. Lecturers may also hold assumptions about the skills and abilities that students come with (Snow 1989). However as different people hold different assumptions (Abercrombie 1960) the assumptions held by the lecturers may not be shared by the students (Marton et al. 2004) and the lecturer could be *"building on sand"* (Laurillard 1993 p30). Therefore it is important to explore how students' prior knowledge and experience influences their learning. Lecturers may be aware that a student misunderstands a concept but not how it relates to the *"correct"* understanding of that concept (Laurillard 1993). This occurs in prosthetics with students mixing up the concepts of suspension and weight bearing, and lecturers not understanding how or why they arrive at this misconception.

Different ways of understanding a concept may not be incorrect but simply come from a different perspective. There may be times when learners fluctuate between one perspective and another perspective. Lecturers cannot assume that everyone approaches a concept with the same viewpoint, as students prior experience may influence their understanding. Also the discipline of the lecturer may have an influence on how they perceive the concept and this may be at odds with the students' disciplinary view.

2.6 Summary

Challenges in learning should be expected. In order to assist students through these challenges there needs to exploration into what the challenges are and why they occur for some but not all learners. There has been very little research exploring the education of prosthetists/orthotists, leaving a large gap in the literature, which this thesis begins to address.

Professional socialisation involves learning to think and act like a member of a discipline. Lecturers will have been socialised into their discipline and this will have an effect on how they view concepts and therefore how they present them to students. If the lecturer is from a different discipline to the students this may result in problems with explicit relevance and application to the students' discipline.

Troublesome knowledge provides a helpful explanation of why certain students find certain concepts difficult, and the literature provides details of some types of troublesome knowledge. However there may be further explanations for why certain concepts are troublesome for students that have yet to be identified.

Threshold concepts direct a focus onto disciplinary learning. To be seen as different from other concepts they must possess some unique characteristics. The criteria model and concepts model of threshold concepts suggest different ways of differentiating threshold concepts from other concepts. It has been noted that there is variation in different stages of learning and understanding a

threshold concept. Suggestions for a way of explaining this variation have been made but there is a lack of literature exploring this issue. Students' prior experience may help to explain some of this variation as everyone has some level of prior understanding of a concept, whether every-day or disciplinary. They also develop their understanding based on their own individual experience of the concept. In the next chapter I explore how previous studies have explored the notion of threshold concepts before considering how my methodology is appropriate for my research questions.

3. Methodology

3.1 Introduction

My research questions seek to explore students' and staff members' experience of what is difficult in studying prosthetics. Although the exact formation of the research questions has altered over the duration of the research the basic premise has not changed. The variation amongst student backgrounds, in the teaching subject areas of staff, in ways of approaching a concept and in what is experienced as difficult, meant that I sought a methodological and analytical approach that initially allowed me to examine the experiences of individuals and the variation within an individual before moving on to explore the variation across the different cases. As I was interested in people's experience I required a methodological approach that was phenomenological. The notions of troublesome knowledge and threshold concepts provide ways of identifying and framing potentially problematic concepts within prosthetics and an Interpretive Phenomenological Analysis approach provides a way of exploring the experience of, and the variation amongst, the potentially problematic concepts.

In this chapter I aim to explain my methodology whilst also highlighting and discussing its imperfections. First I discuss research methodology in threshold concepts. Secondly I discuss my methodological approach and why it is suitable for researching threshold concepts. The ethical issues which I considered are discussed before I move onto my method. I then discuss

issues arising with the method, finishing with a discussion of the limitations of the research.

3.2 Research methodology in threshold concepts

Currently there is no defined method of how threshold concepts could be identified, though Cousin (2009) identifies methods that have been used and considers that research into threshold concepts is a *"transactional curriculum inquiry"* (Cousin 2008 p270) involving lecturers, students and educational developers. Davies (2006 p79) suggests that the identification of threshold concepts requires a method that is *"distinctive and necessary given the characteristics of threshold concepts".* In Meyer & Land's (2003) original paper many of the alleged threshold concepts appear to have been identified by providing academics with the characteristics of a threshold concept and asking for examples. This method has also been used by others (Cousin 2006; Davies and Mangan 2005). However, this method creates issues as academics may just identify what they deem to be important (core, key or fundamental) concepts within their discipline (Davies 2006; Davies and Mangan 2005) although Eckerdal et al (2006) feel that listing core concepts would be a *"good starting point".* Indeed this has already been done for many disciplines in the United Kingdom through Quality Assurance Agency Subject Benchmarks (for example Quality Assurance Agency for Higher Education 2001a; Quality Assurance Agency for Higher Education 2001b; Quality Assurance Agency for Higher Education 2007), and learned societies' curricula documents (for example College of Occupational Therapists 2004;

Society and College of Radiographers 2003). As academics are assumed to have passed through the threshold, do they know what are potential threshold concepts or what is troublesome knowledge since they are not difficult for them now? Lecturers exploring why a potential threshold concept is central to their particular discipline and what the common misconceptions are may result in the initial threshold concept being replaced by another and broader and more generic threshold concept (Lucas and Mladenovic 2006). Therefore I feel that only asking academics is not appropriate for identifying threshold concepts.

Within the literature many data collection methods have been used for research on threshold concepts. Some researchers appear to have identified threshold concepts based on their own personal opinion (Flanagan and Smith 2008; Quinnell and Thompson 2010; Shinners-Kennedy 2008; Sibbett and Thompson 2008). Interviews and questionnaires with students have also been used to identify potential threshold concepts within disciplines (Baillie and Johnson 2008; Cheek 2010; Clouder 2005; Cousin 2006; Cove et al. 2008; Kabo and Baillie 2010; Orsini-Jones 2008; Orsini-Jones 2010; Osmond and Turner 2010; Osmond et al. 2008; Park and Light 2010; Park and Light 2009; Reimann and Jackson 2006; Taylor 2006; Taylor 2008; Thomas et al. 2010; Trafford 2008; Wimhurst and Allard 2007; Zander et al. 2008). Others have used examples of students' work to identify potential threshold concepts (Ashwin 2008; Baillie and Johnson 2008; Cartensen and Bernhard 2008; Cowart 2010; Davies and Mangan 2010; Orsini-Jones 2008; Pang and Meyer 2010; Park and Light 2010; Shanahan et al. 2008; Shanahan and Meyer 2006;

Shanahan et al. 2010; Taylor 2006; Taylor and Meyer 2010; Thomas et al. 2010). Many researchers have also used staff as their participants (Baillie and Johnson 2008; Cousin 2006; Kiley and Wisker 2010; O'Brien 2008; Osmond and Turner 2010; Osmond et al. 2008; Park and Light 2010; Shopkow 2010; Taylor 2006; Thomas et al. 2010; Zander et al. 2008). In addition student evaluations and feedback (Quinnell and Thompson 2010), administrative data (Shanahan et al. 2010), prior research (Ross et al. 2010; Weil and McGuigan 2010), and literature (Kutsar and Kärner 2010) have been used. Different methods may result in different threshold concepts being identified, for example Thomas et al (2010) suggest that students describe threshold concepts which are more specific than staff.

In summary, a variety of different data, data collection methods and participants have been detailed in previous threshold concept research. However the research suffers from gaps in the methodological approach and process of analysis.

3.3 Interpretive phenomenological analytical approach

Whilst previous research on threshold concepts has been clear about its method of data collection, information on the method of analysis and the methodology of the researchers is lacking. For my research I considered several different methodological and analytical approaches and chose to use an Interpretive Phenomenological Analysis (IPA) approach because it supported my world view, and acknowledged the influence of the researcher.

It also allows a focus on both the individual's and the group's experience of a phenomenon. IPA also has a process for data analysis associated with it, with guidelines presented in the literature.

3.3.1 Methodology

As much as I can be aware, my *"unconscious worldview"* (Guba and Lincoln 1989 p183) is interpretivist. "*Reality is socially constructed, complex and ever-changing*" (Glesne 1999 p5) and therefore it is subjective (Tashakkori and Teddlie 1998) and there are multiple realities (Guba and Lincoln 1988). I was aware of certain aspects that my colleagues and myself identified as being problematic for certain students and acknowledge that this may have influenced the questions I asked but I started with an open agenda in relation to students' perceptions of what was difficult and did not begin with a pre-conceived hypothesis. Whilst I had read some threshold concepts literature I came to explore my worldview after I had begun the data collection. This was partly due to time and the need to gather data before the students progressed too far into their new year of study. Thus I share the pragmatic view described by Tashakkori and Teddlie (1998 p21):

> *"Pragmatists consider the research question to be more important than either the method they use or the world view that is supposed to underlie the question."*

Salmon (2003 p25) suggests that

"it is a rare researcher who thinks through an epistemological position before choosing a method. Such positions are more often post hoc rationalisations of what has been done."

It may be that rationalisations may not allow the research method to fit neatly into a box. However, this may not matter if trying, as in my case, to achieve "*methodological appropriateness*" rather than "*methodological orthodoxy*" (Patton 2002 p72).

3.3.2. Analytical approach

I have chosen to use an Interpretive Phenomenology Analysis approach. This approach was developed in health psychology and most research using IPA or an IPA approach is in this field. However, its' use in other fields is expanding (Larkin et al. 2006) and is now used in other areas of psychology, as well as the human, health and social sciences (Smith et al. 2009). It is also being used within higher education research, for example see Roberts (2010), Walker et al (2008) and Kingston (2008). The ontology of IPA is *"broadly realist"* (Reid et al. 2005) in that we cannot directly know the world, instead we know the world through our interpretations based on theory, experience or ideas (Ashwin 2009). As well as being an overall methodological approach, IPA has an associated approach to data analysis. This process links with the philosophy of IPA in that it is idiographic, focusing on the particular before moving to the general with the analysis being *"thorough and systematic"* (Smith et al. 2009 p29). Of course it is possible to follow the guidance for analysis without using IPA as the overall methodological approach. Initially I

was attracted to and decided to use the guidance provided for data analysis. On further reading about IPA I realised that it also aligned with my world view and therefore also became my methodological approach.

Interpretative Phenomenological Analysis was developed by Smith (1996; 2004) in the field of health psychology. Smith and others (2009) describe the theoretical basis to this approach to qualitative analysis. IPA is phenomenological in that it is concerned with making meaning of people's world and experience (Reid et al. 2005; Smith and Eatough 2007; Smith et al. 2009). It draws this perspective initially from Husserl, and then from Heidegger, Merleau-Ponty and Sartre.

Husserl's phenomenology stems from his view that human experience is the fundamental source of knowledge (Racher and Robinson 2003) and must be examined in context and on its' own terms. In order to do this we must step away from our everyday experiences or natural attitude and turn our attention from the object of the experience to the experience itself (Husserl 1927). Adopting a phenomenological attitude by reflecting upon our experience allows us to disengage from the object and our taken for granted knowledge about it and experience of the object. Husserl states that there is a relationship between the process occurring in the consciousness and the object of attention, a relationship that he calls *"intentionality"* (Husserl 1927 p161). This means that consciousness or reflection is always reflection of something. To enable a phenomenological attitude Husserl developed a method known as *"phenomenological reduction"* (Husserl 1927 p163). This

involves putting our assumptions and preconceptions to one side (bracketing), focussing attention on our perception of the world. This perception is then viewed through a series of different lenses to enable *"the core of the subjective experience"* (Smith et al. 2009 p14) or what Husserl calls the *"eidos"* (Husserl 1927 p165) to be established. Husserl's contribution to IPA is this focus on reflection and the systematic exploration of consciousness (Smith et al. 2009). The concept of bracketing is also viewed within IPA as an important part of the research process (Smith et al. 2009). IPA is phenomenological in that it is concerned with making meaning of people's world and experience (Reid et al. 2005; Smith and Eatough 2007; Smith et al. 2009).

Both Husserl and Heidegger rejected the Cartesian divide of subject and object (Larkin et al. 2006). Heidegger (1962/1927) viewed individuals as situated within and unable to be separated from context (Larkin et al. 2006). Heidegger described this situated view of humans as Dasein or there-being (Eatough and Smith 2008; Larkin et al. 2006). Heidegger was also concerned with worldliness, providing the individual with a range of options that are possible and meaningful and readily available to the individual (Smith et al. 2009). According to Heidegger (1962/1927), individuals are thrown into an already existing world of people, cultures, language and objects from which they cannot be meaningfully detached. Individuals have a relational engagement in the world; our being in the world is always in relation to something. These concepts of being thrown into a world and of always being

in relation to something are Heidegger's contribution to the phenomenological aspect of IPA (Smith et al. 2009).

The concept of being in the world is shared by Merleau-Ponty, who also shares Heidegger's emphasis on situated context (Smith et al. 2009). However, instead of focussing on worldliness, Merleau-Ponty explores the situated context by describing the embodied nature of the relationship between the individual and the world, viewing the body as the way of communicating with the world rather than an object in the world (Merleau-Ponty 2012/1945). He also considers the primacy of our individual perspectives stating that

> *"Everything that I know about the world, even through science, I know from a perspective that is my own or from an experience of the world without which scientific symbols would be meaningless." (Merleau-Ponty 2012/1945 p9)*

Merleau-Ponty views our perception of "other" from an embodied perspective beginning with the position of difference:

> *I perceive the other as a behavior, for example, I perceive the other's grief or anger in his behavior, on his face and in his hands, without any borrowing from an "inner" experience of suffering or of anger… But ultimately, the other's behaviour and even the other's worlds are not the other himself. The other's grief or anger never has precisely the same sense for him and for me. For him, these are lived situations; for me, they are appresented."* (Merleau-Ponty 2012/1945 p414)

Because the other's experience belongs to their own embodied perspective we can never entirely share this experience. Merleau-Ponty's perspective brings to IPA that it is not possible to entirely capture the individual's lived experience but also that it should not be ignored (Smith et al. 2009).

The role of individual relationships is Sartre's contribution to IPA. Sartre emphasises that individuals are developmental, using the phrase *"existence precedes essence"* (Sartre 2007/1996 p22) to show that the self is not static, it continually develops. Sartre also discusses the importance of what is absent in defining our perspective of the world and who we are (Smith et al. 2009). In exploring our relationships with other people and their presence or absence, Sartre extends Heidegger's concept of worldliness (Smith et al. 2009).

IPA draws on Husserl's focus on the essence of experience but takes the more modest approach of capturing particular experiences for particular people (Smith et al. 2009). In addition IPA considers the views of Heidegger, Merleau-Ponty and Sartre in that we can only be understood through our involvements in the world and the world can only be understood through our involvement in it. The two cannot be separated (Larkin et al. 2006). We cannot remove the person from the context nor the context from the person. They are interwoven: *"that which weaves together*" (Cole 1996 p135). In viewing context in this way different object-context variations are foregrounded on different occasions, thus different interwoven threads allow different perspectives to be considered. Thus from drawing on Heigegger, Merleau-

Ponty and Sartre, IPA moves away from the descriptive approach of Husserl, to an interpretative approach.

IPA is interpretative in its approach, following hermeneutics as considered by Heidegger, exploring the appearance of a phenomenon and acknowledging the researcher in *"facilitating and making sense of this appearance"* (Smith et al. 2009 p28). I construct "reality" based upon my interpretations of the data, which are participants' interpretations of the phenomenon (Patton 2002). This aspect is acknowledged within IPA, moving the analysis from description to interpretation, acknowledging that the participants interpret his/her experiences and then the researcher interprets these experiences (Reid et al. 2005; Smith and Eatough 2007). This is appropriate for research looking at threshold concepts because the research moves away from a simple description of the experience towards an understanding of the phenomenon that acknowledges both the participant and the researcher (Clarke 2009). This is important since I am an insider researcher, as are many researchers of previous threshold concepts studies, and therefore will both implicitly and explicitly interpret and create meanings of the participants' experiences of the phenomenon and context (Larkin et al. 2006). Therefore it is appropriate to choose an IPA approach in which the researchers role is acknowledged and their reflections are made explicit and legitimate parts of the research (Biggerstaff and Thompson 2008). Thus IPA has a double hermeneutic approach (Biggerstaff and Thompson 2008; Smith and Eatough 2006; Smith and Eatough 2007). The idiographic nature of IPA is also suitable for looking at threshold concepts as it allows the researcher to focus initially on the

individual participant's accounts of what is experienced as difficult before moving to a cross-case analysis allowing multiple realities to be considered (Guba and Lincoln 1988).

The sample size used in IPA varies ranging from a single participant to over 30 participants (Brocki and Wearden 2006; Reid et al. 2005). It is noted that there is no "right" number of participants (Smith et al. 2009; Smith and Osborn 2003). Using multiple perspectives, exploring the phenomenon with different groups of participants can allow *"a more detailed and multifaceted account"* (Smith et al. 2009 p52) and provide a type of triangulation (Reid et al. 2005; Smith et al. 2009). In IPA sampling of participants tends to be purposive (Smith and Eatough 2007; Smith et al. 2009) selecting people who can offer a perspective on the phenomenon under study. Recent threshold concepts research has predominantly used interviews as the method of data collection and therefore since in IPA the data generation method tends to be semi-structured interviews, although other qualitative data generation methods have been used (Biggerstaff and Thompson 2008; Brocki and Wearden 2006; Clarke 2009; Reid et al. 2005; Smith 2004; Smith and Eatough 2006; Smith and Eatough 2007; Smith et al. 2009) I consider IPA to be an appropriate method for my research.

3.3.2.1 Analysis

IPA has a non-prescriptive approach to data analysis with no single method for working with the data (Smith et al. 2009), thus allowing flexibility in how

analysis is conducted (Baillie et al. 2000). The commonality across the analytical methods used is the focus of the analysis, paying attention to the participants' interpretations of their experiences (Smith et al. 2009). As a result a set of common processes and principles has evolved (Smith et al. 2009; Smith and Osborn 2003), moving between the particular and the shared and the descriptive and interpretative, and a commitment to the participant's viewpoint (Smith et al. 2009). Smith et al (2009) provide a detailed approach to undertaking analysis but explain that this is only one way. They suggest initially writing notes on anything that seems important and then move on to the development of emergent themes, reducing the volume whilst maintaining complexity. Then connections between emergent themes are explored, eventually resulting in a framework for the themes (Reid et al. 2005; Smith et al. 2009). The outcome will represent commonalities whilst also accommodating variations (Reid et al. 2005). During the analysis IPA aims to "*allow rigorous exploration of idiographic subjective experiences*" (Biggerstaff and Thompson 2008 p215) thus focusing on the individual, whilst also exploring "*a phenomenon as it is shared by a specific group*" (Clarke 2009 p38) enabling perspectives on generic themes to be considered (Reid et al. 2005; Smith and Eatough 2007). IPA is an inductive approach, with the analysis grounded in the data (Reid et al. 2005), rather than *"imposing a predetermined theory"* (Clarke 2009 p39). The analysis should be interpretive, transparent and plausible and based around "*substantial verbatim extracts*" (Reid et al. 2005 p22).

As the literature on threshold concepts provides few details of the methodological approach previous researchers have taken, I sought an approach that enabled me to acknowledge the variation and similarities amongst participants' experiences, and the role that I play in interpreting their experiences. IPA enabled this but also had similarities with the data collection methods used in previous threshold concept research. In addition IPA has guidance on the analysis of data which provided me with an approach for this.

3.4. Method

In this section I describe and discuss the method I used to conduct my research. First I focus on the recruitment of participants before moving on secondly to the participants themselves. Thirdly I consider the data collection method before finally moving on to the process of analysis using the guidance given for IPA.

3.4.1 Participants

As in some previous research into threshold concepts I chose to ask both staff and students to participate. Whilst I have not included educational developers I do believe that this is still a "*transactional curriculum inquiry*" (Cousin 2008 p270).

3.4.1.1 Student participants

Recruitment of participants occurred through email (students at University A), letter and talking to class groups (students at University B) (appendices 8.2, 8.3, 8.4 & 8.5). Through the recruitment methods I explained who I was, what the purpose of the research was, what was involved should they chose to participate and what the benefits were to them and the wider benefits. Within prosthetics and orthotics the traditional (white, middle class, A-level) student forms only part of the student cohort. The prosthetic and orthotic student population includes overseas students, students with a variety of entry qualifications, and those who have worked either within prosthetics and orthotics as technicians or in a different field. Therefore to ensure that I included students from a range of backgrounds within my research I used purposive sampling to achieve maximum variation (Patton 2002) and "*to permit inquiry into and understanding of a phenomenon in depth.*" (Patton 2002 p46, emphasis author's own). To enable this I asked students to complete a closed answer questionnaire asking for demographic information (appendices 8.6 & 8.7) if they wished to participate. I also asked for an email address upon which I could contact them. I had envisaged that I would be able to select from a range of students in all years from both universities. From these questionnaires I was able to select students (University B) from different backgrounds. Due to a smaller number of volunteers all University A students who volunteered were selected but one failed to attend the interview. The University B students were perhaps more likely to volunteer because they were familiar with me and wished to "help me out" with my PhD. Questionnaires were sent by email and the interview dates and times were

organised by email. Reminders for the email questionnaire/interviews were sent out. In total 18 students participated in the research (Tables 1 & 2).

Table 1: Descriptive statistics of student participants

Age	Range = 18 – 40 years Mean = 25.67 years
Educational Background	A-levels/Highers = 9 BTEC Certificate/Diploma = 1 Undergraduate Degree (healthcare) = 1 Undergraduate Degree (non-healthcare) = 4 Other = 3
Employment Background	Prosthetic Technician = 2 Orthotic Technician = 0 Prosthetic/Orthotic Technician = 1 Other = 9 Not Applicable = 6
Ethnicity	White British = 13 White Irish = 1 Other white background = 1 Black or Black British - African = 1 Black or Black British - Caribbean = 1 Other ethnic background = 1
Gender	Male = 6 Female = 12
University	University A = 7 University B = 11
Year of Study	Year 1 = 6 Year 2 = 4 Year 3 = 4 Year 4 = 4

Table 2: Student participant attributes

Pseudonym	Interview / questionnaire number	Age	Educational background	Employment background	Ethnicity	Gender	University	Year of study
Tom	1	22	A-levels/Highers	Other	Black or Black British-Caribbean	Male	University B	3
Suzanne	2	27	BTEC certificate/diploma	Other	White British	Female	University B	3
Edward	3	25	A-levels/Highers	Prosthetic technician	White British	Male	University B	3
Helen	4	38	Other	Other	White British	Female	University B	2
Greg	5	22	A-levels/Highers	Other	Black or Black British-African	Male	University B	1
Therese	6	23	UG degree (non-healthcare)	Not applicable	Other ethnic background	Female	University B	1
Karen	7	23	Other	Other	White British	Female	University B	2
Catherine	8	31	A-levels/Highers	Prosthetic and orthotic technician	Other white background	Female	University B	1
Emily	9	29	UG degree (non-healthcare)	Prosthe tic technician	White British	Female	University B	2
Jane	10	18	A-levels/Highers	Not applicable	White British	Female	University A	1
Andrea	11	21	A-levels/Highers	Other	White British	Female	University A	1
Marian	12	25	UG degree (non-healthcare)	Not applicable	White Irish	Female	University A	1
Melissa	13	40	UG degree (healthcare)	Other	White British	Female	University A	3
Sidney	14	39	UG degree (non-healthcare)	Other	White British	Male	University A	2
Jonathon	15	22	A-levels/Highers	Not applicable	White British	Male	University B	4
Ben	16	38	Other	Other	White British	Male	University B	4
Jennifer	17	20	A-levels/Highers	Not applicable	White British	Female	University A	4
Sally	18	22	A-levels/Highers	Not applicable	White British	Female	University A	4

3.4.1.2 Staff participants

Staff were contacted by email (appendix 8.12) and interviews organised either by email or in person. The staff invited to participate have all previously worked in clinic as a prosthetist for a variety of years and have a variety of backgrounds. Each lecturer tends to specialise, only teaching specific areas of practice taught in core modules. They may teach only lower limb prosthetics or a combination of upper and lower limb prosthetics. The staff at University B also teach other supporting modules which at University A are either service taught at another local university or taught by non-disciplinary lecturers within the department at University A. A total of 11 staff members who taught prosthetics were asked to participate and 8 agreed to take part in the research (Table 3), the remainder failing to respond or being unable to participate.

Table 3: Staff demographics

Staff Member	Gender	University	Upper or Lower Limb	Number of years qualified	Number of years teaching
Staff 1	Male	University B	Lower	34	>20
Staff 2	Female	University B	Lower	21	10
Staff 3	Male	University B	Upper & Lower	20	11
Staff 4	Male	University A	Lower	18	8
Staff 5	Male	University A	Upper & Lower	37	33
Staff 6	Female	University A	Lower	17	13
Staff 7	Male	University A	Lower	32	>20
Staff 8	Male	University A	Upper & Lower	11	6

Here, in order to clarify terms I define core concepts and modules as those that are central to the discipline. They include ways of thinking and practicing in the discipline and are taught or facilitated by disciplinary members. Supporting concepts and modules are those that are taught separately from the core concepts and modules. They may contribute to the knowledge base of the discipline and act as "building blocks". They may be taught by non-disciplinary members. It is possible that the supporting concepts and modules may not be used on a day-to-day basis but act as a fall-back position when a problem is messy and does not fit an automated pathway (Boshuizen and Schmidt 2008; Hatano and Inagaki 1986).

