AN INVESTIGATION INTO BEGINNER TEACHERS' KNOWLEDGE AND LEARNING STUDY

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Abstract

Following Shulman (1986a), teachers' knowledge is often divided into Content Knowledge (CK) and Pedagogical Content Knowledge (PCK). However, the operationalizing of these ideas in initial teacher education has been hampered by difficulties in defining CK and PCK, understanding their interrelationship and finding effective ways of using these ideas to support Beginner Teachers' (BTs') development. This study uses Phenomenography/Variation theory (Pang & Marton, 2003, 2005) to address these difficulties in the context of BTs of economics and business studies in England in 2011/2. The study found that Learning Study has a statistically significant, medium/large effect on BTs' CK and PCK in comparison to conventional teacher education. This suggests that it should be more widely incorporated into teacher education programmes in England. In addition, the results of the study confirm previous evidence of a positive association between CK and PCK and weaknesses in BTs' conceptual understanding of a fundamental topic in their subject domain (price). No association was found between BTs' degree classifications and their CK or PCK either at the beginning or the end of training. In drawing these conclusions an approach to describing conceptions of price is developed that explicitly accounts for the 'internal horizon' or context of the phenomenon.

Dedications

I would like to thank all of those people around me who have shown such unshakeable faith in me during the writing of this thesis and have talked sense in to me when things have got tough. Without your belief in me – yes, you know who you are - I would not have been able to get this far.

I would also like to thank my supervisor, Peter, for being so utterly brilliant during the last 6 years or so. Like all great teachers, he has challenged and supported me in going far beyond what I ever thought I could achieve. We have crossed paths a few times over the last 25 years or so and I really hope that the completion of this work will not be the last time.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1. Summary and rationale

The importance of raising Beginning Teachers' (BTs') knowledge is often asserted in debates over policy and practice in initial teacher education (e.g. Department for Education, 2011). But how should this knowledge be described? Many researchers have made use of Shulman's (1986a) distinction between Content Knowledge (CK) and Pedagogical Content Knowledge (PCK). This distinction is rooted in the appealing idea that knowing about a topic (CK) is different to knowing about teaching and learning that topic (PCK) (Bucat, 2005). However, in spite of studies suggesting that high levels of CK and PCK are linked to teacher quality (e.g. Baumert et al., 2010; Tirosh, Tasmir, Levenson & Tabach, 2011), progress towards operationalising CK and PCK for initial teacher education has been hampered by difficulties in: i) definition and measurement, ii) understanding the interrelationship between CK and PCK and, iii) finding effective ways of using CK and PCK to support BTs' development (De Jong, 2009; Kind, 2009).

This study explores how Phenomenography/Variation Theory (PVT) might address these difficulties. The central proposition of PVT is that there are relatively few

qualitatively different conceptions of any given phenomenon (Marton 2014). It is therefore possible to distinguish between a BT who understands a phenomenon (or subject topic) in a straightforward way and therefore has a low level of CK, and a BT who understands it in a complex way and has high levels of CK. It is also possible to distinguish between a BT who shows a sophisticated awareness of differences between students' ways of understanding a topic and therefore is likely to exhibit a high level of PCK, and one who does not.

PVT also offers a route to improving BTs' CK and PCK known as 'Learning Study' (Pang & Marton, 2003). Learning Study is a collaborative approach to the planning, teaching and reviewing of lessons that combines aspects of Action Research (AR) and Design Research (DR) with an analysis of learning in terms of PVT (Pang & Marton, 2003). It involves groups of teachers planning, teaching and reviewing lessons structured around variation in critical aspects of a phenomenon. Lessons taught in this way have been shown to have significant effects on the depth of students' conceptual understanding (Pang & Marton, 2003, 2005). An emerging body of evidence also suggests that Learning Study improves teachers' knowledge (e.g. Davies & Dunnill, 2008; Nilsson, 2014).

This study contributes to previous research by measuring BTs' CK and PCK in terms of PVT. It then uses the results to: i) provide evidence of how Learning Study in initial teacher education impacts on BTs' PCK and CK and, ii) examine relationships between CK and PCK.

The central research question in this study therefore is: what are the effects of Learning Study on BTs' CK and PCK? Addressing this question involves examining: i) how BTs' CK and PCK can be described, ii) what the level of BTs' CK and PCK before and after the experience of Learning Study are and, iii) what the associations between BTs' CK and PCK are. Associations between BTs' degree classifications and CK are also explored as part of addressing the second and third of these points.

The study followed the theoretical principles of PVT (and Learning Study) in the evaluation of teacher learning, in the same way that they have previously been employed in the evaluation of student learning (e.g. Pang & Marton, 2003). This involved comparing changes in BTs' understandings of the phenomenon of 'price' in a group taking part in a Learning Study with changes in the understandings of BTs in a control group. The study was quasi-experimental research design. The first stage was to establish: i) BTs' qualitatively different conceptions of price as a

measure of their CK and, ii) BTs' qualitatively different conceptions of students' understanding of price as a measure of their PCK. Explicit variation in the context of the phenomenon formed a key aspect of evidence gathering during this stage. In the second stage, the descriptions of BTs' CK and PCK that had been developed were applied to measure BTs' knowledge and changes in it.

Results from the first stage of the study indicated that BTs' conceptions of CK and PCK varied along the both the 'external horizon' (related to the context of the phenomenon of price) and the 'internal horizon' (related to the phenomenon of price itself) (Marton & Booth, 1997). Twelve conceptions of price (CK) were identified and nine conceptions of students' conceptions (PCK). There were some important similarities between BTs' conceptions of price and the findings of previous studies into students' conceptions of price (e.g. Pang & Marton, 2003; Davies, 2011a, 2011b). The structure of BTs' conceptions of students' conceptions was found to reflect those in relation to CK.

Results from the second stage of the study suggested that in comparison to the control group of BTs (for which no statistically significant effect could be found), the Learning Study group experienced a medium/large, statistically significant effect on

both their CK and their CK. In addition, the Learning Study group's median and mean levels of CK and PCK rose more than those in the control group. These results are in tune with previous findings that have pointed to the positive effects of Learning Study on teachers' knowledge (e.g. Pang, 2006; Van Bommel, 2012; Tan and Nashon, 2013).

This study found that BTs' average levels of conceptual CK and PCK were low at both pre and post-test stages. In addition, no significant correlation could be established between BTs' CK or PCK and their degree classifications either at the beginning or the ending of their training. Given the wide range of studies that have established a strong link between teachers' CK and PCK and the quality of outcomes for their students (e.g. Hadfield, Littleton, Steiner & Woods, 1998; Speer and Wagner, 2009; Griffin, Jitendra & League, 2009; Baumert et al., 2010; Tirosh et al., 2