3.4.2 Data collection

The method of data collection varies amongst the threshold concepts literature but interviews predominate. In my research semi-structured interviews were primarily used as the data collection method using a pre-prepared interview guide (Patton 2002; Smith et al. 2009) as a prompt and checklist to remind me of the areas to be covered. Students in the fourth year of their studies at both universities were on placement in the UK and abroad and it was not possible either for me to visit them or for them to attend either university for interview. Therefore they received a questionnaire by email which contained the same questions as the interview guide, with some extra prompts, which they answered and returned to me by email. The interview guide (appendix 8.10) and questionnaire (appendix 8.11) were piloted with 4 students from University B, with one student in each year. Minor changes to the guide were

made subsequent to this. The data from these pilot interviews and questionnaire are not included in the analysis. At the beginning of the interview and at the start of the questionnaire all participants were reminded of the purpose of the interview/questionnaire and their right to withdraw, given the opportunity to ask questions and complete and sign a consent form (appendices 8.8, 8.9 & 8.13). I asked some background and demographic questions (Patton 2002) at the start of the interview including narrative questions (Smith et al. 2009) about how they had entered prosthetics, progressing to opinion and value questions (Patton 2002) exploring their experience of difficult areas within learning prosthetics. The staff interviews followed an almost identical guide (appendix 8.14). During the interviews I also asked all participants to answer a role-playing question (Patton 2002) of a prosthetic prescription scenario (appendix 8.15), to provide a context to explore how prosthetists and student prosthetists solve a problem commonly encountered in clinic. Patton considers that questions asking participants to re-experience or simulate an experience often generate *"the richest and most detailed descriptions"* (Patton 2002 p194). All interviews were recorded in a digital audio format for subsequent transcription.

3.4.3 Analysis

The analysis was a cyclical process moving between stages in the process. The questionnaire data was saved as a single document for each participant, with further preparation unnecessary. The interview data was in digital audio format. The digital audio recordings of the interviews were transcribed by

myself providing an easier format for analysis (Denscombe 2007). With myself, rather than another person, transcribing the data familiarisation with the data began at this stage, thus bringing myself *"close to the data"* (Denscombe 2007 p183). This transcription formed *"a key phase of data analysis"* (Bird 2005 p227), an interpretive action, rather than simply a way of putting oral data into written format (Lapadat and Lindsay 1999). The recordings were transcribed verbatim as is standard for IPA interviews (Smith et al. 2009), but information such as the timing of pauses was not included as conversation analysis was not used. In addition the transcripts, since they are in written format, also exclude information available that would be available in audio or video format such as body language and tone (Arksey and Knight 1999). Though the transcription is verbatim the data was transformed from its original format (Kvale 1996) and some *"reconstruction"* (Denscombe 2007 p184) was required so that it made sense in written form. The transcripts can be considered as a *"hybrid*", neither the lived oral or formal written text (Kvale 1996), and are only one interpretation of the data (Arksey and Knight 1999). The original transcripts contain *"er", "um", "d'you know what I mean"*, but these have been removed from the quotes selected to support the findings, making them easier to read. Editing such as this is acceptable as it is the *"ideas, logic, beliefs and understandings that are wanted"* (Arksey and Knight 1999 p146).

The analytical process I used follows suggestions provided by Smith & Eatough (2006; 2007), Smith & Osborn (2003) and Smith et al (2009). Some initial analysis began during the data collection (Arksey and Knight 1999; Brocki and Wearden 2006; Kvale 1996; Lincoln and Guba 1985) and during

the transcription process (Bird 2005; Kvale 1996; Lapadat and Lindsay 1999). Initially each transcript was read through to remind myself of the scope of the material gathered and of my thoughts during the interview (Arksey and Knight 1999) and to gain a holistic perspective (Smith and Eatough 2007; Smith and Osborn 2003). Then my initial thoughts of what was significant or interesting were annotated on the left hand margin. On a further reading initial emerging themes were then documented in the right hand margin, thus beginning a move towards abstraction (an example is provided in appendix 8.16). As I continued analysing further interviews the emerging themes were coded straight into NVivo. There were common themes that emerged, but I initially worded themes differently in NVivo, sometimes struggling even to remember a code I had just used. However, Boulton & Hammersley (2006) and Braun & Clarke (2006) suggest that creating many categories allows the researcher to see the features of the data and may challenge the researchers expectations. Once all of the interviews had been coded into NVivo the themes were refined and organised into clusters with superordinate and subordinate themes identified. As I continued with the analysis themes were renamed, amended, merged or subdivided (Arksey and Knight 1999). I analysed transcripts individually, across both participant groups separately and then across student and staff groups. I also endeavoured to read between the lines, identify any implied meanings, and identify any gaps (Smith et al. 2009). I also searched for "*disconfirming as well as confirming evidence*" (Arksey and Knight 1999 p169), as anomalies can provide new insights and discussion of these anomalies help with the credibility of the research (Arksey and Knight 1999).

The final stage of analysis consisted of writing an account moving between a description and the interpretation of the data (Smith and Eatough 2007).

Whilst processing the data I wrote memos, a type of journaling. This started on paper and then progressed during the analysis to electronic memos. This provided me with opportunities for new insights into the data, the ability to document new thoughts and to explore new possibilities, and to assist with recognising preconceptions and assumptions especially those that may have arisen because I was conducting insider research (Knight 2002). The memos were about the data but also about methodological issues which arose (Arksey and Knight 1999). They also acted as a memory aide providing a commentary on my thoughts during the analysis process (Arksey and Knight 1999). They also served as an audit trail (Denscombe 2007), creating a record of my thinking and making the research trail explicit (Smith et al. 2009). The analytical process was inductive and cyclical and I moved backwards and forwards in these stages.

The overall process I took, although presented in a linear fashion, did not occur like this. Transcription of previous interviews occurred whilst further interviews were being carried out. Analysis of some interviews occurred whilst others were being transcribed. So in general the actual process was more "messy" than presented.

3.5 Ethics

All research projects have ethical considerations to make. As part of the process for ethical approval I had to consider these and how I would deal with them. As a health professional I have to adhere to several ethical codes of practice. Therefore I am familiar with ethical concepts and this assisted my awareness and reflections on the ethics associated with this research. Ethical approval was required from both Lancaster University (appendix 8.1) and University A asked to see the paperwork from Lancaster University. The need for ethical approval from the University B was queried and it was confirmed that it was not required as I was a post-graduate at Lancaster University with no involvement of other University B staff members in the collection, transcription and analysis of data, and ethical approval had been granted by Lancaster University. The ethical issues that I was concerned with were anonymity and power.

3.5.1 Anonymity

I had some concerns over anonymity as prosthetics and orthotics is a very small profession and some participants have personal circumstances that may identify them. In addition the participants in some circumstances have named fellow students, lecturers, clinicians. Whilst ensuring anonymity and confidentiality to participants is standard practice within research (Bell 2005) it is very hard to fully achieve (Malone 2003). Whilst Robson (2002 p502) considers that you should take *"reasonable precautions"*, Bell (2005 p48) is firmer stating that *"if you say that participants will be anonymous, then under*

no circumstances can they be identified". I have decided to take Robson's stance and make reasonable precautions. To achieve this I have chosen to provide pseudonyms (Wengraf 2001) for the students and changed names of people mentioned and of clinic locations referred to. Reasonable precautions for the lecturers have involved identifying them as, for example Staff 1, since providing gendered names and the university could provide too much identifiable information due to the small number of lecturers. Kvale (1996 p114) recommends this approach

> *"If a study involves publishing information potentially recognisable to others, the subjects need to agree to the release of identifiable information."*

I informed participants that if I felt that something I wrote makes a student identifiable to others I would check with them whether this would be acceptable, however, this was not required. Other prosthetists and students, due to the smallness of the prosthetic community, may be able to identify individuals but within the wider higher education community participants are less likely to be identifiable.

3.5.2 Position of power

I also considered the potential issue of power over some of the participants. As a colleague rather than a line manager to the staff participants, the issues were related to my knowledge of what they had said to me and their perception of what I might do with this knowledge. Confidentiality and anonymity were iterated in the invitation to participate and reiterated in the

consent form and conversation and verbal explanation before and after the interviews. Power over the students could be perceived as being more of an issue for the students at University B, as I was one of their lecturers and therefore had responsibility for making judgements on their performance and progression through the course. For both groups of students, as with the staff, anonymity and confidentiality were stressed in the invitation, verbal explanation and consent forms.

I feel that I have been able to take reasonable precautions in dealing with the ethical issues that I anticipated. Whilst it may be still possible for individuals to identify themselves despite the precautions I have taken, I do not think that people outside of the prosthetics and orthotics profession will be able to identify individuals. Issues of power were dealt with through explanations to participants and using methods to deal with confidentiality and anonymity.

3.6 Issues

All research has other non-ethical issues that may affect the findings. Here I consider the issue of insider research and how I dealt with it.

3.6.1 "Insider" research

My research is "insider research" (Knight 2002). Whilst IPA acknowledges the influence of the researcher within the research, there are aspects of insider research that should be considered. This is particularly important when

researching within your own department and discipline, in this context undergraduate degree programmes in prosthetics and orthotics. I am therefore unable to detach myself fully from the participants and the data. Detachment may be seen as a way to reduce bias but qualitative research involves that *"understanding comes from trying to put oneself in the other person's shoes, from trying to discern how others think, act and feel."* (Patton 2002 p29). The researcher's existing status, knowledge, and role may affect the perspective of the participants and the researcher's perspective on the data. Situating my research within my own discipline and within the university where I worked raises a number of issues, both positive and negative.

As an insider researcher I have some pre-understanding of the area I am researching. Being an insider granted me *"knowledge, insights and experience"* (Gummesson 2000 p57) including tacit and explicit theoretical understanding and lived experience (Adler and Adler 1987). This pre-understanding granted me access to the *"private life"* of the area of research (Coghlan and Brannick 2005 p61), allowing me *"privileged access"* (Drake and Heath 2008 p136) not available to an external researcher. I also had knowledge of and ability to use the disciplinary jargon (Nielsen and Repstad 1993; Potts 2008), and the legitimate and taboo topics (Nielsen and Repstad 1993). I was able to see beyond the window dressing (Nielsen and Repstad 1993) as I had knowledge of critical events. As a *"complete member"* (Adler and Adler 1987 p67), researching my own area of educational practice I obtained an *"understanding in use"* rather than *"reconstructed understanding"* (Adler and Adler 1987 p82). This enabled me to obtain richer data with a

"deeper and more insightful investigation and exploration" (Smyth and Holian 2008 p40).

I have already described my pre-understandings of difficulties in learning prosthetics within the introduction to this thesis (section 1.5). These pre-understandings relate to my experiences both as a student of prosthetics and a lecturer teaching prosthetics. As a student I found certain mathematical concepts and communication with strangers difficult. As a lecturer I am aware of students confusing certain concepts and that many find the mathematical aspects of the course challenging. I acknowledge these pre-understandings and in developing the semi-structured interview guide I avoided questions that related directly to specific areas of difficulty I was aware of through my experience. In addition, during the interviews, I did not directly prompt participants to explore whether or not they found aspects of difficulty that I was aware of through my pre-understanding. Only if they brought up these specific aspects as difficult or easy, did I explore it further.

However, because I have pre-understanding I may be disadvantaged as it may have limited my ability to stand back from the research and bias may have been introduced. My privileged insights as an insider may be *"superficial or distorted"* (Hammersley 1993 p433). In order to lessen the impact of bias the research suggests that I should develop the approach of *"abstract wonderment*" (Glaser 1992 p22) or avoid pre-conceptions that might affect the data (Ashworth and Lucas 1998). Realistically I do not believe that either approach is possible. IPA acknowledges the role of the researcher and their

impact on the data and explores this (Biggerstaff and Thompson 2008). In IPA pre-suppositions or expert knowledge are considered to be *"valuable guides to inquiry"* (Lopez and Willis 2004 p731) and necessary in understanding and making sense of the person's experience (Shaw 2001). Bracketing is considered to be *"inconsistent and questionable"* (Lopez and Willis 2004 p729) in a hermeneutic tradition. I have predominantly used reflective journaling (memos) (Coghlan and Brannick 2005; Smyth and Holian 2008), together with discussions with my supervisor, acting as an *"external consultant"* (Coghlan and Brannick 2005 p63) to acknowledge and explore my pre-understandings.

As a researcher exploring an area in which I practice as a lecturer, I have two roles. These roles are interrelated which allows smoother transitions between them but also increases the difficulty of blurring the boundaries between these two roles (Ashforth et al. 2000). Whilst it has been suggested that by combining your normal role with that of researcher you are likely to experience some conflict and tension between these roles (Adler and Adler 1987; Smyth and Holian 2008), or feeling like an outsider in both roles (Smyth and Holian 2008) I have not experienced this. Whilst the nature of the data may be affected by colleagues participating in the research (Coghlan and Brannick 2005) I am not consciously aware that this occurred. As my research also involves participants in another institution I could have been perceived as a *"spy"* (Drake and Heath 2008 p134) however my relationship with the members of staff at this institution has hopefully prevented this. Since for some of the students I was one of their lecturers there may have been an

issue of them sanitising what they told me, but also conversely they may have been more likely to tell me more due to familiarity. In addition the journaling and supervisory support has enabled me to challenge issues arising from familiarity with people and organisational issues.

I am an insider researcher, investigating both at the institution at which I worked and within the education of my discipline. Due to the potential of insider research being subject to bias I have written memos and discussed issues with my supervisor. However my insider perspective allowed me to access areas not available to external researchers. I did not experience any issues relating to being a colleague or from being external to one institution.

3.6.2 Quality within qualitative research

All research has to consider issues to do with quality. These can be to do with whether sufficient information has been provided by the researcher to enable the reader to understand what methods have been used and how and why they have been used. I have tried to ensure validity and dependability through clear links between the research question, the evidence and conclusions to be demonstrated within the study (Yin 2003).

3.6.2.1 Dependability

I have chosen to use the concept of dependability rather than reliability where research procedures are explicit and able to be evaluated (Lincoln and Guba

1985). I have endeavoured to do this within this thesis. Since I believe that I, as the researcher have an influence on the data, reliability in the scientific sense is not possible (Denscombe 2007; Kvale 1996). My methodological approach, IPA, acknowledges the role and influence of the researcher and the participants in the process (Reid et al. 2005; Smith and Eatough 2007). In analysing my data I looked not just for commonalities but also differences, and alternative explanations (Reid et al. 2005).

3.6.2.2 Validity

In order to ensure that my research was valid I used the concept of triangulation for completeness (Jick 1983) and understanding, with data collected from multiple perspectives (students in different years, at different universities and views from staff) (Arksey and Knight 1999; Reid et al. 2005; Smith et al. 2009). However, I have not achieved full completeness as this may perhaps only be achieved by collecting data from the supervisors of students on placement and graduates one year or more after completing the course and the non-disciplinary lecturers teaching supporting concepts. Also had time not been a factor a longitudinal study would have allowed me to follow individuals throughout their programme of study, and this perhaps would have identified different aspects in what they found difficult. Lincoln and Guba (1985) advise that to provide assurance that quality data has been produced and that it has been checked in accordance with good practice data should be triangulated, taken back to the participants (respondent validation) and the findings grounded in the data. I have chosen not to do this as

respondent validation can be problematic because the analysis may have taken the data beyond the participants' recognition (Hammersley and Atkinson 1995).

Through using journaling and supervisory support together with a methodological approach that acknowledges the role of the researcher I feel that I have taken appropriate measures to address any issues relating to insider research. I have endeavoured to provide detailed information regarding my methods thus achieving dependability. In addition I have also tried to ensure through collecting data from multiple perspectives I have achieved some level of validity and acknowledge that the approach I took may not have achieved complete validity.

3.7 Limitations

In this section I consider the other limitations of my research. First I consider generalizability. Second I explore the possible limitations due to respondent bias before finally considering some methodological issues.

3.7.1 Generalizability

The context of my research is prosthetics education in the United Kingdom. My research outcomes may or may not be generalizable to other disciplines. I have endeavoured to provide sufficient information to enable the reader to generalize and apply the information to different situations (Goetz and LeCompte 1984; Guba and Lincoln 1981; Guba and Lincoln 1982; Knight

2002). The issue of whether the findings can be useful in other situations should be considered and also the role of the researcher in interpreting the data. Essentially I hope my interpretation is coherent and organised (Stiles 1993), logical (Annells 1996), plausible (Annells 1996; Patton 2002), and empowers the reader and the participants (Guba and Lincoln 1988) within the framework of the study. According to Holloway & Jefferson (2000 p60) the interpretation can be compared to *"throwing a stone in a pond, if an interpretation "works" the ripples reverberate through the analysis".* However there may be more than one interpretation (Annells 1996) and what is presented here is only my interpretation, with the outcomes contributing to knowledge about what students experience as difficult, both within prosthetics and the wider perspective of healthcare and higher education.

3.7.2 Respondent bias

There were some instances when I felt that students and staff were articulating their views on issues outside the context of the research interview (Storey 2007) e.g. alterations to the length and funding of the courses. However, I do not feel that this unduly affected their responses. For some other participants there were personal circumstances that I acknowledge may have influenced their response, but I feel that the impact of these circumstances were negligible.

3.7.3 Methodological limitations

Because I am an insider researcher this may have created limitations that I have already discussed above (section 3.6.1). There were methodological limitations created because due to final year students being on placement a questionnaire rather than an interview was used in order to gain data from them. Due to the nature of a questionnaire I was not able to probe as deep into the responses as I was in the interviews. I could have sent further emails to ask more detailed questions but due to my work load at the time this was not possible. Also perhaps because I was not known to the students at University A I was unable to use purposive sampling and select from a range of students who had volunteered. As a result whilst their educational and employment background varied it was perhaps not as varied as those students from University B.

My interpretations of my findings in the next chapter, and the subsequent discussion presents only one version of the participants' experiences of difficult concepts within prosthetics. Through information provision I hope that the reader can generalise my interpretation to other contexts.

3.8 Summary

Existing threshold concepts research does not detail the methodological approach taken. It does detail a variety of data collection methods and participants, with interviews with students predominating. Few of the articles use both staff and students as the participants. I have used IPA as my

methodological and analytical approach. IPA focuses on peoples' experiences of a phenomenon and their interpretation of it. It acknowledges that the researcher also interprets participant's experiences. Moving from the individual to the general is a feature of IPA research. These features I believe mean that IPA is a suitable methodological approach for researching difficult and potentially threshold concepts. Associated with IPA is a non-prescriptive method for data analysis with guidelines provided within the literature. In this chapter I have described my method, detailing the recruitment and selection process for participants. For data collection I used digitally recorded semi-structured interviews and emailed questionnaires. My data was analysed using guidelines detailed within the IPA literature. I have discussed the ethical and other issues relating to insider research and quality aspects that I have considered during this research project. Finally I have considered the limitations of my methodology. In the next chapter I present my interpretation of the participants' interpretation of their experiences of difficulties in studying prosthetics.

4. Findings

4.1 Introduction

During the analysis there were many themes that were identified. These included themes relating to specific learning, teaching and assessment approaches and which factors helped or hindered students in their learning. Here, I present the superordinate themes that are demonstrative of the conceptual difficulties which students of prosthetics encountered. Five conceptual difficulties were identified from the data. These are “the trouble with numbers”, “the trouble with the body”, “learning to talk”, “how we walk”, and “considering the person”. For each difficulty that I present, I consider whether it may be a threshold concept within prosthetics (Crossing the threshold?). Then for each difficulty I present supporting data under three subordinate themes: “why? how? when?”; “previous experience”; and “hidden understandings”. “Why? how? when?” explores difficulties relating to the relevance, application and location of the difficulty within the course. “Previous experience” explores the variation in students’ backgrounds and the impact this has on how they approach and deal with the difficulty. In “hidden understandings” I present data on the need to hold images and understandings of concepts in your mind whilst carrying out tasks (either clinical or paper based) and the difficulties this presents for the students. First I present two areas of difficulty that I do not consider to be threshold concepts and then I continue with three areas of difficulty that may be potential threshold concepts within prosthetics.

The extracts represent the range of views for each theme. They have been selected because they represent convergence or divergence within the theme. Students who participated through questionnaires did not give as thorough answers to the questions as those who were interviewed and therefore their inclusion within the extracts is more limited. One student, Greg, struggled to identify anything that was difficult for him and as a result his inclusion is limited.

Key

- … material omitted
- [single axis cushion heel] explanatory information added by researcher

4.2 The trouble with numbers

There are modules on both degree courses that involve mathematical concepts. These include the calculation of forces and the stress and strain in materials. These modules must be passed in order to progress through the course. However, once qualified graduates will not use this knowledge within a clinical situation. This of course raises questions regarding the inclusion of these mathematical concepts within the curriculum. Indeed no staff member identified mathematical concepts as a key concept within prosthetics. However, here I focus on the difficulties encountered by students with these mathematical concepts and why I do not consider the trouble with numbers to be a threshold concept within prosthetics.

4.2.1 Crossing the threshold

Numbers and calculations appear to be troublesome for some students due to three reasons: the relevance, application and alignment; students' prior experience and the tacit understanding of experts. Issues with relevance, application and alignment result in students learning the numerical aspects of biomechanics and materials science in a ritualistic manner, with students reporting that they never understood them and forgot them soon afterwards. This ritualisation can be lessened by application to clinically related problems and perhaps considering where they should be placed within the course aligning them with the theoretical and clinical aspects of prosthetics. Some students also appear to struggle with their prior beliefs about maths in order to pass the assessments but may resort to ritualised knowledge to do this. Undoubtedly some of the numerical aspects are complicated requiring several stages of calculation including some which for experts have become tacit and automatic. There does not appear to be a transformative nor an integrative aspect to the numerical aspects of the course. It does not appear to change prosthetic students' way of thinking or become part of who they are. They simply learn enough to pass the assessments. There does not appear to be a bounded aspect to the numerical concepts, unless this is the barrier that some people experience. Because many students take a surface approach to learning these aspects, which enables them to pass the assessments and then forget the information, any learning is reversible. Whilst mathematical based concepts have procedural concepts associated with them, they are not linked to the ways of practicing within prosthetics. From the data, numerical concepts are also not disciplinary concepts as they do not contribute to the

way of thinking within prosthetics. They may however be basic concepts. Therefore, whilst certainly troublesome, the mathematical aspects of the course do not appear to be a threshold concept for prosthetics, but they may well be threshold concepts for mechanical engineering or bioengineering where these concepts and calculations are in regular applied use.

4.2.2 Why? How? When?

The numerical aspects of the course are also used in engineering which is normally considered to be an applied subject but a lack of application to clinical prosthetics appears to make the maths based elements difficult. Emphasising the application to prosthetics and orthotics helped students even though they knew they were not going to use the calculations outside of the module.

> *Emily: In the second year with Gavin, I really enjoyed those classes actually because it really made me think a lot about the knee. He mixed up the maths with the anatomy and what you can do to improve I think varus gait so, oh sorry varus deformity, so because it was applied to something I gained a better*
>
> *Interviewer: you could see the point of it?*
>
> *Emily: I could see the point in it, even though I knew that an orthotist is no way going to sit there and do all that maths to work out that a ten*

degree devi[ation], you know, I knew that that wasn't going to happen but I could, it was like a problem to be solved.

Emily, year 2, University B

The lack of perceived relevance of maths based subjects also causes difficulties. This student talks about the lecturer knowing that this knowledge was not going to be used in a clinical situation.

...she [the lecturer] said I know you're never going to [use it] but as long as you know how you get from here to here to here and then you have go to here, to here, to here and just show me you know the workings, show me you understand beam deflection and the formula that is applied to it.

Melissa, year 3, University A

However, an experience during the summer holidays created a link for another student between the maths based concepts and the "real world" of medicine, demonstrating the relevance to her.

I went on a two week work experience over the summer, shadowing an orthopaedic surgeon. And prior to this I just thought biomechanics was all numbers and it doesn't seem to have any real place in the real world.

Therese, year 1, University B

However, in order to pass the exams, a surface approach to learning was the fall back position and subsequently resulted in forgetting the information

learnt.

> *Craig was really great and he gave us, we had a tutorial session on what could possibly come up in the exam and he gave us examples and I just learnt those examples inside out. I had no idea what they meant, to be perfectly honest, absolutely no idea. I don't even know if I really, if I had interest in it, I just learnt it off by heart 'cause I knew that's what would get me through in the exam. And it did and I can't recall any of it whatsoever.*
>
> *Emily, year 2, University B*

Application and the relevance of numerical aspects to clinical prosthetics may also be affected by the structure of the curriculum. Aligning the numerical based concepts with what is occurring in the clinical, practical modules may impact on students' ability to link ideas from different modules together.

> *I think that the PPOD or biomechanics is too detached from the clinical teaching. And I think that's no reflection on the people who're teaching PPOD. What I mean is, it's the way that it's aligned.*
>
> *Staff 4*

The alignment of modules and the relevance and application of numerical based aspects to clinical prosthetics may impact on the students' perceptions of the concepts. If they cannot see how they will use the concept when working and there appears to be no link with clinical work then they may not make the links themselves. Educators and clinicians may themselves see the

links to practice but this may be hidden to the students and perhaps needs to be made more explicit.

4.2.3 Previous experience

For some people the numerical aspects are easy. Their prior experience of the subject matter provides them with skills and knowledge which they can then transfer to numerical based sections of the prosthetics and orthotics course. These elements of the course are easy for people with engineering, physics or maths backgrounds but also for those who had found maths easy and logical in school

> *...I mean it's helped me; it was helpful last year because we did quite a lot of calculations and so, and I was very good in maths and physics and it was, just to know how to rearrange a formula and things like that...*
>
> *Catherine, year 1, University B*

Most students had some experience of numerical subjects but one student had no prior experience and found that the maths based concepts were the most difficult subject areas for her.

> *…but I had no physics and I found that was the most troublesome.*
>
> *Melissa, year 3, University A*

Seven past and present students who mentioned that they found this aspect difficult often mentioned a barrier or mental block.

I had a sort of mental block over maths, I don't like maths, there's lots of maths in mechanics.

Staff 8

For one student this manifested itself in her emotions and she felt that this stemmed from her prior school experience of maths.

...I remember in the first year I got to the exam and I sat there and I was crying in the exam, because I thought "I really don't [know]". Numbers have this effect on me, I think I have, because I did so badly with them at school, as soon as you give me a mathematical problem I just want to cry. And I can feel it, it's like a physical thing.

Helen, year 2, University B

However, even if a person does find calculations problematic this doesn't necessarily impede their ability in understanding the related concepts that they will use in clinic.

I just totally, just almost a pathological, just a total barrier that came down when you were faced with formulas, numbers, whatever. And such a, a, a terrible barrier to learning, you know, and not, just that, just terrible. And yet biomechanics was so straight forward for me as a fourth year student on clinical placement and working with people.

Staff 6

Those who find maths based concepts problematic deal with the difficulty in different ways. Some shut down, whilst others realise that they can learn and

pass the exam by memorising the necessary equations rather than gaining a deep understanding of the concepts.

> *… the proof of, was it, stress and strain and when I figured out that you had to do it when you were just proving it and it wasn't numbers, … I just copied it out a ridiculous amount of times [laughing]. And it came up in the exam, it was great, I was so happy. And I'm writing it, I'm going don't even know what these symbols mean, it's great [laughs]*
>
> *Andrea, year 1, University A*

This suggests that prior experience of maths has an impact on how people approach the maths based concepts. Those with "good" previous experience have no difficulties. People who have had "bad" prior experiences or who have been told that they are not good at maths find that there are difficulties. The difficulty appears to be mainly their perception of their ability in maths, rather than any inherent conceptual difficulty.

4.2.4 Hidden understandings

Lecturers who teach the numerical aspects can be assumed to be experts in using these calculations. They feel comfortable using them, and may take short cuts or make assumptions within the calculations as Melissa found.

> *... I'd have to go and see Paul or Jill and there was a line missing, there was something, "ah you've got to do that to get to that"...*
>
> *Melissa, year 3, University A*

One member of staff observed that students don't always follow equations and he needed to break them down into smaller steps.

> *I just started writing the equations for the stress/strain graphs and stuff on the board, start to spout and I turn round. Some of them were just writing and others were just like staring at me and the board and you could just tell by the expression, it was like "oh my god, what's he going on about?" ...I did have to do what I don't normally do and [unclear] right ok, let's start again, let's start with this, and let's start just with one equation.*
>
> *Staff 3*

It is known that with experience certain knowledge and practices become tacit. Realising this and then making it explicit may be difficult for experts. Perhaps lecturers need to reflect upon aspects that they find easy in order to gain awareness of what shortcuts and assumptions they are making. With the variety of backgrounds displayed by the prosthetics and orthotics students any assumptions should perhaps be explored.

Previous experience with maths, the relevance, application and alignment of the topic and the tacit understanding of experts all contribute to the troublesomeness of numerical concepts within prosthetics. Students tend to learn enough to pass the assessment but then forget the knowledge. It may be bounded due to the perceived barrier enclosing and preventing access. But because it does not alter how a student views the world and is not used within clinical practice, it lacks the transformative and integrative nature of a

threshold concept. Whilst there are procedural concepts associated with the maths based learning they lack links to disciplinary concepts and to ways of thinking and practicing within prosthetics. I suggest that “the trouble with numbers” is not a threshold concept but it may contain basic concepts.

4.3 The trouble with the body

Prosthetists need to understand the human body and the effect of certain medical conditions upon it. They use this knowledge in clinic both practically and to inform their prescription decision about a person and their current and future needs. Knowing about the body was identified by one staff member as a key piece of knowledge for prosthetists. The approach to learning and teaching in this subject area is different at the two universities. University B uses a problem based learning format with prosthetist/orthotist lecturers facilitating the sessions and problems focussed on pathological clinical scenarios. At University A the study of the human body is taught at a nearby HEI by non- prosthetists/orthotists. Here I focus on the difficulties encountered by students in the understanding and application of knowledge about the body and note the difference in the type of difficulty at the two institutions. I also explore why I consider the trouble with the body to be troublesome but not threshold for prosthetics.

4.3.1 Crossing the threshold

Study of the body appears to be problematic for some students due to issues

of curriculum design, their unfamiliarity with the subject area, and the need to visualise underlying anatomy. Alignment of this subject with the prosthetic modules impacts on the depth of understanding, with aspects that are perceived by the students as less relevant becoming ritual and inert knowledge, as they have, perhaps, taken a surface approach to learning. Whether the learning is facilitated by disciplinary experts or service taught also appears to impact on the how students perceive the subject. With a lack of relevance to clinical practice causing more difficulties when the subject is service taught. Different disciplines within health care will have different perspectives, varying in the areas and aspects of the human body studied. Lack of previous theoretical experience of the human body can result in knowledge appearing alien. For some it is a totally new subject and this appears to impact on their ability to see the relevance of aspects of it to clinical practice if the relevance is not made explicit. The application of anatomy in a clinical situation appears to be problematic as students need to gain a visual image of human anatomy and experience variation across different people to gain a full understanding of what is beneath their fingers. Grasping a understanding of anatomy and being able to apply it may transform the way a person perceives the human body but the level of transformation does not appear to be great and is perhaps linked instead to the understanding of the processes within prosthetic clinical practice. This understanding is bounded in that the depth and the areas of human biology needed for prosthetics are different from those areas needed for other professions. Those aspects that have become ritual knowledge are lost but those that are relevant and applied may well be irreversible. There are

certainly basic concepts with “the trouble with the body” and there are some procedural concepts related to anatomy. However there do not appear to be any disciplinary concepts. The basic concepts may contribute to disciplinary and procedural concepts in other conceptual areas of prosthetics. So aspects of the study of the body partially meet both the the criteria and the concept models of threshold concepts but they do not meet them fully. “The trouble with the body,” therefore, may be a stepping stone or a piece of the jigsaw on the way to another more transformative and integrative threshold concept.

4.3.2 Why? How? When?

Students see the relevance of certain aspects of studying the body, especially pathologies, but for physiological aspects they find the relevance difficult to see and tend to memorise these aspects.

> *[I] wish we did more of the pathologies more in depth because when we’re in a clinic when we’re on our placement, I don’t actually see anybody coming in and asking me going "well could you tell me about the twenty steps of embryology?" but they might ask me "well could you tell me about the symptoms of Marie-Charcot-Tooth? [sic]".*
>
> *Marian, year 1, University A*

The depth of understanding for elements that they do view as relevant is not always at the appropriate level that they need for clinical work. Perhaps the relevance and application has not been emphasised enough. However, because at University A these classes are service taught by non-clinicians

they may not be able to provide the links to practice and therefore the depth required.

> *… you say this is the knowledge you should come to this module with, … "oh yeah, lower limb anatomy, yeah we did that". … "we did that, we sat in the class, we listened to the person, we did the labs", but they're not being honest about how well they understand that.*
>
> *Staff 6 (emphasis participant's own)*

Marian gave an example of knowledge that had become ritual and inert. She had to start at the beginning of the sequence to find the answer which may have been because she was not aware of why some knowledge of embryology was relevant and applicable to prosthetics.

> *…with embryology just trying to follow, trying to trace it from start to finish. Like, I find it, say if I was just asked a question, when does this occur, it would be hard to tell you if it happens at the start or the end, I would need write it all out, learn it off, like from one to ten*
>
> *Marian, year 1, University A*

One student commented that she had struggled with certain aspects because she failed to link different aspects together. Karen explained that because she failed to connect human biology to prescription, she had been unable to apply the knowledge and see its relevance until later in the course.

> *...which is something that I've never really connected before because of*

never really understanding the anatomy and pathologies and stuff like that.

Karen, year 2, University B

Jonathon thought that his knowledge of anatomy was good, but once on placement realised that he needed to understand it more. Its' application and relevance to clinical prosthetics was emphasised by practice.

I thought that my anatomy knowledge was fairly good until I went on placement, and found that it needed a lot of work.

Jonathon, year 4, University B

Alignment between human biology and prosthetic modules also seems to cause difficulties. For one member of staff the difficulties arose due to failure of the students to understand why they were learning a particular aspect but implied that it was also a failure of the course structure.

I'm thinking that the students don't see the importance of learning that and understanding that. Because, well why would they? Why would they put an importance on learning lower limb anatomy if they don't know what's coming next in the course.

Staff 6

Changes to the course at University A have altered the alignment between modules. The students appear to expect staff to know where concepts are located within the whole course (new version). They also appear to perceive that staff fail to realise that there is a difference between what previous

students knew when taking a particular prosthetics module and current students, perhaps suggesting that lecturers need to adapt their teaching.

> *...we're only just learning anatomy alongside at the same time which was difficult 'cause you're having somebody firing at you "oh you should know that" because when they did it years before they'd done an entire year of ...lectures and anatomy and everything and then came in for four weeks and we're going <u>they only taught me this on Monday and it's Wednesday and I don't know!</u>*
>
> *Andrea, year 1, University A (emphasis participant's own)*

But the issue of alignment with other aspects of the whole degree programme was also raised by two students who are on an older version of the course.

> *We did spinal orthotics but we didn't do spinal anatomy 'til two months later.*
>
> *Melissa, year 3, University A*

Learning pathology does not seem to be so troublesome for the students. Perhaps its relevance is more obvious to them and they can apply it in a clinical situation. Five students commented upon the influence of pathology in prescription.

> *...but I took the fact, he had PVD so that suggests that there might be health, systemic health issues which might suggest that he is not likely or able to be so active ...*
>
> *Sidney, year 2, University A*

However, the majority of participants did not mention pathology in their prescription rationale, perhaps indicating that it does not have great significance attached to it when prescribing. Or it may be that the students have not yet experienced the variation in conditions and prescription that occurs in clinical practice. It may also be that for lecturers the links between the condition and prescription have become tacit. Or perhaps it is used clinically in a different way to the way it is presented in text books.

Lack of explanation of how and why the different elements of human biology are needed for clinical practice appears to be problematic. Lecturers without clinical experience may find this difficult to put across, not due to a lack of expertise in human biology, but due to a lack of expertise in how it is applied within prosthetics. The depth of understanding required again may be difficult for them to ascertain. It appears that the links to clinical practice need to be made more explicit for the students. The relevance of pathology, however, appears to be clearer for students. The issue of alignment between modules did not appear to be an issue for the staff or students at University B but the learning and teaching approach was commented upon, though it is not explored here. It seems that issues with timings of certain topics across the year affects students' ability to learn and understand other concepts, particularly in relation to prosthetic theory and practice, applying their knowledge of the body. Both staff and students need an awareness of the whole course structure. Lecturers need to know what and when has been covered in other modules. Students need to know how different topics in

different modules link together and when and why they need certain information.

4.3.3 Previous experience

Prior experience of studying biology and the human body has an effect on the students' perception of the subject and their ease of understanding it. Lack of experience appears to increase the difficulty.

> *...life sciences I find really difficult and it's my worst class, because I've never done biology or anything like that before.*
>
> *Marian, year 1, University A*

Whereas Melissa had previous experience of studying the body from another health care profession and struggled to understand why her colleagues found it difficult.

> *They found it hard and I couldn't understand why they found it hard, and I'd say but it's really real. I was amazed in my class how many people actually would fail the anatomy exams.*
>
> *Melissa, year 3, University A*

As with maths experience, experience with biology affects students' perceptions of that subject. The level of experience affects the starting point for students and whether they find it easy or difficult. Although no student mentioned a barrier when studying biology the gap in their level of understanding of different subjects may create a perceived hurdle.

4.3.4 Hidden understandings

Anatomy is predominantly learnt by prosthetic students in the United Kingdom from a book or handouts rather than through dissection. Anatomy is viewed as a drawing or photograph with little connection to a real person so, as explored above, there are issues with making the relevance and application of the concepts more explicit. In clinical practice we must link those images to what we feel through palpation of the person's body and have a good understanding of surface anatomy.

> *...when you're locating bony landmarks, you sometimes think that you've got the right area and then you haven't...*
>
> *Edward, year 3, University B*

Karen commented that she would like an x-ray of the person's residual limb, suggesting that she has not yet learnt to connect what she is feeling with mental images of anatomy.

> *… in trans-tibial we have a sheet with where you put the markings on the stockinette, … but then when you can't find it on the person it's just like ah ok let's have a feel and see what we can find [laughs]. Be good I think if, if you could be given like an x-ray of someone, … it'd be great if you could see exactly where things are and then actually then, sort of, think right well that's just the skin on top so I should be able to find things quite easily and understand it more.*
>
> *Karen, year 2, University B*

Because we are dealing with people who have had an amputation or who have a congenital deficiency the underlying anatomy may differ from the "normal" and students sometimes have difficulty in identifying what is there.

> *I still struggle with the anatomy, especially if it's, you know, [not] what you'd expect it to be. I feel the other day I had trouble with him, casting him, because there, things that weren't quite in the right place that you'd expect to find it. I was like whoops where's that?...*
>
> *Karen, year 2, University B*

The addition of plaster bandage also adds another problem to the visualisation of anatomy as it can feel different again, through both plaster and skin and soft tissue.

> *... before I put that cast on I was like feeling about [the anatomy] and I got my lecturers to come and check it and stuff but it was just like once you have the [plaster] wrap on like trying to re-find that place that you've got, … you never know if you're quite right and stuff.*
>
> *Jane, year 1, University A*

Prosthetists have to also use their internalised images of anatomy in rectification. Alterations that we make to the plaster cast must be done in a way that is anatomically correct.

> *… in rectification, I sometimes, and I suppose build ups [additions of plaster], I think "oh my mall, my lateral malleolus is like a brilliant build up, it's gorgeous" and then the lecturer might come and say , "it looks a*

bit pointy, does that look anatomical to you?" And I'd be like "oh no actually it doesn't, it doesn't look like my ankle".

Marian, year 1, University A

In reality human anatomy can vary from the standardised format presented in text books. Students need to build up experiences of variation in anatomy, through experience with a wide range of people, in order to assist them in understanding it. Only with this experience of anatomical variation can they accept variations from the normal.

The main difficulties in studying the body relate to the position of the subject within the overall course and its relevance to clinical practice and the development of a mental picture of anatomy. Previous experience affects how students approach and cope with the subject but it is possible that alternate learning and teaching approaches and changes to curriculum design may alleviate issues due to alien knowledge. Even though "the trouble with the body" partially meets the criteria and concept models of threshold concepts, it lacks transformative power, and does not link to a disciplinary concept. Therefore I suggest that "the trouble with the body" is not a threshold concept.

4.4 How we walk

Walking or gait is an important aspect within prosthetics and orthotics. Prosthetists need to understand both normal and abnormal gait and be able to observe and identify variations in gait. An understanding of the biomechanics

of gait (location of forces in relation to joints) and the ability to identify variations from normal walking (gait deviations) is required. These knowledge and skills are used together with our knowledge of the causes of these variations in order that the prosthesis can be adjusted (if appropriate) to reduce or eliminate these variations, a process called dynamic alignment. Problematic areas within learning about gait were identified by both staff and students. These include difficulties arising from the relation of supporting modules to the core prosthetic modules, a lack of prior experience in the observation of gait and the development of tacit understanding and mental images of what happens during normal and abnormal gait. In this section I explore these difficulties and why "how we walk" may be a threshold concept in prosthetics.

4.4.1 Crossing the threshold

Prosthetists identify people with amputations and other conditions, walking down the street and can sometimes even identify what type of prosthetic knee has been prescribed. This integration into everyday life happens during the students' time at university, at an early stage in some cases.

> *...you end up trying to see what sort of amputation they've got and what socket they're wearing and what sort of shoe they've got on or, oh that's slightly too long they've got a bit of a. You end up gait analysing people and like, "stop it", you have to tell yourself. But that's what's become, being blasé about, there isn't that many amputees in the world*

but you just see a lot of them all the time.

Suzanne, year 3, University B

...every time, every time I walk down the street I see people with gait deviations everywhere, I can't help it. And I can't believe that there are so many people with them. And I spot them everywhere.

Marian, year 1, University A

… I'm a cashier in Tesco and they have very long straight aisles and you can see people walking up and down. I'm like, I can, I'm just analysing people's gait now all the time now...

Therese, year 1, University B

These students have experienced a change in the way they view gait. It has become part of them, and the way they view their world. It appears that they have crossed some sort of threshold.

There are certainly troublesome aspects of understanding how people walk. Learning gait deviations may initially be memorised and effectively become ritual knowledge. The information may become inert if the student does not move away from viewing deviations as list. The concepts explaining how we walk are alien to everyday understanding of walking. The theories behind gait are initially complex for students but are basic for experts and have become tacit, and this creates issues in explaining and enabling students to "see" the variation and forces in walking. Some troublesomeness may be averted by

altering the focus of the learning and perhaps by considering where within the programme it is introduced to the students. Once gait is understood it transforms the student, resulting in them watching people walk outside a clinical environment. It requires integration of various aspects including normal and prosthetic variations, forces and components. It is bounded by the particular approach to exploring gait but shares the boundary with other professions such as physiotherapy and of course orthotics. Because it is in constant use by prosthetists it is hard to imagine that people would lose their understanding of this concept. "How we walk" involves both basic (the stages of gait), procedural (the process of observing and correcting gait) and disciplinary (viewing gait as forces acting on the body) concepts. The procedural and disciplinary concepts are intertwined with procedural concepts requiring experience in observing gait, which transforms the student's way of viewing walking. Therefore it is proposed that "how we walk" is a threshold concept in prosthetics.

4.4.2 Why? How? When?

Awareness of relevance improves as students progress through the course and Jennifer commented on this, but also highlighted the need to foreground the relevance.

> *For a while I didn't understand why we were learning so much biomechanics...As we did more practical work, I found we were beginning to apply the biomechanics to actual P&O. Just being shown why we had to learn certain things helped me realise why it was*

important to understand it….Don't dismiss things as irrelevant- it'll just be that you haven't found out what its application is yet!

Jennifer, year 4, University A

When lecturers revised biomechanic topics, in a prosthetic theory class, the understanding developed, suggesting that highlighting the relevance and application has a positive impact on learning.

I think they've realised that when Oliver and Cathy for example, do just recap the biomechanics it falls into place for everybody much quicker.

Melissa, year 3, University A

This repetition and revision made it easier for Sally and made an impact on her understanding of clinical prosthetics.

It was well explained in mechanics classes and then again in P&O science classes so when it came to having to put the theory into practise it was easy enough as we had thought about it a few times before….Aligning sockets is definitely much easier when you understand what is happening and why.

Sally, year 4, University A

A lecturer commented on students' perception of their experiences within the supervised clinical situations as not being "real" to them and therefore they approached the situation differently. Emily also commented on this feeling that the clinical work isn't reality; it's not someone's actual leg.

..it's not someone's [real prosthesis], they're not walking on it thinking oh I'm going to have live with this for a year, whatever. So there aren't any problems to solve.

Emily, year 2, University B

This may result in students not linking what they do in the university clinic to what would happen in a real hospital clinic and the impact on the person wearing a prosthesis. Students may fail to see the "real" relevance of the concepts.

Altering the focus of learning appears to affect how students understand the principles behind alignment and gait. Andrea comments upon a session where the focus was on learning about different prosthetic knees, but as part of this she had to align several prostheses and at the end of the session realised she had also learnt about alignment.

[They brought in] all different kinds of knees and alignment wasn't the issue but you had to set up all these knees. But we were setting up to see how the knee worked. So you're just setting them up because you had to, but no one was going to come over and say "oh you know you're getting a lateral whip here, you're getting that". ... So we must have set up six, seven [prostheses] during the day. And it was at, actually at the end of the day when I was putting the last thing together I'm realising, see if you'd given me this any other day I'd've freaked out about doing it. ... So it was not having the pressure on of doing it [alignment], it was the,

it was a by-product.

Andrea, year 1, University A

One of the lecturers also commented on this session and the positive effect of altering the focus of the learning.

Now it's under the pretence that they're getting experience with the different types of knee joints. And each one's in a category, so different types of swing phase, different types of stance phase and almost everything's covered. It's under the pretence that that's what we're, we're doing, you'll get a chance to try out this knee. But each time they do it they have to bench align and align that knee. And before you know it and that's another one where you see the lights going on...

Staff 4

So by altering the focus of the learning away from an aspect of troublesomeness, but still requiring engagement with the difficult aspect, students may find it easier to approach the troublesomeness.

The need to make the relevance and application explicit is again highlighted here. Repetition of topics can have an impact on learning, but the difficulties may also be reduced because the repetition was linked to a core prosthetic module so issues of alignment are also present.

4.4.3 Previous experience

Whilst everyone is familiar with walking, prior knowledge is limited to an

everyday understanding. The process of dynamic alignment (observing the person walk and altering the positioning of the prosthesis according to what you find) is new to all. Three students had prior prosthetic and orthotic technical experience. Emily explained that although this gave her some advantages over other students, dynamic alignment was new to her and her previous experience was of no assistance. Another student with prosthetic technical experience also made a similar comment.

> *I could bench align a trans-tibial prosthesis but when it was on the patient, again, I was at the same level as any other student technically.*
>
> *Edward, year 3, University B*

The descriptive element of biomechanics is generally a new concept for all students, though there will be some exceptions. It is new even for those with prior experience of engineering who may be familiar with the calculation elements but not the descriptive side.

> *Well I suppose the biomechanics really is sort of new to me in respect, but all the mechanics I've covered it all before.*
>
> *Marian, year 1, University A*

However, students may have pre-existing assumptions about gait. Marian commented that she had made an assumption previously that all amputees of a certain level would exhibit the same gait deviations. Eventually she came to realise that this is not the case and that there is variation in how people walk, demonstrating a change in her way of viewing gait.

> *...all the different ways that people with the same level of amputation, all*

the different ways they walk and just because you have two trans-humeral [sic] amputees, or people with trans-humeral [sic] amputations, that, that they can walk completely differently. And initially I, I, I didn't... I suppose [at] the start of this year I just thought they would have the same gait deviations and stuff like that but then when I was watching other people's patients walk, I was just like, god there like, there's a real difference.

Marian, year 1, University A

Apart from a pre-existing assumption, in "how we walk" previous experience has little impact on students' understanding. There is little variation among students and the whole concept is new to them.

4.4.4 Hidden understandings

Prosthetics uses Newtonian biomechanics as its theoretical basis. Newton's third law states that every action has an equal and opposite reaction. For example the chair one sits on is creating a force downwards through the floor and the floor is creating an upward force that is equal in size and direction. So when people are walking they send a force down through the floor and the floor sends a force back up. This upwards force is known as a ground reaction force and is invisible. Through research on gait, using force plates and computer software, the ground reaction force can be visualised. Through computer software, diagrams of what happens during gait can be created and used to explain the effect of the ground reaction force on each joint of the

lower limb at different stages of the gait cycle. The images of where the ground reaction force is directed are then used by the prosthetist during alignment in positioning the limb to enable the person to walk as best they can. The forces acting on the person's residual limb (socket forces) can also be visualised. Altering the position of the prosthetic limb affects these forces.

Four lecturers mentioned the visualisation of socket forces as an aspect that students find difficult. Two mentioned that drawing diagrams of the forces, and therefore providing a visual image, assisted with understanding.

> *...the way that the alignment moves, where they see the forces, when you can draw, I try and draw it on the board, free hand what they're, what they're seeing on the patient and try to get them to put on the ground reaction force and the support force and try and work them through the problem and they suddenly see the moments going the right way and, and they can grasp it.*
>
> *Staff 4*

But it also continues to be problematic for some students. The same staff member expressed frustration when students fail to grasp the impact of forces on gait.

> *...some of them don't understand that a knee joint in front of the weight line going to buckle.*
>
> *Staff 4*

Jennifer found understanding the biomechanics of gait difficult, but she was not alone. She found that a picture helped with her understanding.

Jennifer: I found it difficult to visualise what was happening at each stage, complex with so many joints involved

Question: What helped you to understand it?

Jennifer: Drawing stick diagrams of the situation showing the various forces

Question: Were you the only one who found it difficult?

Jennifer: I don't think so!

Jennifer, year 4, University A

Experiencing the effect of excess pressure in a prosthetic socket in a clinical situation can assist with the visualisation and understanding by providing a memory of a person and what happened. It also increases the variation of experience thus building up a mental picture of what can happen.

Andrea: ...and trans-femoral helps because my patient had [pressure] in their groin and you couldn't have it up there, so that meant that it was pushing that way, so you had to make sure that that pressure wasn't high and that just made it, you know, it made sense that way 'cause it, it was going round that way

Interviewer: ok, so you were able to visualise what was happening?

Andrea: yeah, I could see it and that worked.

Andrea, year 1, University A (emphasis participant's own)

Questioning what is happening in terms of the forces and making the links between what they see and do and the theory can impact on their understanding. However, this may be some time after and with some oscillation between understanding and not understanding. This suggests that this is a concept that may not be quickly grasped, and requires links to be made between theory and practice.

...they can understand how an alignment unit can change the limb set up and what gait deviations that will cause. And that's really laterally after they've really studied, they've had some alignment experiences, then they've gone back to the books. And they get to grips with that and then you say "well ok so, for instance, the patient has a lateral thrust of the knee so where are the excessive stump socket interface forces going to be?" and then they, that's another bolt on that they hadn't actually considered. So it's making those links to what they're changing with the patient, on the patient, with their prosthesis and how that then links to what they've learned in biomechanics.

Staff 6

As well as knowledge of the forces, students also need to develop knowledge about and visualisation of gait deviations. Variation within this aspect of

walking is vital. Students appear to find some deviations easy to recognise as Sidney found.

> *...watching somebody walk and, I can do the simple things, I can see, spot a drop foot, I can see foot slap, that sort of thing.*
>
> *Sidney, year 2, University A*

At other times the level of the amputation exaggerates some deviations as Edward found.

> *When we fit the hip disarticulation patients, they presented with some quite obvious gait deviations, they were very obvious gait deviations, they were very easy to spot. But other times, you know, it's been, it's been quite tricky.*
>
> *Edward, year 3, University B*

Marian found that the more she observed gait and the more deviations she noticed the easier it became. She needed to experience variation in gait patterns in order for her to be able to identify different deviations.

> *…initially the difficulty was to see what was wrong, so to see the gait deviations, so the more accustomed, or the more gait deviations I saw then the easier it came to distinguish them from, from normal gait.*
>
> *Marian, year 1, University A*

Tying up the principles of gait deviations with the practicalities of what to alter to improve the person's walking makes the whole process easier as noted by Sally.

Aligning sockets is definitely much easier when you understand what is happening and why....You need to be able to realise when a deviation is caused by the socket or prosthetic alignment and when the problem is with the patient, eg muscle weakness or contractures.

Sally, year 4, University A

Creating a picture by imagining oneself as a person with a gait deviation assists with understanding, rather than learning a list. One student and a staff member commented that deviations began to make sense when they stopped learning them as a list presented on a piece of paper.

I really started [to] learn those [gait deviations] when I started to be able to visualise them, to really understand them to actually try and carry those out, so have a walk round the living room with one shoe on and one shoe off or sticking your leg out to the side. And I think once you, you can then start to really, kind of, internalise them rather than being a list.

Staff 2

Edward commented on variation between the novice student and the experienced prosthetist in their ability to recognise gait deviations. This suggests that some aspect of recognising gait deviations has become automatic or tacit in experts.

… whereas somebody who's got a trained eye will, will know straight away...

Edward, year 3, University B

Being able to visualise the forces acting on the body during gait enables students understanding of what happens when we walk. The impact of forces in the wrong location or wrong direction in walking can also assist with this understanding. It seems that to assist students in understanding the principles of gait and alignment they need images in their minds of how people walk and where invisible forces are directed. They gain this through internalising images of forces, experiencing variation in the way people walk and how to correct abnormal gait patterns. These images of people walking are gained through experience in the clinical environment but also through watching people in the street.

Effectively prosthetists see things that a member of the public does not see and this requires integration of the knowledge and a transformation in identity and in how walking is perceived. This remains with the prosthetist as it used on a daily basis not just in clinic but also unintentionally. Learning this is troublesome due to its visual nature and the need to view walking in a different way. How and when the theory behind gait is presented to the students may also impact on its troublesomeness. Understanding of gait is bounded through its specialised nature especially in terms of alignment of the prosthesis, but it shares similarities with other professions' understandings of gait. Experience and the development of memories are important in the acquistion of procedural concepts. Disciplinary and procedural concepts combine together and build upon basic concepts, altering the way in which a person thinks and practices. Therefore I consider "how we walk" as a potential threshold concept in prosthetics.

4.5 Considering the person

The assessment of a person's prosthetic needs and the subsequent prescription of a prosthesis is central to the prosthetist's scope of practice (British Association of Prosthetists and Orthotists 2010). From my data students appear to struggle to relate what they want to prescribe for the individual and instead either list advantages and disadvantages or describe the component in detail. However, students appear to progress through some stages in understanding prescription, from component focussed, to person centred and to a holistic view of prescription. Here, I focus mainly on the "hidden understandings" involved in "considering the person", with some discussion on curriculum design and the impact of previous experience on the difficulties experienced by students and suggest that "considering the person" is a threshold concept.

4.5.1 Crossing the threshold

Two members of staff identified the individual and their needs as being a fundamental concept for prosthetics.

> *... the importance of putting, of recognising that the individual or the patient is really the centre of all that they will do. ... It has to be the individual, they have to be interested in working with people, you know, and recognising that, that it's the person themselves that, or the whole person that they should be considering.*
>
> *Staff 7*

Recognising the variation in people and the impact this will have on prescription affects students' ability in problem solving as this staff member suggests.

> *...there's always going to be another completely different patient when you go out into the real world and they need to be able to problem solve a way round that. [unclear] you know, we'll show them trans-tibial patients that are unilateral trans-tibial patients but what if they're a hip disartic[ulation] on the other side with a partial hand on one, [laughs] you know. ... If you can't problem solve your way round these things then you're not going to get on in life, in our job.*
>
> *Staff 8*

The data from six of the lecturers suggested that they focused their prescription on the individual and his needs and abilities.

> *He's a carpenter so you're talking about somebody who has upper limb dexterity and therefore wouldn't have any real problems with managing the prosthesis in terms of rolling liners on or donning or doffing.*
>
> *Staff 7*

The data from students indicated a focus on the advantages and disadvantages of the components but eleven students had progressed to link the prescription with the individual to varying degrees. Here Tom combines component advantages with a patient group.

> *I think he'd rather benefit [from] a Super SACH [Solid Ankle Cushion Heel], 'cause they're light and they reasonably comfortable because of*

the cushion that they have and yeah, they are usually designed really for the people who just want to sat [sic] and relax, the older market usually

Tom, year 3, University B

This lack of focus on the individual is possibly due to a less developed mental map, which does not contain sufficient information to enable students to link with and individual's needs. However, two staff members also used component focussed rationales in their prescription choice rather than link to the person's individual needs. In this case this lecturer did not refer to Fred's individual needs when prescribing a prosthetic foot.

…a fairly simple and reliable foot like a dynamic foot.

Staff 6

So a person centred view of prescription is perhaps an "expert" view and what happens when you cross a threshold, but there may also be variation amongst "experts" with not all demonstrating this view. It may also only be a step along the path to expertise.

Eleven of the students were able to link the component prescription to the individual's needs, though the level of doing this varied. Jennifer was able to recognise needs related to a particular group of people with an amputation (in this case people who have recently had an amputation), demonstrating that she was on the path towards person centred prescription.

As a recent amputee it would be beneficial to have as much

adjustability as possible both in the socket and the components.

Jennifer, year 4, University A

Ben linked the function of a component to one aspect of individual need but also included the aspect of quality, which is not related to individual need indicating perhaps some oscillation in understanding the concept.

The foot is good quality and activity level so he can keep walking to church.

Ben, year 4, University B

Catherine commented that the functional aspects of a particular prosthetic foot were suitable for the individual, which demonstrated that perhaps she was at the beginning of the path towards person centeredness.

...because it said he is, it seems that he is an active prosthetic user and if he wants to work in his garden and he wants to go to church, so that [the foot] adapts quite good to uneven terrain, uneven ground.

Catherine, year 1, University B

Emily directed her attention onto the individual and his specific requirements before moving onto what component might meet these needs, showing that she had developed a person centred view.

I'd look at how, how, what kind of grasp he might need how, how, how wide his hand needs to open to hold those types of devices maybe to make it look more natural.

Emily, year 2, University B

Part of a prescription rationale is excluding what is not suitable as Melissa was able to do. So Melissa was also on the way towards person centeredness.

> *The gentleman's active, whoo, I think back to feet and things, not a, not a SACH [Single Axis Cushion Heel] foot.*
>
> *Melissa, year 3, University A*

Staff were able to see future developments with the people in the clinical scenarios and commented upon this in their prescriptions. A couple of students were also able to achieve a long term perspective, demonstrating that they had achieved or were close to achieving a person centred view.

> *…once his volume stabilises, a new prescription could be considered.*
>
> *Jonathon, year 4, University B*

Holistic management was also evident, with staff and some students considering psychosocial needs, the person's history, the impact of mood, and the input of the inter-disciplinary team in the rehabilitation process in addition to the needs of the individual.

> *He lost his arm <u>recently</u> due to a car accident, right ok, so how's he, how's he coping with that you know, psychologically, how's he coping with that.*
>
> *Staff 3 (emphasis participants own)*

Holistic awareness wasn't only apparent in the prescription scenarios. Jane found that reading a book had given her awareness of the impact of amputation.

I'm actually reading this book at the moment called "Nine Lives" which is a story, like nine different amputee stories and it was, you really don't realise what some of these people have been through.

Jane, year 1, University A

Tom realised the impact that the individual had on himself and his management of the person.

… the attitude of the person, obviously someone coming in, comes in a bad mood so it could be very distracting 'cause you'd be trying to calm them down.

Tom, year 3, University B

Two lecturers and one student considered the involvement of other health care professionals.

Only the fact I would assume that the physiotherapist would be involved in working hard to get that flexion contracture out.

Staff 6

This awareness of holistic management demonstrates another perspective on prescription. It may also require experience of variation in people's ability to cope with amputation, and of the involvement of others in the rehabilitation process. This may be the final threshold within "considering the person".

Prescription is initially problematic for students, as they seek definites, wanting there to be one solution to a prescription. They deal with this difficulty by

focussing on the components and their advantages and disadvantages. At some point there is normally some recognition that everyone is an individual and their needs are different. The variation in prescription options and the need to focus on the individual becomes accepted as normal. Those staff and students who did not consider the individual's requirements perhaps have a different understanding of prescription compared to those that do. Finally within this concept the view of a person changes to a wider, more holistic focus, involving recognition of psychosocial issues and the role of others in the management of the individual.

The prescription process is certainly troublesome. Learning the advantages, disadvantages and potential patient groups for different components may be initially memorised and becomes inert as a result. To move on from this surface approach to learning, students need to experience a variety of components and also gain experience of different prosthetic users wearing the components. A mental map of memories of people and their prosthetic management is developed and is drawn upon to assist with the decision making. The variation available through university classes is limited. The real process of variation acquisition only appears to begin once the student is on clinical placement. It is very possible that elements of the prescription problem solving process become tacit in experts. It is also subjective, thus making it difficult for newcomers. Learning about different components is initially alien and linking the individual's needs to whether particular components are suitable is complex. Achieving a level of understanding that places the individual's needs at the centre of the prescription process transforms the

student from focussing on the components, to the individual her/himself and then to a holistic view. It requires them to integrate knowledge about components with knowledge about the person and their needs and other aspects of health care. This combination of knowledge forms a boundary around the concept of prosthetic prescription as no other health care professional has the depth of knowledge of this combination. Since the concept of placing the person at the centre for prescription is used daily it is unlikely to be irreversible, but it is possible that there are at least three different ways of understanding prescription: a component focussed prescription, a person centred prescription and a holistic prescription. These different ways of understanding may be hierarchical, with the inclusion of the former view within the subsequent view. The basic concepts within "considering the person" are possibly knowledge relating to advantages and disadvantages of different prosthetic components. Procedural concepts may include the process of assessment during which information about the person and their prosthetic management is obtained and is transformed into memories. How the individual then views the management is then the disciplinary view with a holistic perspective being the disciplinary "way of thinking". Therefore I believe that "considering the person" meets all of the criteria within the criteria model and contains both basic, procedural and disicplinary concepts with associated memories. I suggest that "considering the person is therefore a threshold concept in prosthetics.

4.5.2 Why? How? When?

Classes in prosthetic theory and practice occur throughout the degree programmes at both universities, currently culminating in a year of clinical practice. These classes are perhaps viewed as the core modules of the programmes with the other modules taking supportive roles. As such there are fewer issues with relevance, application and alignment within these core modules. Conversely the supporting modules can prove troublesome in their relationship with the core modules. However, entering the "real world" of prosthetics, as opposed to the university clinics, does not occur until year four of these programmes. Because of this there is some distance between what is learnt at university and actual practice in the real context. Sometimes learning does not fall into place until placement. Earlier placements have now been introduced at both universities. At University A this is from third year and at University B from first year. This may assist with relevance and application of the supporting subjects. But it may generate alignment issues as students will not have covered all aspects in class and it is not possible to predict who is seen in clinic.

Until placement students are not exposed to the variety of prescription options. The data suggests that what they chose to prescribe is affected by their exposure to the various choices as this staff member explains.

> *…probably just, experience and preference. Like I have a preference for TEC [Total Environmental Control] and TEC sleeves that the students might not have, they might just look at that, [and think] PTB*

[Patella Tendon Bearing] or ICEROSS [Icelandic Roll On Silicone Socket], you know, because that's what they've been exposed to.

Staff 8

But students do sometimes have awareness of aspects they have not yet covered.

The socket? Trans-tibial weight bearing, I think we haven't covered this in our, this in our last year lecture but I would go for ICEROSS

Catherine, year 1, University B

Issues with curriculum design do impact on the development of the knowledge base that students draw on to solve prescription choice. They can learn some of the variation in component choice and people, but clinical experience appears to be the factor that develops this more fully. Both courses have now introduced earlier placements and this may assist in lessening the difficulty students have in prescription.

4.5.3 Previous experience

All but four of the students who participated have no prior experience of prosthetic practice. Those who do have experience have gained this through working as a technician, fabricating prostheses or as a prosthetic user. Experience of componentry affects the range within which a prosthetist may prescribe. Experience of using the different componentry also influences their

choice. Three staff expressed a personal preference for certain componentry, based upon their clinical experience of using the components.

> *The type of cosmesis would be, really I'd prefer to use a sort of a Dawskin cosmesis or, or a, you know, what do you call it? A SkinFX or thing as well, so I think that's important in men and women, doesn't matter about their age, I just think that the, the days of the old stockings, it's just, I just think it's appalling.*
>
> *Staff 4*

But a student who was a prosthetic technician was also able to express a preference based on her experience.

> *… I don't really like friction wrists because I think they're really round and think they look really ugly, so for his cosmetic hand I'm not sure I'd give him a friction wrist, I'd give him an oval wrist 'cause it just looks more cosmetic.*
>
> *Emily, year 2, University B*

This type of personal preference in prescription is only something that can be developed through experience of using different prosthetic components. Very few students approach prosthetics with this type of experience. Therefore for almost all students prescription is a completely new concept.

However some students do come with preconceptions of prescription. Here Greg realised that he needs to consider the individual whereas previously he appears to have believed that there was only one type of prosthesis.

Greg: …that different prostheses, with different activity, not just one for all. So that bit has, sort of improved, you do know that [different components] can be used for running, that can be used for walking, and that can be used for swimming

Interviewer: ok, so it's not a one size fits all?

Greg: it's not a one size fits all.

Greg, year 1, University B

Some preconceptions can be maintained until later years of the course. Sally learnt that not all people with an amputation need or want a prosthesis, a change in her view of prosthetic management.

One major point that came out of the upper limb course last year was that prostheses aren't for everyone and patients should be given as much information as possible as to all the options before making a decision … Made me sit back and look at the whole person and any issues they have rather than jumping straight in and assuming prescribing a prosthesis is the solution for everyone.

Sally, year 4, University A

Whilst previous knowledge and experience of prosthetic prescription is limited amongst the students, they may have preconceptions some of which may take time to resolve.

4.5.4 Hidden understandings

Prescription is a difficult concept for students to learn. It requires students to identify pertinent information when assessing a person with an amputation and combine it with knowledge about prosthetic components. Variation in both people and components is essential and memories of these aspects join the theoretical knowledge to form a mental map of prescription upon which experts can draw.

Data from both lecturer and student interviews indicated that there was variety and subjectivity in the practice of prosthetists. This variation appears to be a problematic area for students. They initially want the decision of what to do for a person to be standardised.

> *I think P&O can be quite a subjective subject even for experienced people in doing it, where there is no black or white a lot of the time and people do have different opinions on how best to resolve the same situation. And that confuses the students a lot; they expect it to be black and white. This is this type of patient and this how you resolve their problems and this is the result you'll get at the end.*
>
> *Staff 8*

> *You know, it's just, there's a lot to learn actually with that, isn't there, there's so many different practices and people have got a right and a wrong for everything which makes it a little bit confusing.*
>
> *Karen, year 2, University B*

The variation in individuals and practices makes prescription difficult. One staff member commented on this and that many years after qualifying he still found it difficult, but the difficulty now appears to be the realisation that what is prescribed impacts on a person's life, rather than the process of prescription.

> *I think patient prescription's impossible. I've always found that, partly because of my own insecurities about whether or not I'm able to do this in the right way and whether my decision is affecting the rehabilitation of someone. ... just think every single person, no matter how straight forward they look or how difficult they look is not straight forward, everybody's an individual and you need to take a lot of time to sit down and consider it.*
>
> *Staff 4*

The difficulty with variation in prescription, is perhaps not obvious to the students whilst at university because staff select prosthetic users who can cope with the demands of student learning, therefore impacts on the development of memories of people.

> *...what they don't realise is our patients are kind of hand picked for them. They're not elderly diabetics who couldn't walk one length of the bars. So, so they, they think because they've got a good result on someone that is actually helping them as well, and maybe not flagging up all of the issues that "yeah it's easy, I can do this on anyone"...*
>
> *Staff 4*

Data from the interviews suggested that there were “standard” prescriptions that were used in practice. This may be a short cut to prescription used by an experienced clinician or an example of alternative understanding. Both final year students and staff drew on “standard” prescriptions.

> *...I’d probably go for something which is just going to meet their functional needs and try and keep it as light as possible for them, try to make it as reasonably cosmetic, <u>the usual</u>...*
>
> *Staff 1 (author's emphasis)*

> *This is a fairly standard prescription...*
>
> *Jonathon, year 4, University B*

The “standard” prescription may also be based upon stereotypes of groups of people.

> *...my stereotypes of what older, what elderly people may need...*
>
> *Tom, year 3, University B*

When deliberating on a prosthetic prescription both staff and students drew on images of people. These images may be based on prosthetic users that they have previously met. Students’ prosthetic user memories can be limited by their lack of exposure to the variation in people but over time this develops.

> *I’m just thinking of what we did in the clinic, yeah, just everything exactly with the patient I had and what I did for that patient...*
>
> *Marian, year 1, University A*

All students used memories of either patients or people they knew.

> *...[laughs] sounds like our old gardener actually, that's really funny...*
>
> *Karen, year 2, University B*

When they didn't have a memory to use one student tried to put herself in the position of the prosthetic user and imagined what she would want from a prosthesis in that situation.

> *...you would kind of imagine what a 34 year old man would do and again I'm putting myself in that, I try and put myself in that situation, and think well what would I want, you know...*
>
> *Helen, year 2, University B*

One staff member felt that they were "being naughty" in using a patient memory.

> *...do you know what I think I'm a bit naughty because I looked at this, I looked at what he'd done and I then I started to drift off, into previous experience ... I started thinking about who I'd seen who was anything like this bloke and I remember someone who was not exactly the same but similar and I thought [laughs] that's what I did.*
>
> *Staff 3*

Whilst generally useful these prosthetic user memories and stereotypes can lead to them making assumptions which can assist in deciding upon a prescription.

...they've got 2 children and 3 grandchildren, I suppose from the, from reading it you assume that they are nearby and that he's a grandfather and he enjoys playing with his [grand]children but he might not and they might live in Timbuktu and never see each other.

Staff 4

Staff members acknowledged that using assumptions can result in important elements for that person being missed and not considered in the prescription decision.

...in doing that [making assumptions] I might have missed a couple of little bits...

Staff 3

Whilst initially troublesome for the student it seems that these memories of people are an important aspect which is drawn upon when developing a prescription and rationale. Variation in the range of people expands the mental map creating a wider and more varied map upon which to draw. However, reliance on memories and making assumptions can potentially lead to the prosthetist not acknowledging the individual's requirements in their prescription rationale.

Employing a holistic view of prosthetic management appears to be an end stage in a series of thresholds beginning with a focus on components, moving onto the individual before finally considering wider aspects of prosthetics. The lack of variation in university clinics seems to be the cause of one of the

difficulties with “considering the person”, with this potential threshold concept not gaining much of the knowledge required until the placement year at the end of the courses. Experience in the variation of both people and prosthetic management is a necessary requirement to gain a holistic view. Although students approach the concept with little direct experience they may hold some preconceptions about prosthetics and about people with an amputation. Some of these conceptions may continue as stereotypes and “standard” prescriptions which can be both useful and a barrier to providing a holistic approach. Acquisition of a holistic perspective is potentially transformational, changing the person’s view of prosthetic management. Knowledge about prosthetic components used during prosthetic management can be considered to be a basic concept. But the process of prescription and the way of viewing the person and their prosthetic management are procedural and disciplinary concepts respectively, with associated memories. Therefore I propose that “considering the person” is a threshold concept for prosthetics.

4.6 Learning to talk

Every discipline has its’ own words and terms and their associated meanings. They act as a form of short hand for disciplinary members enabling communication with members of both the discipline and associated disciplines. The interviews indicated that prosthetic students must learn to communicate not only with each other, with lecturers, and with other disciplinary members but also with people with an amputation with whom they must not use disciplinary language. Difficulties with learning disciplinary

language as well as problematic areas in communication are considered here in relation to students perception of relevance, its application and position within the curriculum, the effect of previous experience with disciplinary language and in communicating with others. I explore how behind the words and phrases are disciplinary concepts. Together these troublesome areas contribute to “learning to talk” being a possible threshold concept.

4.6.1 Crossing the threshold

The interviews suggest that disciplinary language is difficult for students with its use of Latin and Greek based medical terms, and differences from everyday use of words. Hidden behind the words and phrases are basic and disciplinary concepts. Acquisition and use of the language enables students to demonstrate to other disciplinary members that they are part of the community and share understandings with them. Progressing towards the threshold in terms of disciplinary language terms seems to emerge gradually, with the realisation that they have understood a concept and are able to discuss and explain it to someone outside prosthetics.

> *I go home and I’ll have a really good chat with my mum and she’ll be like “oh what have you been doing?” and I’ll say about it and it’s, I’m suddenly more enthusiastic about the subject because I can talk about it, because I know about it and I’m kind of, I surprise myself, I’m like “Oh, that must have gone in then!”*
>
> *Suzanne, year 3, University B*

The new terminology causes problems for students. It is foreign to them. The words are more than words. There are ideas and concepts behind them, with the words effectively becoming a shorthand for the discipline.

Meeting and dealing with prosthetic service users is initially difficult for many students. It may be the first time they have met a person with an amputation. They also must combine talking with the person, finding out specific information and including more general chit-chat whilst, at the same time, carrying out the necessary tasks. Both lecturers and students identified that “nerves” made this more difficult.

> *I found it really difficult, well in meeting patients for the first time, but that was more to do with nerves and worrying that I would say the wrong thing. Or was it, was it better to say the wrong thing than just sit there and say nothing at all like, or take the risk…*
>
> *Marian, year 1, University A*

> *....patient assessment is one thing that they find incredibly difficult ... maybe firstly dealing with a patient for [the] first time so they’re nervous.*
>
> *Staff 4*

One staff member recalled that they were initially nervous, but once it became apparent that people with an amputation were "normal" their nerves vanished.

> *I think one of the other problems was nerves when I first met patients. It was the most terrifying experience ever [laughs]. And it was kind of*

strange because I wasn't particularly a nervous person about anything else and I was quite sociable and you know, could chat to people quite relaxed. But I think it was just the thought of "these are real patients, I'm meeting real patients for the first time" and that was scary. But by the time I'd finished the first day of doing it, it was fine. It didn't bother ever, ever again.

Staff 8

But those nerves stop or decrease and students begin to enjoy the clinical sessions.

…I've overcome my nerves now definitely, I really look forward to them now, but initially I think the first three times, three or four times I was really nervous going meeting patients yeah, definitely.

Marian, year 1, University A

Approaching communication with people with an amputation is scary for some students but as they progress through the courses this abates and communication becomes much easier with the people with an amputation who assist in university clinics.

…from the first year you, you're sort of nervous with patients, whereas you come to the 3rd year and your just talking to them all as if they're just one of your mates almost.

Edward, year 3, University B

These extracts suggest that there is an initial threshold of nerves that must be passed. By the third year of the course students are more comfortable in communicating with people with an amputation. Issues of communication with people with an amputation are not experienced by all students. Those with previous experience of communicating to “strangers” have no problems with this threshold.

The people with amputations who participate in the teaching programme are well mannered, friendly and considerate of the student and their learning. In clinic students will need to be able to deal with service users with different personalities and in different moods who are perhaps angry or upset. This student recognised the difference between the service users he had seen at the university and those in the “real world”

> *I feel the most important thing learnt on placement was how to interact with real patients, as this is something that is not possible at university. It is important as you have to learn to communicate and possibly deal with incompliant patients, which prepares you for the real world.*
>
> *Jonathon, year 4, University B*

This suggests that there is a final hurdle of difficulty in communicating with others that happens later once on placement.

“Learning to talk” certainly proves troublesome, primarily due to its foreignness, for some students without previous linked experience. Communicating with “strangers” also has problematic areas relating to the

students experience of talking with others and the nerves which they experience. Relevance of the disciplinary words may seem obvious to experienced clinicians but initially this also causes troublesomeness. It is bounded in that the disciplinary language is only understood by a small group of people within prosthetics but the boundaries are also shared or blurred with other healthcare professions. However as part of learning the language you must also learn when not to use it. Understanding the language allows you to understand other linked subjects and becomes part of your normal speech, integrating you into the prosthetic and wider health care community. This integration in the community also transforms the person. Speaking the language is part of becoming a prosthetist. Is it irreversible? As with all language learning there are words we remember and those we do not. Unless we continually or regularly use the language we lose confidence and this may cause some reversal in ability. The procedural concept is knowing when to use the disciplinary language and when not to. Whilst learning the words and phrases can perhaps be considered basic concepts within “learning to talk”, the meaning and concepts behind them are disciplinary concepts as they are part of the way of thinking within prosthetics. Therefore because it meets both the criteria and the concept models I consider “learning to talk” to be a threshold concept in prosthetics.

4.6.2 Why? How? When?

Sometimes students question why they need to know and use new disciplinary words. Why are they relevant to their future prosthetic clinical

practice? Where they are introduced to these new words may impact on the perceived relevance. This student was introduced to them in a module focussing on anatomy and physiology.

> *...but like at first when we were taught it, we were actually taught it in biology, and I was like why do I need to know all this? But yeah, it's, you understand it now...*
>
> *Jane, year 1, University A*

They must communicate with other disciplinary members, members of associated professions e.g. doctors, physiotherapists, technicians and prosthetic users and carers. Using and understanding the disciplinary language helps them to feel part of the community. But when they mix with other health care professions using the terminology they see its' relevance.

> *…being around other medical professions or being at lectures and conferences and obviously they are using all these terminologies.*
>
> *Tom, year 3, University B*

Students, as well as learning new words and phrases, also need to use the words appropriately but students sometimes struggle with the application.

> *I've got to say with talking to the patients they're usually pretty reasonable but when we ask them to speak to, for example, myself as a fellow prosthetist/orthotist and to use appropriate terminology they then sink badly. Their understanding of the terminology is poor, their ability to actually interlace it in conversation is exceedingly difficult.*
>
> *Staff 1*

But another lecturer found that students struggled with communication with patients.

> *Communication. If, I think that [sighs] well for, this is, this is really for me with the early module, early course module that I do. And communication because if they can't communicate with someone they, they will not be able to provide the very best of care for that person, they won't get the best out of that person.*
>
> *Staff 6*

The lecturers also commented upon assessment identifying that students know that there are questions we need to ask the person but failing to understand why we ask those questions. They fail to link the practice to the theory.

> *I think that they don't grasp the importance of getting information from someone in the right way. So they can all sit and they, and, so for instance they can sit, I mean, with a with a sheet of paper, lives, type of house, adaptations. All those elements of a patient history written down and they get all the answers but it's, there's been no rapport, there's been, it's been very regimental, there's been no really digging deep, they've asked what's on the sheet. They don't know the importance of asking someone if they smoke and how many cigarettes do they smoke they don't, they're just asking that question because it's on the sheet.*
>
> *Staff 6*

One university has a course specifically focussing on communication skills. However, this staff member appears to be questioning this course's impact as students are in their view, still struggling with communication.

> *But even now, even when they've been through a course and they've touched on the topics, when, when they're examined on it they still take a fairly circuitous or higgledy piggledy, (that's a good word), route to get the information, rather than doing it in a, a recognised, logical order.*
>
> *Staff 7*

Perhaps reorganisation of the contents of this supportive module to be located within the core modules may help with application.

Therefore, once again relevance, application and alignment cause difficulties for students and in turn staff. Making the rationale behind the language and its' use more explicit, may alleviate some of the difficulties.

4.6.3 Previous experience

Previous experience in learning to talk includes both experience of the disciplinary words and phrases and also experience of communication with others. Language learning is known to be difficult for some people and in prosthetics it is no exception since many of the words, especially those related to anatomy are foreign as they are Latin or Greek as Tom finds.

> *I think it's mainly the strange, like Latin and Greek words that you come across.*
>
> *Tom, year 3, University B*

...and it's names that, you know, it's terminology that you're not used to, you know, brachioradialis, you know, what, what the hell does that mean, you know? [laughs]

Staff 5

One staff member indicated that students do not only encounter new words and terminology at the start of the course. One area that they teach is in the third year of the course when students learn about myoelectric prosthesis which involves some electrical terminology.

I think some of the more complicated things like maybe control, myoelectric control, they do find quite difficult. It's just, I guess again that's a new concept trying to, and it is quite complicated to understand different types of threshold controls and rate controls and it's. And I guess that's a new language that's coming in, it's like trying to understand a foreign language. And like anything it takes time to, to appreciate if you don't have a background maybe in electronics, terminology like gain and thresholds and such like.

Staff 5

Sometimes the new words have some familiarity and you can link them to words in everyday language.

Like some words you already know what they mean like superior and inferior, they're more common words.

Tom, year 3, University B

Other discipline words are not part of everyday language and don't bear any similarity to a common word.

> *I guess sometimes anatomy, when it comes to learning the specific names that like other you'd call it something else like in normal life but then you have to start calling it this.*
>
> *Tom, year 3, University B*

Sometimes previous knowledge creates a barrier to learning the terms. This student was familiar with x, y and z as names of planes in engineering but initially failed to link coronal, sagittal and transverse planes in anatomy to their engineering equivalents.

> *... in first year, getting the coronal and transverse and sagittal planes, just because they're all new words to me, even though I did know about planes, they'd just been x, y and z to me before that. ... I should've just probably put in like, do you know, x is sagittal, y is coronal, but I didn't and so it took me ages to learn those words off.*
>
> *Marian, year 1, University A*

In prosthetics the foreignness and lack of previous experience of these mainly Latin or Greek words tends to be the main troubling aspect.

Twelve of the students had been in either full time or part time/holiday employment. From the interviews they explained that this employment experience brings a range of skills and knowledge to their study of P&O, but

predominantly in relation to dealing with people. Jane and Andrea both had previous experience of dealing with people through their employment. They found that the skills this experience gave them in communication allowed them to focus on the practical aspects of casting and fitting when in clinic.

> *…probably because it's one of the fundamentals, so it means that I don't stress about that, so I can concentrate on other things.*
>
> *Jane, year 1, University A*

> *...it helps me, because it means if I'm in the clinic I don't have to think about that, which is good, whereas some people think about the fact that you have to keep speaking to the patient while you're there. Whereas I can, it's multi-tasking that's, that's a part my brain that's just working and just having the conversation about the weather and whatever, that's just going, and you can focus on the fact that you can focus on the fact that you have no idea what you're doing [laughs], not no idea but you can concentrate on and my hand has to go there and there and there...*
>
> *Andrea, year 1, University A*

Melissa and other students found that their experience of working with the public meant that they were comfortable in communicating with people. The variation amongst students was also mentioned.

> *…it took them from first year to second year, whatever, to maybe get easier to talk and not be just nervous or shy or, whereas for myself I think I could talk to them quite freely because I was used to and*

preferred, and always have, older patients in my own environment at work.

Melissa, year 3, University A

Some students come with communication experience gained before coming on the course, whilst some others through employment at university develop this. Andrea worked at a call centre and was used to dealing with people who were in some cases very irate, a skill she could use in prosthetics when dealing with challenging people.

..a lot of the, the actual rapport with people and even for the, dealing with difficult patients as I believe we were calling them, if you can deal with somebody wanting you to put, put their two year old child on the phone to tell them why Santa's not bringing their Christmas presents you know, somebody who had to sit and wait in the waiting room for ten minutes is no bother [laughs].

Andrea, year 1, University A

Emily's previous experience in a prosthetic workshop also helped her communicate with people who can be difficult.

I work in plastics and I work with a guy that nobody else likes to work with and I've got several theories why he likes to work with me and we do argue like a married couple and I think he quite enjoys that but I think it's taught me how to get on with people in difficult circumstances with huge time pressures to get the job done, to learn from each other and

get it done really well and really quickly.

Emily, year 2, University B

Karen, who had been working on a fundraising call line had not realised that perhaps she was developing communication skills from this part time employment. This suggests that some students lack awareness that communication skills can be transferable. Or it may indicate that they create barriers or boundaries around aspects of their life outside the course, perhaps indicating that they have not yet crossed a threshold in communication.

...might do actually yeah [surprised] sort of getting more information out of patients. And also just conversing with them as opposed to keep asking about their limb all the time or whatever, it's good to have a chat with people isn't it really, make them feel a bit comfortable if you're [laughs].

Karen, year 2, University B

Prior experience in communication allows students to talk with more ease with people and to cope with those that are challenging. This experience can be gained during the course but students may not be aware of its development. Communication experience assists students, allowing them to focus on other aspects of their learning.

Some students, particularly those with backgrounds involving work experience in dealing with people find communicating with people requiring prosthetic management less nerve wracking. Their previous experience may have

provided them with the skills and emotional capital to deal with people. They approach this aspect better prepared to deal with people. Though some of the students with prior experience can be considered to be mature students, maturity alone does not appear to influence students' communication ability.

4.6.4 Hidden understandings

In learning to talk the interviews suggest that what is hidden is the meaning behind words and phrases. Both the words and phrases and the meanings behind them can be troubling. Some students showed some awareness of their misunderstandings, others failed to realise that they did not understand.

There are pairs of words that are incredibly similar to each other, normally with one letter change and they may also sound very similar. These words are often opposites. Both staff and students mentioned these words being problematic.

> *…obviously the similarities of the words, so abduction and adduction sound exactly the same so it's very hard to differentiate what the person's talking about.*
>
> *Tom, year 3, University B*

The definitions of these similar words also cause confusion. The definitions may require other alien words to be understood, in the following case distal and proximal, and perhaps lecturers don't realise that their explanation of the word is causing problems.

…it's the definition of what part is considered the adducted part, so it was the distal part rather than the proximal 'cause the way that, well some peoples head were aligned it was that it will be, well it was particularly me, was it was more of the proximal part, so if I saw the proximal part I would say well that's going this way so it must be that.

Tom, year 3, University B

Understanding the terminology results in light bulb moments for some students and several students identified abduction and adduction specifically.

…and then trying to remember abduction and adduction. It's when you have to apply it to real life you think ahh, but I suppose when you get the hang of it, it is a light bulb moment.

Therese, year 1, University B

One word or abbreviation can also provide a whole concept to a member of a discipline rather than just the words.

I mean clearly there are odd words that you've, you can never learn to use until you've got an understanding of the concept sometimes. So I mean a PTB is a PTB and you can, you can look up that what that word that means but until, once you get the, kind of, real concepts in your head [of] what that actually means it has a much bigger meaning and a more understanding meaning that comes with that, it's not just a word is it, it's kind of, you know, you automatically, well I do, you automatically say a word you get a vision of it don't you, abduction,

adduction, flexion it, it's kind of a, it's a very visual thing …

Staff 2

But students do progress in their language learning and learn ways to clarify and define words that they do not know. They attach them to other elements of their mental map.

But as you got used to hearing it, it just became a standard thing that even if you'd never heard a word before, like because I suppose in the degree at first, they mix and match in different words that you'd be able to associate with something else and be able to roughly figure out what the person was talking about even if you didn't know [the word].

Tom, year 3, University B

Their mental map may also include ways of remembering the word or phrase. This is sometimes provided by other people.

...that was my mum that taught me that. Ad is together and ab, because if it's adduction then it's towards you and ab is the other...

Suzanne, year 3, University B

And I did quite often look for little clues in terms of, you know, maybe there was, like trapezium thumb, you know, the, the metacarpals of the thumb articulates with the trapezium because there's a wee rhyme, you know.

Staff 8

There are occasions when students learn or use the wrong word, demonstrating misunderstanding or mimicry.

> *...it was only half way through the second year that I realised that this [points to breastbone] wasn't your stifisternum it was your xiphisternum...*
>
> *Suzanne, year 3, University B*

> *...the terminology anterior, posterior and they are confused with, medial proximal, lateral distal and you know that they're trying to describe the right thing but they're just describing it in the wrong way. Because they've given you the reason for the gait deviation and what they would do to correct it but then they say something that's entirely different.*
>
> *Staff 6*

These misunderstandings may suggest that they are within a liminal space, oscillating between misunderstandings, able to use a word or phrase but not fully understanding its meaning and full disciplinary.

It is easy to forget that when students enter a discipline that there is a new language for them to learn. The new disciplinary language can be troublesome and in prosthetics new to most students. The acquisition of the language also provides them with entry to the discipline, enabling them to converse with other members, joining the club. They share hidden meanings and understandings of different concepts. Encountering this new language in a supporting subject can cause issues with relevance. In prosthetics they must

also learn when not to use the disciplinary language. This can also be troublesome because of nerves and a lack of previous experience in dealing with the public. As they progress through the course there appears to be an integration of the language and an ability to talk to others into their identity. This assists with the transformation into a prosthetist. Learning the actual words and terms used within the discipline is a basic concept, with appropriate use and understanding of the concepts and meanings behind the words and terms being procedural and disciplinary concepts. Therefore I consider "learning to talk" to be a threshold concept.

4.7 Conclusion

There are several areas that prove to be problematic within prosthetics. Some of these problem areas may not be linked to the notions of troublesome knowledge or threshold concepts and have not been considered here. Those difficult concepts presented in this chapter are considered in relation to troublesome knowledge and threshold concepts. It is suggested that some concepts within prosthetics are difficult and troublesome but are not threshold concepts. Three concepts are suggested as threshold concepts. Across the different difficult concepts there are similarities and differences in what the difficulty is.

The overall alignment of the curriculum and its modular parts appears to impact on difficulties students may experience. Students of prosthetics appear to be focused on the end result of becoming a prosthetist. This is

demonstrated in their difficulties with concepts when they cannot see the relevance to clinical prosthetics. My findings suggest that improvements to the alignment between modules and making the relevance explicit could impact on the depth of understanding. Of course there may be aspects that are not relevant and may not be applied in clinic, so perhaps it should be considered whether these should be removed from the curriculum or approached in a different way.

Prior experience appears to affect the way students approach different concepts. This prior experience can act either as an enabler, giving them a head start on students without experience, or it can be a barrier especially in relation to maths based concepts. Given that higher education students now come from a very wide range of backgrounds with a variety of qualifications and employment experience perhaps lecturers need to explore their assumptions of what experience students come with. This may then affect how they approach teaching and learning. Lecturers' previous experience may also cause difficulties as certain aspects may have become tacit and obvious to them. It may be that these aspects are then overlooked and assumptions made about students that are not always applicable.

Some concepts have "hidden understandings". These can include visual images that the prosthetist uses to understand anatomy and biomechanics, memories of people and prosthetic management, and meanings behind words and phrases. These hidden understandings contribute to the person's mental map of the concept. Within these hidden understandings variation is normally

required to gain a fuller understanding and ability to use that concept. However, it also needs to be acknowledged that variation can also be problematic. Variation of too many aspects within a concept fails to enable students to direct their attention on one aspect of variation at a time. Eventually the variation in practice is accepted and students are able to select the appropriate variation in prosthetic management for that person. There may also be more than one way of understanding a concept with all ways being valid but different or hierarchical ways of perceiving the concept.

Areas of troublesome knowledge and some potential threshold concepts have been compaired to both the criteria and the concept models of threshold concepts. It is suggested that some difficult areas are certainly troublesome but are not threshold concepts for prosthetics. However, these concepts may be threshold for other subjects. Whether a concept is threshold or only troublesome appears to relate to its use in that discipline. They are not concepts with well-defined definitions. They are more messy concepts with different pieces needing to be fitted together like a jigsaw puzzle. Threshold concepts may be more transformative and integrative than concepts such as Newton's third law; maybe they are greater than the sum of the whole. The small pieces are essential and may be considered to be basic concepts. However I suggest that both procedural and disciplinary concepts are also needed for a concept to be considered to be threshold. Associated with the procedural concepts are memories. Therefore a threshold concept may involve the complex interaction of different types of concepts which integrate

together enabling a transformation of the person’s way of viewing that concept.

5. Design, Experience, Tacitness and Threshold?

5.1 Introduction

In this chapter I will argue that my outcomes for this project have the following implications for research around threshold concepts. First, curriculum design may impact on whether or not students find concepts troublesome. Second, prior experience may be both helpful and unhelpful to learning. Variation in prior experience may help explain pre-liminal and sub-liminal variation. Third, tacit knowledge should be explored further within the framework of threshold concepts and troublesome knowledge. Finally I consider the criteria model and concepts model of threshold concepts and what my research says about these models and how to identify a threshold concept.

5.2 Curriculum design

My research outcomes suggest that some troublesomeness arises from issues relating to curriculum design, specifically relevance, application and alignment within the programme. If the relevance of a concept is not obvious to the student either tacitly or explicitly then they appear to put the concept to one side and move their focus to other areas. Most issues of relevance occurred in subjects that are located within supporting modules rather than core modules. Core modules are those taught by disciplinary experts and are central to ways of thinking and practicing. Supporting modules add to the knowledge base but may not be taught by disciplinary experts. From the

results here I suggest that making the relevance and application of the information explicit enables students to link theory with practice and therefore assists in preventing knowledge from becoming ritual and inert. I suggest that these difficulties may be as a result of problems with curriculum design. Whilst I acknowledge that the learning, teaching and assessment approach used within the module may have some influence on the difficulties encountered by students, here I discuss the importance of how students perceive relevance, and application and the influence of whether it is taught by an expert in or outside the student's discipline.

5.2.1 Failure to see relevance

Previous research has found links between perceived relevance and disengagement in maths subjects, the limited time resources of students and their motivation. My outcomes show that perceived relevance and disengagement is not limited to maths subjects and that the relationship between perceived relevance and disengagement is more important in supporting subjects. From my research outcomes (Findings 4.2.2 & 4.3.2) it appeared that concepts that have a perceived low relevance to the practice of the discipline can be troublesome. If students fail to see the relevance of a topic to their discipline then they may disconnect from engagement with the subject matter (Quinnell and Thompson 2010). This may be because of competing demands on their time, students make a decision on where to focus their studying based on their view of how relevant the subject is (LeBard et al. 2009). This certainly seems to have occurred with the maths based

subjects within prosthetics. Here students acknowledged memorising sufficient subject knowledge to pass the assessment but failed to grasp the reason behind learning this information and therefore failed to understand it. A lack of motivation impacts negatively on learning (Orsini-Jones 2010) and this may be linked to the relevance and application not being made explicit. The research outcomes here build upon this existing literature, developing the notion that students decide what to focus their attention on. In addition the research outcomes presented here extend the importance of the relationship between relevance and student engagement to subjects other than maths. My outcomes also show that students appeared to accept relevance as a given in the core modules and that relevance is more of an issue in supporting modules.

One effect of the failure to see relevance is that the student may become disenchanted with the course and withdraw. Another effect, demonstrated here in the research outcomes (Findings 4.2.2 & 4.3.2) is that they learn enough to pass the assessment, resulting in ritual and inert knowledge (Perkins 1999; Perkins 2006; Perkins 2007). Therefore they may fail to acquire understanding of the concepts required to think and practice within their discipline. Whilst students may be able to pass assessments without understanding (Bowden et al. 1992; Brumby 1984; Dahlgren and Marton 1978) this is surely not how lecturers would wish them to learn. By *"teaching better"* (Perkins 2007) and encouraging a deep approach to learning (Marton and Säljö 1976a; Marton and Säljö 1997) lecturers can avoid knowledge becoming ritual, inert or forgotten. Why a subject is being studied should be

made explicit to students. This source of troublesomeness appears to be a factor in supporting concepts rather than in threshold concepts in prosthetics. In order to enable and encourage students to engage with the subject matter not only should methods that encourage a deep approach to learning be considered but also aspects of curriculum design related to contextual application and relevance to the student's discipline. This includes who teaches it and if it is a supporting subject how it is used in practice.

5.2.2 Application and relevance

It is not only whether students engage with the subject, but also to what depth they engage that is affected by curriculum design. In relation to anatomy it appears that students may have a troublesome understanding of anatomy from classes but it is not until they have experienced the application of anatomy in practice (through clinical placements) that they realised the depth required (Findings 4.3.2). Staff noted that students failed to grasp the depth required, suggesting that the students were unaware of why they should be learning anatomy. This issue of application of human biology may be lessened by earlier exposure to "real-world" prosthetics through clinical placements. Perkins (2008) discusses the issue of relevance to the transfer of knowledge and it may be that for "the trouble with the body" (Findings 4.3.2) and "the trouble with numbers" (Findings 4.2.2) students are unable to transfer any learning that they achieve to situations outside the classroom. This may be because the learning experiences have not facilitated this transfer. Whilst some research on threshold concepts has attempted to facilitate the

application of a disciplinary concept to the everyday world of students (for example Reimann and Jackson 2006; Shanahan and Meyer 2006) it may be that at an early stage in their course students are unable to extrapolate disciplinary concepts to their personal world outside the discipline. My research outcomes (Findings 4.3.2) suggest that in some subjects actual real world experience, rather than proxies, is required to develop the students' awareness of how the concept is used within the discipline. As well as the position of the supporting concepts within both modules and the whole curriculum, their troublesomeness may also be affected by who teaches them. This aspect is related to the lecturer's ability to contextualise the subject matter to the students' discipline.

5.2.3 Disciplinary or Non-Disciplinary Teaching.

From my research outcomes the relevance and application of "how we walk", "considering the person" and "learning to talk" (Findings 4.4.2, 4.5.2 & 4.6.2) did not appear to cause problems for students. Whilst the relevance may not initially be obvious to the students this appears to become clearer as they progress and encounter increasing amounts of practical work where they applied the concepts. The practical work enabled the link between theory and practice to be developed and the students experienced what and how knowledge is used in practice. This may be because most of the learning of these concepts occurs in core modules taught by disciplinary specialists and students therefore assume that it is relevant. Relevance and application appear to be more problematic in those subject areas that are within

supporting modules. In “the trouble with the body” (Findings 4.3.2) for students at University A, where this subject is service taught by non-disciplinary experts, relevance and application of anatomy and physiology are problematic. Some of the maths based elements on both courses are also taught by non-disciplinary specialists and students struggled with relevancy and application issues in these subjects as well (Findings 4.2.2). The possible negative impact of subjects being taught by non-disciplinary specialists has been mentioned by others (Association of British Neurologists 1995; Cox 1987; Flanagan et al. 2010; LeBard et al. 2009; Mitchell 1988), suggesting that the input of discipline specialists is required. It has also been found that personal epistemological, and learning and teaching beliefs influence lecturer’s approach to the educational context of their students (Bain et al. 1998). Variation in how the same concept is viewed occurs between disciplines (Hmelo-Silver et al. 2007; Lynch et al. 2000; Medin et al. 1997; Pfundt and Duit 1994; Smith et al. 2009). If the subject is being taught by a lecturer in a different discipline to that of the students, they may have a different perspective on the concept and its’ use than that of the students’ discipline, especially as context and knowledge are woven together (Cole 1996). Currently there is little research on the possible effect on learning of non-disciplinary specialists teaching disciplinary students. Being taught a subject by non-disciplinary experts may create separation in the minds of the students as suggested by McCormick (2008). McCormick considers that that there may be a clash in how the subject is viewed by those teaching it and those in the student’s discipline. It is likely that this variation will involve differences in how the subject/concept is applied within the different

disciplines. My findings develop this literature adding that who teaches a subject is more important for supporting modules than core modules. In core modules students appeared to accept that topics were automatically relevant. I also suggest, from the research outcomes, that repetition of a topic, within a core module, previously covered in a supporting module enabled students to see the relevance, perhaps making the links to practice more explicit through being contextualised (Kinchin et al. 2010; Tsui 2004) by disciplinary experts. Application of a concept also occurred more naturally, with the links between theory and practice occurring in context. However, there are examples within my research of topics that the students understand why they are studying them, which do not appear to be linked to who is teaching them, for example within “the trouble with the body” (Findings 4.3.2) students appear to understand the relevance of studying pathologies whether this topic is facilitated by disciplinary specialists or service taught. Therefore there may be subjects and concepts within a discipline that the relevance is automatically understood and can remain implicit. Those that are problematic in relation to relevance and application require careful consideration regarding who teaches them or how they are presented to students.

Students’ perception of the relevance and application of a subject affects whether or not they engage fully with the subject matter. For supporting subjects in general, the relevance needs to be made explicit. Within core subjects, and some aspects of supporting subjects, there appears to be an inherent implicit relevance. There also needs to be appropriate application within the students’ discipline in order to encourage students to engage to an

appropriate disciplinary level with the concepts. These issues with relevance and application are sometimes exagerated by the supporting subject being taught by a non-disciplinary lecturer as they may be unaware or unable to ensure relevance and appropriate application to the student's discipline.

5.3 Previous experience

The students on the prosthetics and orthotics programmes have diverse backgrounds with experience from previous learning, employment, leisure activities and everyday life. Previous research has acknowledged that today's students vary in their educational and employment backgrounds and that this will have an effect on their engagement with higher education. Variation in the starting points of students' knowledge is acknowledged by Kiley & Wisker (2010) and Land & Meyer (2010). Students' prior experience from whatever source will have some impact on their learning and their engagement with the discipline (Anderson and Hounsell 2007; Bloomer and Hodkinson 2000). The suggestion by Schwartzman (2010) that threshold concepts are only applied to new experiences is perhaps questionable. This may be because whilst the effect of previous experience of a layperson's understanding and everyday language on threshold concept acquisition has been explored, for example Flanagan and Smith (2008), there appears to be a gap on the effect of other aspects of a student's previous experience on whether a concept is troublesome or not. The role of previous knowledge or experience in similar or different subject areas has had little focus within the literature on threshold concepts and troublesome knowledge. Schwartzman ignores the experience

brought by students to their learning, considering that students are a blank slate. Supported by my findings I disagree with Schwartzman and instead suggest that all students come with experience which may help or hinder the acquisition of a threshold concept, and adding another dimension of potential troublesomeness. Engagement with a threshold concept may bring a new disciplinary view onto an existing perspective. Here I consider both positive and negative experience and pre-liminal and sub-liminal variation and consider whether the two are actually describing the same notion.

5.3.1 Negative impact

Previous research has considered the negative impact of previous experience on learning threshold concepts (Flanagan et al. 2010; Kabo and Baillie 2010; Orsini-Jones 2010). I build upon this research adding to the knowledge base of how students cope with the negative effect of experience. Students' tacit and content knowledge (previously learnt knowledge about the concept) varies greatly (Shanahan et al. 2010). School explanations of concepts may not be sufficient and these must be revisited or introduced for the first time (Flanagan et al. 2010; Orsini-Jones 2010). In addition some prior study creates large barriers for certain subject areas. "The trouble with numbers" (Findings 4.2.3) demonstrates that concepts involving numbers are troublesome for prosthetics students. The "trouble with numbers" may suffer from a pre-existing and commonly held belief that maths is hard (Richardson 2011). My research adds to Menec and Perry's (1995) work identifying that students with poor previous maths experience may be at risk of failure when

studying maths based subjects. Trying to overcome the idea that maths is hard may be a huge challenge for lecturers teaching maths based subjects to students with bad prior experience of maths. Fear of a subject has been identified for maths (Ben-Shlomo et al. 2004), and grammar (Orsini-Jones 2010) and poor previous learning experiences may cause students to react negatively. Students deal with this fear in different ways, through retreating, temporising, avoiding or engaging (Savin-Baden 2006). This research suggest that students with previous difficulties with numbers react by avoiding or delaying engagement with the difficulty, contradicting Quinnell & Thompson (2010) who suggest that some students retreat from the liminal space when faced with numbers. By avoiding or delaying engagement with the issue students managed to circumvent the problem (Savin-Baden 2006) through using memorisation to enable success in an assessment that they must pass. This surface approach to learning may have enabled them to pass an assessment with misconceptions (Land and Meyer 2010) and therefore mimic understanding (Meyer and Land 2006) but it results in ritual knowledge (Perkins 1999; Perkins 2006; Perkins 2007).

Abercrombie (1960) states that students have a lack of experience. Rather than a lack of experience my outcomes suggest that most will have a lack of disciplinary experience but that they hold everyday conceptions. The disciplinary view may be new, strange and alien (Perkins 1999) for the learner but they are likely to have some everyday understanding of a concept. Everyone has some understanding of language (Findings 4.6.3) and walking (Findings 4.4.3) but the disciplinary view is likely to be different and therefore

alien to this view. Shanahan & Meyer (2006) found that everyday conceptions of disciplinary words interfere. However my findings suggests that some words are troublesome because they are foreign (Findings 4.6.3). In addition the meaning behind the words and on which occasions they should be used caused difficulties (Findings 4.6.3).

5.3.2 Positive impact

When prior experience is mentioned within the threshold concepts literature it is generally with the view that it hinders the development of threshold concept learning. My outcomes indicate that students also have experience which positively supports their engagement with certain concepts, adding to the research by Ross et al (2010). There is also *"positive transfer"* from previous experience (Robertson 2001 p83). Which concepts and what type of experience varies. Pre-existing knowledge helped with disciplinary conceptions in "learning to talk" (Findings 4.2) where existing communication experience reduced troublesomeness and with "considering the person" (Findings 4.5.3) where prior experience as a technician assisted with developing a personal view of different prosthetic components. My outcomes also suggest that people hold onto stereotypes as can happen in "considering the person" (Findings 5.3). These everyday conceptions about different groups of people can both help and hinder. They can prevent experts (and novices) from fully exploring the situation, but also act as short cuts in problem solving. Students with good maths experience did not have difficulties with the maths aspects of the courses. Some learners' prior experience may have

enabled them to take an ontological step towards understanding and crossing the threshold before starting a course as Land and Meyer (2010) suggest happens with medical students. This step means that they may be better positioned to engage with the concepts to which they will be introduced. For example here Melissa had experience already of a health care profession (Findings 4.3.3) and therefore was well positioned to engage with the study of the human body unlike her colleagues who struggled with the relevance of this topic. Therefore I suggest that we should not view all prior experience as being a hindrance to learning. Some prior experience is useful.

5.3.3 Pre-liminal and sub-liminal variation

Meyer et al (2008) introduce the notion of variation within threshold concepts. I suggest that two of the suggested parts of variation may be describing the same thing. Meyer et al (2008) differentiate their idea of variation from the phenomenographic view of variation of the critical features of a concept. They state that there are critical features of some concepts that cannot be varied. Instead they explore variation in how learners experience a new, transformative conceptual space, specifying four types of variation: sub-liminal, pre-liminal, liminal and post-liminal. Sub-liminal variation is viewed as the tacit understanding that a learner has in relation to the concept being studied, and this may or may not align with the disciplinary view of the concept. Pre-liminal variation is described as how a learner first experiences the concept, how it *"comes into view"* (Land and Meyer 2010 p63), and this will be affected by the learners knowledge and experience. It also includes

variation in how the portal into the liminal space is formed. Pang & Meyer (2010) view the pre-liminal stage of a threshold concept as an implicit way of understanding the concept from a disciplinary view, with sub-liminal variation representing a non-disciplinary view of the subject. My outcomes suggest that these two types of variation appear to be linked. Indeed in their earlier paper Meyer & Land (2006) appear to view pre-liminal variation as a combination of what they later differentiate as sub-liminal and pre-liminal variation. Here, I view sub-liminal variation as the variation in how a learner, rather than an expert, already views the concept in question before they have "learned" the concept in a disciplinary context. The learner may be either conscious or unconscious of their understanding of the concept. Their pre-existing understanding may also correspond to the disciplinary view or may be a layperson's view or an alternative understanding of the concept. My view of pre-liminal variation is that it is the way that the disciplinary way of understanding the concept comes into view for the learner and this will be affected by their sub-liminal view of the concept. I believe that the two are intertwined and describe different aspects of the same type of variation. If a student's sub-liminal, pre-existing understanding of a concept, corresponds with the disciplinary view then the way the concept comes into view (pre-liminal) will likely not be troublesome because they are aligned and therefore match. If their sub-liminal view is different from the disciplinary view then the pre-liminal view does not match with the sub-liminal view and the concept may therefore be troublesome. From my findings I suggest that the prior experience of a student can both assist (for example communication experience in "how to talk" (Findings 4.6.3) and hinder (for example

experience of maths (findings 4.2.3)), and may affect both sub-liminal and pre-liminal variation. Whilst the learner may not be aware of their pre-existing conceptions (their sub-liminal view) they surely affect how the threshold concept “comes into view” (pre-liminal view) and therefore I would suggest are a form of pre-liminal variation rather than a separate category of sub-liminal variation. My outcomes suggest that not all students are in a pre-liminal state (Pang & Meyer’s 2010 definition) when they approach a subject. This pre-liminal or perhaps pre-pre-liminal state could perhaps be compared to Vygotsky’s (1978) zone of proximal development in that learners need to be within the zone in order to develop their understanding of a concept. Although not evidenced in my research it is possible that some learners may already be post-liminal for some concepts dependent on their experience.

It cannot be assumed that learners all start from the same position. Their previous experience contributes to how they perceive a concept, and can have either a positive or negative impact on their learning. Their existing understandings need to be explored so that lecturers can enable them to develop and if appropriate cross the threshold. The variety in previous experience amongst students may help to explain why not all students struggle with the same concept. There also appear to be links between pre-liminal and sub-liminal variation; I suggest that they are one and the same.

5.4 Tacit knowledge

All of the concepts identified in the analysis had examples of hidden understandings. Previous literature has identified that the episteme of a discipline is tacit knowledge (Perkins 2007), and that there are different ways of understanding a concept. My research outcomes show that tacit knowledge includes more than just the episteme and that the ways of understanding a concept needs to be explored further in order to explain liminal and post-liminal variation.

5.4.1 More than the episteme

Perkins (2007) and Land & Meyer (2010) state that tacit knowledge involves the rules of the game and the protocols for how disciplines reason and problem solve. My findings (Findings 4.2.4) indicate that this aspect is problematic as experts omit stages, and take shortcuts that they are perhaps unaware of (Glaser 1999; Koedinger and Anderson 1990; Kuipers and Kassierer 1984; Tardieu et al. 1992). However, my outcomes also indicate that tacit knowledge consists of more than the episteme, including visualisation, meanings behind words and memories.

Visualisation of images of various sorts was difficult for some students. They found it difficult to visualise invisible forces (Findings 4.4.4) and underlying anatomical structures (Findings 4.3.4). This ability to visualise and manipulate images has also been found to be necessary in other disciplines (Abercrombie 1960; Osmond et al. 2008; Ross et al. 2010), and part of an individual's

knowledge base (Hong and O'Neil 1992). The visualisation of invisible concepts (Lawson and Drake 2000), such as forces, has been found to cause problems for students. Weil & McGuigan (2010) state that visualisation is difficult and a possible threshold concept. This study suggests that visualisation itself is not a threshold concept; instead it is one aspect of tacit troublesome knowledge.

Other research has identified that disciplinary language is troublesome (Baillie and Johnson 2008; Flanagan and Smith 2008; Ross et al. 2010; Shinners-Kennedy 2008; Taylor 2006; Taylor 2008). My outcomes (Findings 4.6.4) suggest that whilst there are difficulties with the words often due to their Latin or Greek origins, most of the issues lie with the concepts behind the word and use of the disciplinary language. Ross et al (2010) and Taylor (2006) have also identified a problem with words in biology, resulting in a focus on the words rather than the underlying concepts. My outcomes extend this area of difficulty to another discipline. Davies and Mangan (2010) suggest that it is possible to use the disciplinary word without disciplinary understanding, demonstrating possible mimicry (Meyer and Land 2006). Disciplinary language learning, as demonstrated in my findings (Findings 4.6.4) involves not only the words and their meaning but also building upon Entwistle's (2006) findings, when to use them. Unlike Taylor (2008) who notes that teachers viewed specialist biology language as troublesome but not threshold, I suggest that use of disciplinary language is threshold.

Whilst previous research has identified that experience of variation of the critical aspects of a concept is necessary for learning (Marton et al. 2004), my research indicates that this is important in particularly for “considering the person” and “how we walk” (Findings 4.5.4 & 4.4.4). However, one aspect that is not identified in the literature is experiential memories, their role in learning and the ways of thinking and practicing of a discipline. In prosthetics part of learning the concept “considering the person” (Findings 4.6.4) contains memories of people and their prosthetic management as part of the tacit knowledge. These memories are then used as a form of short cut when problem solving.

5.4.2 Ways of understanding

Previous research has shown that there is variation in how a concept is understood (for example Patrick 1998; Rovio-Johansson 1998; Tullberg 1998), with variation demonstrated between experts in the same and similar disciplines (Hmelo-Silver et al. 2007; Lynch et al. 2000; Medin et al. 1997; Orsini-Jones 2010; Smith 1990) and between students (Thomas et al. 2010). However, within the threshold concepts literature there appears to be an assumption that there is an “approved” view of a concept and that this will be held by all disciplinary experts. In my research I have found that there is variation in understanding across the participants especially for “considering the person” (Findings 4.5.4). These different ways were not limited to the students at different stages in their learning but also included variation in the way staff viewed the concept. It cannot be assumed that because students all

progress through the same or similar course that they all end up with the same view of a concept, showing that there is considerable liminal and post-liminal variation (Land and Meyer 2010). This is demonstrated in the variation in different ways of experiencing “considering the person”. The development of schemata (Inhelder and Piaget 1958) has been referred as an example of difficulty (Perkins 2007) and a possible explanation of how threshold concepts integrate and transform understanding (Schwartzman 2010; Timmermans 2010). My research suggests that peoples’ individual experiences shape the development of their mental representation of a concept.

Tacit troublesome knowledge includes the episteme of the discipline but it also includes other aspects of knowledge. These include visualisation of objects, the meanings behind the disciplinary words and experiential memories of the application of concepts. It is likely that there is more than one way of viewing a concept and whether this is a “wrong” understanding or a “different” understanding and an individual’s understanding varies according to their experience of the concept.

5.5 Crossing the threshold: criteria and concept models

Previous research has suggested a criteria model for threshold concepts but there is no consensus on how many and which criteria are essential for a concept to be considered threshold. Other research has developed a model of different types of concepts, some threshold, some not. My research adds to the debate on which criteria are essential for a concept to be a threshold

concept. It also adds to the view that a threshold concept is a combination of procedural and disciplinary concepts.

5.5.1 Criteria model

If threshold concepts are to be different from these core concepts then they must possess some unique feature. The criteria model (Meyer and Land 2003) sets out possible features for a threshold concept. However there is a lack of agreement within the literature over which and how many criteria are essential for a threshold concept. This study adds to Cowart's (2010) assertion that a threshold concept must meet all criteria, and that integration and one type of transformation are essential. The possible threshold concepts (Findings 4.4.1, 4.5.1 & 4.6.1) in prosthetics all have an ontological and conceptual transformation (Cousin 2009). There does not appear to be any transformation occurring for "the trouble with numbers" (Findings 4.2.1). The "trouble with the body" (Findings 4.3.1) may have a conceptual shift but not an ontological one, therefore I disagree in part with Park and Light (2010) that transformation is essential. Rather it seems that the type of transformation must be ontological rather than just a change in knowledge. It seems that integration, Park and Light's other essential characteristic, does appear to be essential as it enables transformation (Taylor and Meyer 2010) and that lack of integration makes "the trouble with the body" (Findings 4.3.1) and "the trouble with numbers" (Findings 4.2.1) difficult concepts but not threshold concepts. The integration within "how we walk", "considering the person" and "learning to talk" (Findings 4.4.1, 4.5.1 & 4.6.1) all require integration of

several different pieces of information creating a disciplinary view (Cousin 2009) of the concept. Irreversibility is mentioned by only a few papers (Cowart 2010; Orsini-Jones 2010; Ross et al. 2010). I found no evidence to suggest that irreversibility is the main characteristic of a threshold concept (Ross et al. 2010). Perhaps this is related to whether irreversibility can be confirmed or denied (Entwistle 2008). Or is it an assumed given as if a concept is in regular use within the practice of a discipline then it is unlikely to be forgotten and linked to whether a concept is a troublesome concept or a threshold concept? Acquisition of concepts that are troublesome but not threshold may be reversible, i.e. understanding and ability to use that concept may be lost. I suggest that this may happen if a troublesome but not threshold concept is not in regular use in the normal practice of the person. It may also be that a threshold concept is not reversed and lost but superseded or replaced by another threshold concept. For example some scientific concepts are replaced by other concepts as a person progresses in their learning of that science discipline. Thus in the case of threshold concepts one transformative ontological change is not lost or reversed but subsumed by another transformative ontological change. Whereas if the concept is only troublesome then it may be reversed. The bounded nature of a threshold concept is also rarely mentioned in the literature on threshold concepts. This may be due to Meyer & Land's (2003) definition of boundedness as what differentiates disciplines. I suggest that there are concepts that maybe are threshold in another discipline but not in prosthetics (Findings 4.2.1) and vice versa (Cousin 2009). There may be threshold concepts within a disciplinary school that are not threshold in another school of that discipline (Meyer et al.

2008). However there are threshold concepts that could apply across several disciplines (Ross et al. 2010), and the analysis here supports this notion (Findings 4.6.1). The criteria model provides one way of differentiating threshold from other concepts. The criteria of boundedness may help to explain why a concept may be threshold either in only one, or across several disiciplines.

5.5.2 Concept Model

In a similar way to the criteria model of threshold concepts, Davies and Mangan's (2007) concept model tries to explain the differences between threshold concepts and other types of concepts. My outcomes suggest that not all difficult concepts are threshold concepts (Findings 4.2.1& 4.3.1). I suggest that some difficult concepts are supporting concepts. These may be what Ricketts (2010 p47) calls *"threshold issues*", a step in learning which occurs before the acquisition of a threshold concept. Or they are basic concepts (Davies and Mangan 2007), since some of the information covered in these difficult areas may then be used within possible threshold concepts as I suggest may happen in "how we walk" and "learning to talk" (Findings 4.4.1 & 4.6.1). Supporting concepts could also be viewed as introductory or *"breadth first"* concepts (Zander et al. 2008 p105), where courses are front loaded with the "important" information. All the difficult concepts, whether threshold or not, that I have identified, have procedural concepts associated with them. What differentiates the difficult concepts from the possible threshold concepts is the contextualised experience including the

development of memories which are used during the procedural concepts (Findings 4.4.4, 4.5.4 & 4.6.4). This experience appears to assist with the integration and transformation within the learners understanding, developing the student's knowledge base. Whilst some supporting concepts may have associated procedural concepts they do not appear to have any associated disciplinary concepts. Disciplinary concepts appear to be part of the disciplinary view (Cousin 2009) and perhaps this is why some concepts may be threshold in one discipline but not in another. In addition if the disciplinary view is shared across more than one discipline as may be the case for "how to talk" (Findings 4.6), then the threshold concept may be applicable across several disciplines.

Both the criteria model and the concepts model assist in differentiating supporting concepts from threshold concepts. It appears that in the criteria model the type of transformation is important, with conceptual change occurring in both supporting and threshold concepts, whilst ontological change occurs only in threshold concepts. In the concepts model all concepts may have associated procedural concepts but in order for a concept to be threshold there must be associated experiential memories. Also the disciplinary concepts are essential for a concept to be threshold and may help explain why some concepts may be threshold in one discipline but not another or be cross-disciplinary.

5.6 Summary

There are difficult concepts within prosthetics. Some of these are threshold concepts and some are not. The difficulties for those that are not threshold focus is around their relevance and application especially when taught by a non-disciplinary lecturer. Some difficulties are related to poor previous experience of the subject but previous experience can also help for certain students in certain subjects. All learners will come to a concept with some level of understanding and this will play a role in how they engage and understand the subject and may explain some of the variation in understanding. Whilst the episteme of the discipline is tacit troublesome knowledge, tacit knowledge is more than this. It may include aspects of visualisation, conceptual understanding of the disciplinary language and memories of individual experiences. These experiences will also shape how they view the concept and their individual nature may help explain why there are different understandings of the same concept. In differentiating threshold concepts from other concepts the criteria and concepts models can be used together. Integration and ontological transformation together with both disciplinary and procedural concepts and associated memories appear to be required for a concept to be threshold.

6. Conclusion

This thesis explores what is experienced as difficult in prosthetics by staff and students. I undertook a qualitative approach to explore these issues, interviewing and using questionnaires, gaining information on the experience of difficult concepts from staff and students at two UK universities providing undergraduate courses in prosthetics and orthotics. Students in all four years of the prosthetics and orthotics programmes were included, with staff limited to those who taught prosthetics. I used an Interpretive Phenomenological Analysis approach as my methodological and analytical approach. My intention was to answer the following research questions: What is experienced as difficult, and potentially threshold, concepts in prosthetics? What can explain the possible reasons for the difficulties which students have with these concepts? Is there variation in student's perception of what is difficult? If so why?

6.1 Answers to research questions

From the perspective of both staff and students of prosthetics the difficult concepts are related to numerical based concepts, and the anatomy and physiology of the human body. In addition there appear to be three threshold concepts that are difficult. These are learning about and how to use language within different settings, knowledge and observational skills relating to gait (walking) and viewing prosthetic management from a holistic viewpoint. The difficulties which students have with these concepts are linked to issues of

curriculum design, the previous experience of the students and the invisible imagery and memories required to develop a full understanding of the concepts. The problems related to curriculum design cause more issues for concepts that are difficult but not threshold, primarily due to the background of the lecturer and their ability to ensure relevance and appropriate application. The concepts that are potentially threshold are mainly problematic due to the requirement to develop mental images of various kinds. Previous experience and knowledge affects how students approach and mentally conceive a concept. Therefore it is the students' previous experience that contributes to why some students struggle and others do not.

6.2 Difficult concepts (substantive conclusions)

Five difficult concepts were identified in prosthetics from the data. These were "the trouble with numbers", "the trouble with the body", "how to talk", "considering the person" and "how we walk". Within these difficult concepts the final three are suggested to be threshold concepts, with the former two being difficult but not threshold. The "trouble with numbers" and the "trouble with the body" suffer from difficulties due to curriculum design. Primarily these are linked to relevance and application, but they are also troublesome due to their timing within the curriculum. Students' poor previous experience certainly causes problems for maths based subjects resulting in a barrier to learning. For most students at University A their lack of experience of anatomy and physiology, linked with curriculum design issues, meant that they had difficulties with relevance and application. These issues were not apparent at

University B which took a problem based learning approach to learning about the body. Maths based subjects had problems when lecturers left out steps of the process and in anatomy there were problems due to an inability to visualise the underlying anatomy on a person. Neither the “trouble with numbers” nor the “trouble with the body” seemed to integrate with other aspects and whilst there is some transformation occurring in studying anatomy it is not significant and is perhaps linked to a clinical procedure rather than a way of seeing. The other three concepts I suggest are threshold concepts within prosthetics. These concepts had fewer issues related to curriculum design, with relevance and application perhaps being both implicit and explicit. Previous experience appears to help with disciplinary problem solving for “how we walk” and “considering the person” but both help and hinder in “learning to talk”. Hidden aspects were prevalent in all three of these concepts and this appears to be the main source of difficulties. There was transformation and integration for all three possible threshold concepts, but it is also possible to show how they meet all five of the criteria suggested by Meyer and Land (2003). The “trouble with numbers” and “the trouble with the body” contain basic and procedural concepts according to the concept model (Davies and Mangan 2007), but lack disciplinary concepts. “How we walk”, “learning to talk” and “considering the person” contain basic, procedural and disciplinary concepts together with associated memories.

6.3 Conceptual conclusions

Relevance and application are related to whether students see the point of

engaging with and therefore trying to understanding a concept. If they fail to see the relevance then they disengage and take a surface approach to learning which enables them to pass the subject. Making the relevance explicit and facilitating application of the concept in a disciplinary context assist students' understanding of why they are studying it. Ensuring explicitness of relevance and context appropriate application and the resulting level of engagement and understanding by students may be hindered when experts from a different discipline are teaching. Everyone has previous experience whether from education, work, hobbies or everyday life. This experience can have a positive or a negative effect on learning. It should not be ignored as it affects how a student approaches a concept and helps to explain the variation in understanding whether this is described as pre-liminal or sub-liminal variation, and which I believe are the same. Not all tacit troublesomeness is due to the episteme of the discipline. Some is due to requiring mental images to explain and understand concepts, whilst other troublesomeness is due to experts taking short cuts or the disciplinary language. Also tacit troublesomeness may be due to students' lack of contextualised memories upon which they can draw when solving problems. There is also more than one way of understanding a concept and how you view this concept is affected by the experience you have. The criteria model and the concept model of threshold concepts help to differentiate threshold concepts from other concepts. Integration and transformation of an ontological nature appear to be essential for a concept to be considered as threshold. In addition both procedural and disciplinary concepts combine to form a threshold concept with procedural concepts requiring contextualised

memories to separate them from non-threshold concepts.

6.4 Contribution to knowledge

Prosthetics and orthotics as a discipline, is under-researched pedagogically. The literature on programmes focussing on entry level as a prosthetist/orthotist is under theorised. This research adds some much needed exploration into learning to become a prosthetist/orthotist. Previous research on threshold concepts has suggested many different possible threshold concepts within various disciplines and possible ways to help students through the difficulties experienced. The literature assumes troublesomeness but lacks explanations of why the troublesomeness occurs and why it is not universal with all students experiencing the same difficulties. In this research I explore the sources of the troublesomeness and a possible reason why there is variation in student experience of difficulty.

In relation to troublesome knowledge my research suggests another form of troublesomeness due to curriculum design. I also suggest that tacit troublesomeness should be expanded to include other aspects of tacit knowledge. I add to the discussion on pre-liminal and sub-liminal variation, suggesting that these are the same and are affected by the previous experience of a student which can either help or hinder their engagement and understanding with the concept. My research adds to the debate on how a threshold concept differs and can be differentiated from other concepts. I suggest that threshold concepts require integration and ontological

transformation and both procedural and disciplinary concepts with associated procedural memories.

6.5 Critical reflection

My research is not perfect and there are things which I have learnt from the process of writing this thesis.

Had time allowed I would have considered a longitudinal study, following students from the start of their course through to the first year of practice as a prosthetist. This would perhaps have enabled me to see how students' experience of difficulties developed and changed over the duration of the course and into practice. This may have highlighted different areas of difficulty. Additionally I would have been able to ask students to reflect back on what they had found difficult in previous years and did they still have difficulty with these concepts and did they have insight into how they had moved on from any prior difficulties.

Action research had been suggested at the initial stage of my research. However, I felt that this was not appropriate. I did not have sufficient time to evaluate a difficult aspect, change some aspect of how this difficult was presented to the students and evaluate and repeat the cycle. I was also taking a whole programme approach rather than focussing on one module and taking an action research approach on the whole programme at the university at which I worked would have required much more involvement from my

colleagues and for them also to be interested and to put considerably more of their resources to my research and into changing their teaching. This would have been even more difficult at a university at which I did not work.

I could have limited my research by focussing only on the prosthetics and orthotics course at one university but this would have given different results and outcomes as it would have provided a narrower view of what was experienced as difficult within prosthetics; and certainly aspects of the issues relating to curriculum design would not have been found. Focussing on only one module within the whole programme would again have given very different results and would not have allowed exploration of a disciplinary view of difficult concepts but instead only a module view. This may have enabled a closer look at concepts within concepts but would have lacked how these linked to other aspects of the course and the discipline.

Personal contact greatly assisted with encouraging participation. Students at University A were less likely to have had previous contact with me and therefore I was just a stranger wanting to ask them questions. Students at University B and staff at both universities knew me and perhaps had some feeling of wanting to help me with my research. Perhaps, because they did not know me, students at University A did not volunteer in sufficient numbers to enable me to sample purposely. However, whilst I was not able to sample from University A I still achieved participants with different backgrounds.

6.6 Further research

During this research my three research questions were answered, although as outlined in the following section further work is desirable to progress this research area.

The research was bounded by exploring only difficult areas in prosthetics. Whilst I believe that some of the difficult concepts and possible threshold concepts identified here are equally applicable to orthotics further work is required to explore if this is actually the case. The research here focused on two courses in the UK, but there are courses in prosthetics and orthotics across the world at various different educational levels. Questions arise regarding whether students in different countries or at different educational levels experience the same or different problems when studying prosthetics and orthotics. As I have already mentioned I limited my research to the experiences of students and staff at two universities in the United Kingdom. Prosthetists and orthotists practicing in the clinical situation also have a role to play in facilitating learning with students who are on placement with them and they may experience different difficulties with students than do the lecturers. Learning also continues after the completion of degree programme and it may be that the achievement of any threshold concepts may not occur until new graduates build up their own clinical case load with the experiences and the challenges this presents. Both courses have recently made changes to the course structure with clinical placements introduced earlier. In one case there has been a movement back to having anatomy and physiology taught by non-disciplinary lecturers. Whether these changes have an effect on the difficulties

experienced would be interesting to explore. It would also be interesting to expand this work internationally to other universities who teach prosthetics (ISPO category I) at both undergraduate and postgraduate levels, as these programmes may have different approaches to curriculum design and which may result in similar or different threshold concepts. Also further research could explore if any of the concepts identified here are threshold in other disciplines.

6.7 Implications for practice

There are a number of implications for practice that I feel arise from my research. These include implications related to curriculum design, acknowledgement of students' prior experience, and how threshold concepts may be researched.

It appears that the learning of difficult concepts, and specifically those that are supporting concepts, needs to be context appropriate whether or not service taught, in order for students to see their relevance and be able to apply them in a disciplinary way. The context of learning should be meaningful to students (Kinchin et al. 2010; Tsui 2004) and assist their perception of relevance. This may be achieved through using problem based, *"real-world"* experiences (Osmond and Turner 2010). This could be addressed by running additional sessions run by discipline experts (LeBard et al. 2009), but whether extra sessions make a good use of resources and time needs to be questioned. It may be that disciplinary specialists could teach these supporting concepts.

However, with the increasing requirement to reduce costs in United Kingdom higher education, multi-disciplinary classes may become more common place. This may exacerbate this form of troublesomeness unless disciplinary contextual requirements are considered when creating learning outcomes, activities and assessment. Perhaps disciplinary specialists need to support service taught subjects with appropriate contextual material. As well as poor alignment between concept and context there were also some difficulties resulting from poor alignment between supporting concepts and the rest of the curriculum (Neame 1984). This suggests that in addition to a module view, a whole programme view is required when designing a programme enabling consideration of when both supporting and threshold concepts are introduced (Timmermans 2010).

Given that I suggest previous experience has both a positive and negative effect on learning concepts it seems sensible to suggest that lecturers need to be aware of this experience so that they can then present learning opportunities that are appropriate for the students' needs. It cannot be assumed that all students have the same starting point. Learning opportunities should be created that encourage the development of threshold concepts but also opportunities that assist students in getting to the point where they can develop their acquisition of threshold concepts.

Previous research into threshold concepts has predominantly used students at one point in their degree course or within one module as participants. My research suggests that by using students through all years of their degree and

lecturers, the development from novice to expert can be considered. Other research has mostly focused on certain stages within the acquisition of threshold concepts. I suggest that by interviewing at all stages of learning the progression through difficulties can be evidenced. Also, there may be difficulties which as a learner progresses through and which they may forget about. This approach facilitates understanding of these difficulties. It is also important to explore difficulties and concepts throughout a course because understanding may happen at different times for different learners. The integration of several pieces of information and experience may be required and these may not join up until sometime after a threshold concept has initially been introduced. In addition examples of possible post-liminal variation and liminal variation can be explored. These features may not be attended to if the participants are only for example, staff or first year students.

Overall I have identified some difficult concepts within prosthetics and suggest that three of these may be threshold concepts. These difficulties appear to arise due to issues related to curriculum design, the prior experience of the students, and tacit knowledge needed to gain a fuller understanding of a concept. The variation in experience that students have helps to explain why not all students experience difficulties with the same concept. Threshold concepts are perhaps best identified using both the criteria and the concept models as aspects of both appear to help in the identification of these concepts. My research helps to fill a large gap in knowledge about the education of prosthetists and orthotists. It also explores other areas of potentially troublesome knowledge than previously identified and adds to the

debate on how threshold concepts should be identified and why there is variation in understanding threshold and other concepts. I suggest a number of implications for practice and research into threshold concepts. Finally I suggest alternatives to the way I have conducted my research and areas for further research.

7. References

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8. Appendices

8.1 Lancaster University ethics form

Department of Educational Research

Ethical Approval Form for PGR Students

This form must be completed for each project involving the collection of data from human participants that you undertake. It must be approved and signed by your Supervisor **PRIOR** to any data collection and a completed, signed, copy sent to Alison Sedgwick. This procedure is part of new University regulations, as of Autumn, 2007. It is designed to protect both the PGR student and the research participant during the course of fieldwork and any other research ventures.

You must allow time to make any amendments suggested by your supervisor and report any significant changes to the project to them as soon as possible.

In completing this form, please consult the BERA Ethical Guidelines for Educational Research (http://www.bera.ac.uk/publications/guides.php).

Name of PGR student: Sophie Hill

Name of supervisor: Paul Ashwin

Project title: Difficult Concepts within a discipline: tacit, troublesome, threshold?

Summary of research project:
This project will investigate students' and lecturers' views of difficult concepts within prosthetics. The research will take place within the Directorate of Prosthetics and Orthotics, University of Salford in which I am a lecturer and within the National Centre for Prosthetics and Orthotics, University of Strathclyde. The participants will be students on the BSc (Hons) Prosthetics and Orthotics at both institutions and the lecturers who are prosthetists on both programmes.

Research Questions
- Explore how concepts that students find difficult may be identified
- Explore why these concepts are difficult to learn
- Identify ways which students find help them to understand these difficult concepts

Research strategy
Participants

Prosthetics and orthotics is only taught at two universities with the UK. Participants will be recruited from both institutions. The teaching staff at both universities includes lecturers who are prosthetist and/or orthotists, bioengineers, and researchers. All teaching staff who are prosthetists will be asked to participate – a total of 9. The students on the prosthetics and orthotics courses are from a wide range of backgrounds. Volunteers will be sought but to ensure representation across gender, age ethnicity, educational and employment background purposive sampling will be used. Each cohort, at each university, has a potential of 30 students. 3 students from each year group will be selected from those that have volunteered to participate, making a total of 24 students. This provides a manageable, but sufficiently broad range of participants and resulting data.

I will speak to prosthetic lecturers at the University of Salford individually to inform them of the project and organise interviews if they are willing to participate. Staff at the University of Strathclyde will be contacted by phone and/or email. I will speak to the years 1 – 3 students at the Universities of Salford and Strathclyde in their year groups and put up posters on their notice boards in the student communal area of the Blatchford Building (Salford) and National Centre for Prosthetics and Orthotics (Strathclyde). Students in year 4 will be contacted by letter explaining the project. For the 4th year students at the University of Strathclyde, the stamped letters will be given to the department for them to address. To enable the participation of a representative sample of students, purposive sampling of those who volunteer will occur based upon information gathered from the volunteer information form (attached). At the interviews those who choose to attend will again have the project explained to them, and will complete an informed consent form. If they do not wish to participate they can leave the interview prior to the start of the data collection. The informed consent form will inform them that if they wish to withdraw at any time they can do so. The data will be recorded and then transcribed. The participants will receive an anonymised copy of the transcript. For the students in year 4, those who wish to participate will be asked to complete and return a form with details of the email address upon which I can contact them in the enclosed SAE. They will then be sent an informed consent form and questionnaire based upon the semi-structured interview used with other students.

Issues of Vulnerability

Working with colleagues and researching their conceptions could be perceived as the researcher having power over the colleagues. However, I am not the line manager for my colleagues at Salford and the data once analysed will hopefully be useful to all of my colleagues in their approaches to learning and teaching. It may also be useful to them by allowing them to reflect on their teaching.

It will be explained to the students that whether they participate or not, it will not influence their progression on the programme. Those who participate will have this explained to them again prior to the start of the interview. It will also

be explained that there are no right or wrong answers and they should be able to speak freely.

Some of the students at the University of Strathclyde may be under the age of 18. Therefore a Criminal Records Bureau/Disclosure Scotland check may be required. I have an existing CRB check (approx 2 years old) undertaken for the University of Salford as part of my role as lecturer. However, the University of Strathclyde Code of Practice on Investigations on Human Beings Annex 2: Guide to recruitment of volunteers from particular groups states that "anyone of sixteen or over is for these purposes treated as an adult". Therefore this may not be required.

Data Generation

To explore what students find difficult it is appropriate to include both students and staff as participants. This will enable a comparison of what students find difficult and what staff perceive that students find difficult. Semi-structured interviews with staff and students in years 1-3 will be used. Face to face interviews will be digitally audio recorded and transcribed, augmented by notes taken during the interview. The face to face interviews will be held at the two universities. Whilst it may be possible to interview students in year 4 face to face this presents some logistical problems as they are spread across the UK (and abroad) for their final year placements. Email correspondence in the form of questionnaires will be used for these students, utilising the same semi-structured format as for the face to face interviews. Pilot interviews/questionnaire will be held with 4 students (one per year group) at the University of Salford and will inform the remainder of the interviews and questionnaires with the students at both universities. The interviews with the students will in turn inform the interviews with the lecturers.

Existing documents containing details of the prosthetic and orthotic curriculum such as programme and module specifications, the Quality Assurance Agency/ National Health Service subject benchmark (2001b) and the Health Professions Council's Standards of Proficiency for Prosthetics and Orthotics (2003) and the International Society of Prosthetics and Orthotics learning outcomes (International Society of Prosthetics and Orthotics 2002) will be analysed for any information that relates to the findings from the interviews and email questionnaires.

Data Analysis

The analysis will seek to generate meaning in the data using an ad hoc approach, allowing an overall sense of the data to be gained at first reading and then returning to the data to code it. The coding is likely to initially be descriptive, moving then to pattern coding developing and grouping initial coding into fewer themes. Whilst the coding occurs memoing will also occur helping the researcher move from description to conceptualisation of the data. Nvivo will be used to store and order the data analysis through coding and memoing. The analysis will consider whether the difficult concepts that students and staff identify fit the criteria for troublesome knowledge and threshold concepts. The possible variation between staff and different levels of students will be analysed in relation to the progression from novice to

expert. Alternative explanations and reasons for differences in the data will be sought as part of the analysis which will assist with the validity of the findings.

The digital recordings and the anonymised transcripts of the interviews will be kept for 5 years and then destroyed.

Rationale for Project

Whilst higher education should challenge students, some concepts appear to be more challenging than others. What it is about these concepts that students find difficult is often hard for lecturers to understand. Perkins (1999) notion of "troublesome knowledge" may be useful in exploring these difficulties. Troublesome knowledge may be complex (lacking an obvious organising principle), alien (from another culture or discourse), counter-intuitive, ritual, inert (Perkins 1999) or tacit (Meyer and Land 2003). Use of tacit knowledge is considered to be one of the features of an expert practitioner and differentiates them from a novice (Benner 1984; Dreyfus and Dreyfus 1986). Concepts may also be difficult because they may result in a change in or questioning of the students beliefs and thinking. This transformative nature is one of the features of a threshold concept (Meyer and Land 2003). These are considered to be *"akin to a portal, opening up a new and previously inaccessible way of thinking about something."*. Threshold concepts may also be troublesome and the other characteristics are considered to be probably irreversible, integrative, and bounded. Meyer and Land (2003) see threshold concepts as knowledge and ways of understanding that knowledge that you need to acquire to think like a member of a discipline. The model of skills acquisition from novice to expert (Benner 1984; Dreyfus and Dreyfus 1986) may be useful in exploring progression through difficult concepts and in understanding how experienced disciplinary members think compared to students especially in relation to knowledge that becomes tacit.

In previous, currently unpublished, research I have explored what lecturers at the University of Salford thought was difficult and challenging for students. This piece of research further explores those findings, seeking to expand to lecturers outside the prosthetics and orthotics course at Salford and to also include student's views on what is difficult and challenging for them in studying prosthetics. This research will be submitted as part of my PhD, Department of Educational Research, Lancaster University.

Where will the research be carried out? Do you have permission from the organisation(s) concerned?

The research will be carried out within the Directorate of Prosthetics and Orthotics, University of Salford and the National Centre for Prosthetics and Orthotics, University of Strathclyde. Ethical permission is being sought from both institutions.

Will you be exposed to any risks in conducting the research (e.g. collecting data in potentially dangerous environments)? If yes, please indicate how you will minimise this risk.

No, I will not be exposed to any risks in conducting the research.

What measures will be taken to safeguard the confidentiality of the data?
Copies of the participants' informed consent will be kept in a locked filing cabinet. The data will be anonymised by allocating pseudonyms to the different participants, with the transcripts and recordings being kept in a locked filing cabinet.

Pseudonyms will be allocated to the two universities.

To ensure that contact details of the students in year 4 at Strathclyde, other than those provided by the participants, are kept confidential, stamped unaddressed letters will be given to Strathclyde to address and send to students at their placement centre.

Who will have access to the data?
Each participant will be given a copy of their anonymised transcript. They will also, where possible, be informed of any published journal articles arising from the research. My supervisor will have access to the transcript data. Once the data has been analysed then it will form part of my PhD thesis and it is intended to submit journal articles and conference presentations based upon this

Please attach a copy of the written information sheet for participants that you will use (example attached).

Please attach a copy of the consent form that you will use (example attached).

Declaration:
The information on this form is accurate to the best of my knowledge and belief, and I accept full responsibility for its accuracy.

Signature of student: **Date:**

Approval of supervisor: **Date:**

8.2 Invitation and information sheet: University of Salford students in years 1 – 3

Name of Project: Difficult concepts within a discipline: tacit, troublesome, threshold?

Researcher: Sophie Hill

Supervisor: Paul Ashwin

Date: 2nd October 2008

Dear …,

I would like to invite you to take part in a research study which is part of my PhD studies in the Department of Educational Research at the University of Lancaster. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. Please ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

The study aims to explore the areas of prosthetics that for some reason are difficult. I am interested in what these difficult areas are, why they are difficult and how you as a student work through them.

Why have I been invited?

You have been invited because you are a student on the BSc (Hons) Prosthetics and Orthotics at the University of Salford or Strathclyde.

Do I have to take part?

Your participation in this study is entirely voluntary and you may withdraw from this study at any time by contacting Sophie Hill in writing or by email. Whether you agree or disagree to participate in this research project it will not affect your progression through the BSc (Hons) Prosthetics and Orthotics programme.

From those that volunteer to participate in the study, 3 students from each year at each university will be selected to enable a cross section of students with different backgrounds to participate.

What will taking part involve for me?

Outline:

- If you wish to volunteer for the study you will need to complete the attached volunteer information sheet, to enable me to select a range of students and then contact you via an email address that you provide.
- Data will be collected by semi-structured individual interviews. The interviews will be digitally recorded and transcribed.
- The interviews will take place at the university at which you are a student
- The interview will take up to an hour
- You will receive an anonymised transcript of your interview
- My supervisor will have access to the transcript data. Once the data has been analysed then it will form part of my PhD thesis and it is

intended to submit journal articles based upon this. Conference papers may also be submitted and presented.

- The data will be anonymised by allocating a pseudonym to all participants

What will I have to do?

You will have to complete and sign an informed consent form. You will have to participate in a face to face individual semi-structured interview. This project is not linked in any way with your continued progression on the BSc (Hons) Prosthetics and Orthotics.

What are the possible benefits of taking part?

For yourself, participating may help you reflect upon your learning. It will also provide you with some experience of a qualitative research project. In general, the study may help with future developments of the prosthetics and orthotics course at both universities and with health care courses in general. It will also add to the evidence base of education.

Thank you for reading this information sheet.

Sophie Hill

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Faculty of Health and Social Care

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8.3 Invitation and information sheet: University of Salford students in year 4

Name of Project: Difficult concepts within a discipline: tacit, troublesome, threshold?

Researcher: Sophie Hill

Supervisor: Paul Ashwin

Date: 2nd October 2008

Dear …..,

I would like to invite you to take part in a research study which is part of my PhD studies in the Department of Educational Research at the University of Lancaster. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. Please ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

The study aims to explore the areas of prosthetics that for some reason are difficult. I am interested in what these difficult areas are, why they are difficult and how you as a student work through them.

Why have I been invited?

You have been invited because you are a student on the BSc (Hons) Prosthetics and Orthotics at the University of Salford or Strathclyde

Do I have to take part?

Your participation in this study is entirely voluntary and you may withdraw from this study at any time by contacting Sophie Hill in writing or by email. Whether you agree or disagree to participate in this research project it will not affect your progression through the BSc (Hons) Prosthetics and Orthotics programme.

From those that volunteer to participate in the study, 3 students from each year at each university will be selected to enable a cross section of students with different backgrounds to participate.

What will taking part involve for me?

Outline:

- If you wish to volunteer for the study you will need to complete the attached volunteer information sheet, to enable me to select a range of students and then contact you via an email address that you provide.
- Data will be collected by email initially using a questionnaire. If I have further questions on your answers I will write these on your answers and email them back to you. This information will be collected into a word document (the transcript)
- The questionnaires will be emailed to the email address you provide.
- The questionnaire will take up to 30 minutes to complete initially
- You will receive an anonymised transcript of your responses

- My supervisor will have access to the data. Once the data has been analysed then it will form part of my PhD thesis and it is intended to submit journal articles based upon this. Conference papers may also be submitted and presented.
- The data will be anonymised by allocating a pseudonym to all participants

What will I have to do?

If you have any questions please email or phone me on the contact details given. If you wish to participate please complete, including an email address that I may use to contact you the attached form. From those that volunteer I will select 3 students from each year at each university to ensure that there is a cross section of student backgrounds. If you are selected you will have to complete an informed consent form and participate in an email questionnaire. After you have completed the questionnaire, I may ask you further questions in order to explain or ask for more information on your responses. This project is not linked in any way with your continued progression on the BSc (Hons) Prosthetics and Orthotics.

What are the possible benefits of taking part?

For yourself, participating may help you reflect upon your learning. It will also provide you with some experience of a qualitative research project. In general, the study may help with future developments of the prosthetics and orthotics course at both universities and with health care courses in general. It will also add to the evidence base of education.

Thank you for reading this information sheet.

Sophie Hill

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8.4 Invitation and information sheet: University of Strathclyde students in years 1 – 3

Name of Project: Difficult concepts within a discipline: tacit, troublesome, threshold?

Researcher: Sophie Hill

Supervisor: Paul Ashwin

Date: 16th October 2008

Hello,

I would like to invite you to take part in a research study which is part of my PhD studies in the Department of Educational Research at the Lancaster University. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. Please ask me (by email or phone) if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Who am I?

My name is Sophie Hill and as well as being a part time PhD student at Lancaster University, I am also a lecturer in prosthetics and orthotics at the University of Salford. You may have spoken to me or emailed me previously as I am the admissions tutor for the course at Salford. I grew up in Edinburgh and studied P&O at the National Centre, graduating in 1993. Prior to working at Salford I worked in clinic as a prosthetist/orthotist for a prosthetic contractor in Cambridge.

What is the purpose of the study?

The study aims to explore the areas of prosthetics that for some reason are difficult. I

am interested in what these difficult areas are, why they are difficult and how you as a student work through them.

Why have I been invited?

You have been invited because you are a student on the BSc (Hons) Prosthetics and Orthotics at the University of Salford or Strathclyde. Later on in the study I will also be interviewing some lecturers at both universities.

Do I have to take part?

Your participation in this study is entirely voluntary and you may withdraw from this study at any time by contacting me in writing or by email. Whether you agree or disagree to participate in this research project it will not affect your progression through the BSc (Hons) Prosthetics and Orthotics programme.

What will taking part involve for me?

- If you wish to volunteer for the study you will need to complete the attached volunteer information sheet, to enable me to select a range of students and then contact you via an email address that you provide. The volunteer information sheet asks about your age, gender, ethnic background, educational background, and employment background. From those that volunteer to participate in the study, 3 students from each year at each university will be selected to participate. If you are interested in volunteering then please complete the questionnaire and return it to me by email. My email address is s.hill@salford.ac.uk
- Data will be collected by semi-structured individual interviews. The interviews will be digitally recorded and transcribed.
- The interviews will take place at the university at which you are a student
- The interview will take up to an hour

- You will receive an anonymised transcript of your interview
- My supervisor will have access to the transcript data. Once the data has been analysed then it will form part of my PhD thesis and it is intended to submit journal articles based upon this. Conference papers may also be submitted and presented.
- The data will be anonymised by allocating a pseudonym to all participants

What will I have to do?

You will have to complete and sign an informed consent form prior to the interview. You will have to participate in a face to face individual semi-structured interview. During this I will ask you questions about your learning during the P&O course. This project is not linked in any way with your continued progression on the BSc (Hons) Prosthetics and Orthotics.

What are the possible benefits of taking part?

For yourself, participating may help you reflect upon your learning. It will also provide you with some experience of a qualitative research project. In general, the study may help with future developments of the prosthetics and orthotics course at both universities and with health care courses in general. It will also add to the evidence base of education.

Thank you for reading this information sheet. If you have any questions then please contact me.

Sophie Hill

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8.5 Invitation and information sheet: University of Strathclyde students in year 4

Name of Project: Difficult concepts within a discipline: tacit, troublesome, threshold?

Researcher: Sophie Hill

Supervisor: Paul Ashwin

Date: 16th October 2008

Hello,

I would like to invite you to take part in a research study which is part of my PhD studies in the Department of Educational Research at the University of Lancaster. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. Please ask me (by email or phone) if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Who am I?

My name is Sophie Hill and as well as being a part time PhD student at Lancaster University, I am also a lecturer in prosthetics and orthotics at the University of Salford. You may have spoken to me or emailed me previously as I am the admissions tutor for the course at Salford. I grew up in Edinburgh and studied P&O at the National Centre, graduating in 1993. Prior to working at Salford I worked in clinic as a prosthetist/orthotist for a prosthetic contractor in Cambridge.

What is the purpose of the study?

The study aims to explore the areas of prosthetics that for some reason are difficult. I am interested in what these difficult areas are, why they are difficult and how you as a student work through them.

Why have I been invited?

You have been invited because you are a student on the BSc (Hons) Prosthetics and Orthotics at the University of Salford or Strathclyde. Later on in the study I will also be interviewing some lecturers at both universities.

Do I have to take part?

Your participation in this study is entirely voluntary and you may withdraw from this study at any time by contacting me in writing or by email. Whether you agree or disagree to participate in this research project it will not affect your progression through the BSc (Hons) Prosthetics and Orthotics programme.

From those that volunteer to participate in the study, I will select 3 students from years 2 & 3 at each university. In year 4 I will select 6 students to participate (3 near the beginning of year 4 who will receive the questionnaire now and 3, currently on their prosthetic placement, who will receive the questionnaire at the end of their prosthetic placement. This will enable the collection of views from a cross section of students with different backgrounds at different times in their study.

What will taking part involve for me?

- If you wish to volunteer for the study you will need to complete the attached volunteer information sheet, to enable me to select a range of students and then contact you via an email address that you provide. The volunteer information sheet asks about your age, gender, ethnic background, educational background, and employment background. If you are interested in volunteering then please

complete the questionnaire and return it to me by email. My email address is s.hill@salford.ac.uk

- I will select 6 students from year 4. 3 of you will be asked to complete the questionnaire now and a further 3 who are currently on your prosthetic placement at the end of the placement.
- Data will be collected by email initially using a questionnaire. If I have further questions on your answers I will write these on your answers and email them back to you. This information will be collected into a word document.
- The questionnaires will be emailed to the email address you provide.
- The questionnaire will take up to 30 minutes to complete initially
- You will receive an anonymised copy of your responses
- My supervisor will have access to the data. Once the data has been analysed then it will form part of my PhD thesis and it is intended to submit journal articles based upon this. Conference papers may also be submitted and presented.
- The data will be anonymised by allocating a pseudonym to all participants

What will I have to do?

If you are selected you will have to complete an informed consent form and participate in an email questionnaire. The questionnaire asks you questions about your learning during the P&O course. After you have completed the questionnaire, I may email you again to ask you further questions in order to explain or ask for more information on your responses.

This project is not linked in any way with your continued progression on the BSc (Hons) Prosthetics and Orthotics.

What are the possible benefits of taking part?

For yourself, participating may help you reflect upon your learning. It will also provide you with some experience of a qualitative research project. In general, the study may help with future developments of the prosthetics and orthotics course at both universities and with health care courses in general. It will also add to the evidence base of education.

Thank you for reading this information sheet. If you have any questions then please contact me.

Sophie Hill

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School of Health Care Professions

Faculty of Health and Social Care

University of Salford

Salford

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0161 295 2281

8.6 Student demographic information questionnaire years 1 - 3

Difficult concepts volunteer information

I am willing to volunteer to participate in the study on difficult concepts, being conducted by Sophie Hill

Name	
Age	
Year of study	1 2 3 4
Gender	Male Female
Ethnicity	White – British White – Irish Other White Background Black or Black British – Caribbean Black or Black British – African Other Black Background Asian or Asian British – Indian Asian or Asian British – Pakistani Asian or Asian British – Bangladeshi Chinese or other ethnic background - Chinese Other Asian Background Mixed – White and Black Caribbean Mixed – White and Black African Mixed – White and Asian

	Other Mixed Background Other Ethnic Background
Educational background	A Levels/Highers/Advanced Highers BTEC National Certificate/Diploma Higher National Certificate/Diploma Undergraduate Degree Undergraduate Degree in another healthcare discipline Postgraduate Degree Other (please specify) _____
Employment background	Prosthetic technician Orthotic technician Other (please specify) _____
Email address: please provide an email address upon which I may contact you to organise an interview or send a questionnaire	

8.7 Student demographic information questionnaire year 4

Difficult concepts volunteer information

I am willing to volunteer to participate in the study on difficult concepts, being conducted by Sophie Hill

Name	
Age	
Year of study	1 2 3 4
Gender	Male Female
Ethnicity	White – British White – Irish Other White Background Black or Black British – Caribbean Black or Black British – African Other Black Background Asian or Asian British – Indian Asian or Asian British – Pakistani Asian or Asian British – Bangladeshi Chinese or other ethnic background - Chinese Other Asian Background Mixed – White and Black Caribbean Mixed – White and Black African Mixed – White and Asian Other Mixed Background

	Other Ethnic Background
Educational background	A Levels/Highers/Advanced Highers BTEC National Certificate/Diploma Higher National Certificate/Diploma Undergraduate Degree Undergraduate Degree in another healthcare discipline Postgraduate Degree Other (please specify) _____
Employment background	Prosthetic technician Orthotic technician Other (please specify) _____
Which placement are you currently on?	Prosthetic placement Orthotic placement
Email address: please provide an email address upon which I may contact you to send a questionnaire	

8.8 Consent form: students in years 1 - 3

Title of Project: Difficult concepts within a discipline: tacit, troublesome, threshold?

Name of Researcher: Sophie Hill

	Please initial box
1. I confirm that I have read and understand the information sheet dated October 2008 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.	
3. I understand that my participation is not linked in any way to my progression through the BSc (Hons) Prosthetics and Orthotics programme.	
4. I consent to the interview/session being audio-recorded.	
5. I agree to take part in the above study.	

Name of Participant:

Date:

Signature:

8.9 Consent form: students in year 4

Title of Project: Difficult concepts within a discipline: tacit, troublesome, threshold?

Name of Researcher: Sophie Hill

	Please initial box
1. I confirm that I have read and understand the information sheet previously given out for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.	
3. I understand that my participation is not linked in any way to my progression through the BSc (Hons) Prosthetics and Orthotics programme.	
4. I consent to the email questionnaire data I provide, being collated into one document to be used for data analysis.	
5. I agree to take part in the above study.	

Email address that I may be contacted on:

Name of Participant:

Date:

Signature:

8.10 Interview guide students in years 1 – 3

In this interview I am going to ask you questions about your learning and things that you have learnt in relation to prosthetics. Please remember that there is no right or wrong answer. I am interested in all answers. I am particularly interested in your learning about prosthetics. This may include things you have learnt about in prosthetic focussed modules and in other modules that link to prosthetics. The things you have learnt may be theoretical or classroom based or they may be practical things that you learnt in the clinic, plaster room or workshop.

1) Can you tell me a little about yourself? What is your background?

The next few questions all relate to what you have been studying in relation to prosthetics during the course.

2) Think back to something you found easy to learn. Can you tell me about it?
    a) Why do you think it was easy?
    b) What helped you to understand it?
    c) Were you the only one who found it easy?
    d) What other things do you need to understand to gain a good understanding of this?

e) Has your understanding of this affected your understanding of other things?

3) Think back to something you found difficult to learn. Can you tell me about it?
   a) Why do you think it was difficult?
   b) What helped you to understand it?
   c) Were you the only one who found it difficult?
   d) What other things do you need to understand to gain a good understanding of this?
   e) Has your understanding of this affected your understanding of other things?
   f) What advice would you give to students who are also struggling with this?

4) Have there been any “light bulb” moments? Times when you suddenly understood something?
   a) Can you tell me about that?
   b) Was there anything you or someone else did that helped you understand it?
   c) What other things do you need to understand to gain a good understanding of this?
   d) Has your understanding of this affected your understanding of other things?

e) What advice would you give to students who are also struggling with this?

5) Have there been things that took you a long time to understand?
   a) Can you tell me about that?
   b) Was there anything you or someone else did that helped you understand it?
   c) What other things do you need to understand to gain a good understanding of this?
   d) Has your understanding of this affected your understanding of other things?
   e) What advice would you give to students who are also struggling with this?

6) Are there things that you didn't understand earlier in the course but do now?
   a) Can you tell me about that?
   b) Was there anything you or someone else did that helped you understand it?
   c) What other things do you need to understand to gain a good understanding of this?
   d) Has your understanding of this affected your understanding of other things?
   e) What advice would you give to students who are also struggling with this?

7) Are there things that you thought you had understood but realised later that you didn't?
   a) Can you tell me about that?
   b) Do you understand it now? Can you explain it to me?
   c) Was there anything you or someone else did that helped you understand it?
   d) What other things do you need to understand to gain a good understanding of this?
   e) Has your understanding of this affected your understanding of other things?
   f) What advice would you give to students who are also struggling with this?

8) What do you think was the key thing or things that you learnt last year?
   a) Why was this/are these key thing(s) for you?

9) Without going into too much detail, was there anything external to the course e.g. a job that affected your learning?

10) Case scenario

    I'm going to give you a prosthetic case scenario to read. I would like you to come up with a prosthetic prescription for this person. There is no right or wrong answer.

    Give case scenario

a) What would you prescribe?

b) Why would you prescribe that?

c) What did you consider when making your decision?

d) On a scale of one to ten, with 1 being very difficult and 10 being very easy, how easy or difficult did you find deciding on the prescription?

e) Why was it easy/difficult for you?

11) Can you tell me what you think learning is?

a) Tell me about how you learn things?

b) Do you study in the same way all the time?

c) How do you know that you have learnt something?

8.11 Questionnaire for year 4 students

In this questionnaire I am going to ask you questions about your learning and things that you have learnt in relation to prosthetics. Please remember that there is no right or wrong answer. I am interested in all answers. I am particularly interested in your learning about prosthetics. This may include things you have learnt about in prosthetic focussed modules and in other modules that link to prosthetics. The things you have learnt may be theoretical or classroom based or they may be practical things that you learnt in the clinic, plaster room or workshop or on placement.

1) Can you tell me a little about yourself? What is your background? How did you come to study P&O?

The next few questions all relate to what you have been studying in relation to prosthetics during the course.

2) Think back to something you found easy to learn. Can you tell me about it?
    a) Why do you think it was easy?
    b) What helped you to understand it?
    c) Were you the only one who found it easy?
    d) What other things do you need to understand to gain a good understanding of this?

e) Has your understanding of this affected your understanding of other things?

3) Think back to something you found difficult to learn. Can you tell me about it?
   a) Why do you think it was difficult?
   b) What helped you to understand it?
   c) Were you the only one who found it difficult?
   d) What other things do you need to understand to gain a good understanding of this?
   e) Has your understanding of this affected your understanding of other things?
   f) What advice would you give to students who are also struggling with this?

4) Have there been any “light bulb” moments? Times when you suddenly understood something?
   a) Can you tell me about that?
   b) Was there anything you or someone else did that helped you understand it?
   c) What other things do you need to understand to gain a good understanding of this?
   d) Has your understanding of this affected your understanding of other things?

e) What advice would you give to students who are also struggling with this?

5) Have there been things that took you a long time to understand?
   a) Can you tell me about that?
   b) Was there anything you or someone else did that helped you understand it?
   c) What other things do you need to understand to gain a good understanding of this?
   d) Has your understanding of this affected your understanding of other things?
   e) What advice would you give to students who are also struggling with this?
6) Are there things that you didn't understand earlier in the course but do now?
   a) Can you tell me about that?
   b) Was there anything you or someone else did that helped you understand it?
   c) What other things do you need to understand to gain a good understanding of this?
   d) Has your understanding of this affected your understanding of other things?
   e) What advice would you give to students who are also struggling with this?

7) Are there things that you thought you had understood but realised later that you didn't?
   a) Can you tell me about that?
   b) Do you understand it now? Can you explain it to me?
   c) Was there anything you or someone else did that helped you understand it?
   d) What other things do you need to understand to gain a good understanding of this?
   e) Has your understanding of this affected your understanding of other things?
   f) What advice would you give to students who are also struggling with this?

8) What do you think was the key thing or things that you learnt last year?
   b) Why was this/are these key thing(s) for you?

9) Without going into too much detail, was there anything external to the course e.g. a part time job that affected your learning?

10) Case scenario

    I'm going to give you a prosthetic case scenario to read. I would like you to come up with a prosthetic prescription for this person. There is no right or wrong answer.

    Give case scenario

    a) What would you prescribe?

b) Why would you prescribe that?

c) What did you consider when making your decision?

d) On a scale of one to ten, with 1 being very difficult and 10 being very easy, how easy or difficult did you find deciding on the prescription?

e) Why was it easy/difficult for you?

11) Can you tell me what you think learning is?

a) Tell me about how you learn things?

b) Do you study in the same way all the time?

c) How do you know that you have learnt something?

8.12 Invitation and information sheet for lecturer participants

Name of Project: Difficult concepts within a discipline: tacit, troublesome, threshold?

Researcher: Sophie Hill

Supervisor: Paul Ashwin

Date: 13th March 2009

Dear ….,

I would like to invite you to take part in a research study which is part of my PhD studies in the Department of Educational Research at the University of Lancaster. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. Please ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

The study aims to explore the areas within prosthetics that for some reason are difficult. I am interested in what these difficult areas are, why they are difficult and how students are helped through them. Students at the Universities of Salford and Strathclyde have already participated exploring what they find difficult. I am now at the stage of asking lecturers to participate. In this study only lecturers who are prosthetists will be included.

Why have I been invited?

You have been invited because you are a lecturer on the BSc (Hons) Prosthetics and Orthotics at either the University of Salford or the University of Strathclyde who is also a prosthetist and teaching prosthetics.

Do I have to take part?

Your participation in this study is entirely voluntary and you may withdraw from this study at any time by contacting Sophie Hill in writing or by email.

What will taking part involve for me?

Outline:

- Data will be collected by semi-structured individual interviews. The interviews will be digitally recorded and transcribed.
- The interviews will take place at the university at which you work
- The interview will take up to an hour
- You will receive an anonymised transcript of your interview
- My supervisor will have access to the transcript data. Once the data has been analysed then it will form part of my PhD thesis and it is intended to submit journal articles based upon this. Conference papers may also be submitted and presented.
- The data will be anonymised by allocating a pseudonym to all participants

What will I have to do?

You will have to complete and sign an informed consent form. You will have to participate in a face to face individual semi-structured interview. The interview will take place at the university at which you work.

What are the possible benefits of taking part?

For yourself, participating may help you reflect upon your teaching and the learning of the students. In general, the study may help with future curriculum design and learning, teaching and assessment strategies by identifying the difficult areas for students. It will also contribute to both the research base of prosthetics and orthotics and higher education.

If you wish to take part in this research, then please contact me (by email or phone) to enable me to organise a suitable time for an interview.

Thank you for reading this information sheet.

Sophie Hill

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8.13 Consent form: lecturers

Title of Project: Difficult concepts within a discipline: tacit, troublesome, threshold?

Name of Researcher: Sophie Hill

	Please initial box
1. I confirm that I have read and understand the information sheet dated 13/3/09 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.	
3. I consent to the interview/session being audio-recorded.	
4. I agree to take part in the above study.	

Name of Participant:

Date:

Signature:

8.14 Interview guide: lecturers

In this interview I am going to ask you questions about your teaching and the students learning in relation to prosthetics. Please remember that there is no right or wrong answer. I am interested in all answers. I am particularly interested in the student's learning about prosthetics. This may include things they have learnt about in prosthetic focussed modules that you and others teach and in other modules that link to prosthetics. The things they learn may be theoretical or classroom based or they may be practical things that they learn in the clinic, plaster room or workshop.

1) Can you tell me a little about yourself?
    a) What is your background?
    b) How did you get into prosthetics?
    c) How long have you been qualified?
    d) How long have you been working in education?

2) Teaching
    a) Tell me about what you teach?
    b) Do you teach in the same way all the time?
    c) How do you know that you have taught something well?

3) Can you think back to when you were a student? What did you find difficult to learn and why?

The next few questions all relate to what you your teaching, especially in prosthetics

4) What do you think the students find easy to learn. Can you tell me about it?
    a) Why do you think it was easy?
    b) What helps them to understand it?
    c) Did all the students find it easy?
    d) What other things do students need to understand to gain a good understanding of this?
    e) Does the student's understanding of this affect their understanding of other things?

5) What do students find difficult to learn? Can you tell me about it?
    a) Why do you think it was difficult?
    b) What helps them to understand it?
    c) Did all students find it difficult?
    d) What other things do students need to understand to gain a good understanding of this?
    e) Does the student's understanding of this affect their understanding of other things?
    f) What advice would you give to students who are also struggling with this?

6) Are there things that students consistently find difficult?

7) Are there occasions when students suddenly grasp something, a “light bulb” moment? Times when you suddenly understood something?
   a) Can you tell me about that?
   b) What helped them understand it?
   c) What other things do the students need to understand to gain a good understanding of this?
   d) Does their understanding of this affect their understanding of other things?
   e) What advice would you give to students who are also struggling with this?

8) Have there been things that students take a long time to understand?
   a) Can you tell me about that?
   b) What helps them understand it?
   c) What other things do they need to understand to gain a good understanding of this?
   d) Does their understanding of this affect their understanding of other things?
   e) What advice would you give to students who are also struggling with this?

9) Do you find that there are things that students don’t understand earlier in the course but do later on?

a) Can you tell me about that?
b) What helps them understand it?
c) What other things do they need to understand to gain a good understanding of this?
d) Does their understanding of this affect their understanding of other things?
e) What advice would you give to students who are also struggling with this?

10) Are there things that students think they understand but don't?
    a) Can you tell me about that?
    b) What helps them understand it?
    c) What other things do they need to understand to gain a good understanding of this?
    d) Does their understanding of this affect their understanding of other things?
    e) What advice would you give to students who are also struggling with this?

11) What do you think are the key thing or things that you teach?
    Why was this/are these key thing(s)?

12) What do you think are the key thing(s) in prosthetics?
    Why are these key things?

13) Do you find there are non-university things that affect the students learning?

14) Case scenario

I'm going to give you a prosthetic case scenario to read. I would like you to come up with a prosthetic prescription for this person. There is no right or wrong answer.

Give case scenario

a) What would you prescribe?
b) Why would you prescribe that?
c) What did you consider when making your decision?
d) On a scale of one to ten, with 1 being very difficult and 10 being very easy, how easy or difficult did you find deciding on the prescription?
e) Why was it easy/difficult for you?

15) Can you tell me what you think learning is?

a) Tell me about how you learn things?
b) How do you think students learn things
c) Do all students learn in the same way?
d) How do you know that the students have learnt something?

8.15 Case scenarios for all interviews and questionnaire

1) Upper Limb

Lachlan runs his own business dealing with geographical information systems for environment projects. This requires him to meet people, work with computer programmes on computers and hand-held devices both in the office and outdoors, sometimes in remote areas both in the UK and abroad. He lost his arm recently due to a car accident. In the accident he also broke his tibia but this has healed and he is up and walking again. In his spare time he enjoys going down the pub with his mates, bird watching and playing golf occasionally. His residual limb is at trans-radial level and is 55% of his sound arm. He is 34 and is due to return to work shortly.

2) Lower Limb

Fred is 68 years old. He has recently undergone a trans-tibial amputation due to PVD. Fred gave up smoking about 20 years ago and he is not diabetic, nor overweight. His residual limb is of medium length with good muscle coverage and Fred has good knee and hip control, but he does have a knee flexion contracture of 5°. Fred was a carpenter before he retired and still likes to make things in his shed. He lives with his wife Mary, and they have 2 children and 3 grandchildren. Before the amputation Fred and Mary used to walk to church (approx ¼ mile) where Fred is a church warden, every Sunday.

8.16 Example of worked interpretative phenomenological analysis data analysis approach

Initial thoughts	Transcript	Emerging themes
	R: see if your brain works (mumbles). Has there been anything that's taken you a long time to understand?	
	I7: in terms of prosthetics,	
	R: yeah	
	I7: biomechanics, yeah, I've really, really struggled, 'cause maths is not one of my strong points at all. I mean, when I was at school if you were good at maths or you were good at English, they brought you on. The government brought you on, in, in either maths or English, you know, give me a word I can spell it, you know, I did really well in. And that's probably why I do so well in my assignments and things like that. <u>But maths I'm absolutely, I'll hold my hands up, I am *terrible* at maths, you know, I still fingers and thumbs when it comes to um.</u> But yeah, I understand the principles now, and <u>I think doing that extra year when I failed it the first time round really I wouldn't have been doing myself any favours if I'd've gone into the second year.</u>	
Bad at maths		Previous experience - causing problem
Repetition of year helped with maths/biomech understanding		Repetition/revision of concepts
Practical made		Application - impacting on

concepts clearer Identifies level of maths needed Failed to understand and coped by surface learning Scared to admit that she didn't understand Numbers causing problems rather than descriptive biomechanics	And I think redoing it, it kind of, sunk in a bit more and then in the second year with Chris when we actually did the practical, it all felt, that was a light bulb moment, I were like "*oh yeah I understand it now*", you know, um yeah it all fell into place then, in the second year. So I just think it was all very, if you haven't got a basic knowledge of maths and you haven't done angles and stuff like that, I don't think you stand a chance really, 'cause it was all very, it was very scientific and I was "I don't know what you're talking about" kind of think, you know, and I just kind of wheedled my way through the first year. I don't think I did myself any, any favours but I just kind of sat there and went "yeah, ok" and I never asked any questions 'cause you don't want to look daft, you know, you don't want to think "god he's going think I'm really thick here" um and Craig he gave us all the help we needed really but sometimes it was kind of, you didn't want to ask him because you thought "I feel a bit stupid" 'cause I really should know this. So yeah, biomechanics has been my real bug bear R: was there anything	perception of relevance Application – impacting on understanding Previous experience – level of maths Relevance – impacts on understanding Relevance – lack of relevance results in surface learning Previous experience? Numbers are problematic

	specific in biomech? I7: it was, it was all the maths, it was *all* the maths, you know	
Emotional and physical reaction to maths based concepts in exam	R: so the description type stuff was ok? I7: the description type stuff was fine, yeah, and again putting it into practice. But all this, you know, moments and turning moments and angles and I got, I remember in the first year I got to the exam and I sat there and I was crying in the exam, because I thought "I really don't". Numbers have this effect on me, I think I have, because I did so badly with them at school, as soon as you er, give me a mathematical problem I just want to cry. And I can feel it, it's like a physical thing, you know. Um, but yeah that, that really, I just whorrrr	Previous experience – creates barrier to learning
Practical biomechanics enabled understanding of concepts	R: but then in second year when you had practical stuff were you able to relate I7: I was able to relate what, what we'd been taught by Craig in the first year into	Application – enabled understanding rather than surface learning

Learning enough to pass without understanding	what we were actually doing. And I though whoah, you know, yeah and the graphs all made sense and everything kind of fell into place, so I thought, d'you know what, it's not as bad as I thought this. And I did really well in my, my biomechanics, I got 86% in biomechanics. Which was a real achievement for me because I thought I'm never going to be able to do, I'm never going to be able to, you know, to get this at all and I think I just scraped through the exam in, in, in the first year. I learnt what I needed to learn to get me through the exam. You know, being brutally honest and, and that was it you know.	Application and relevance – lack of these results in learning enough to pass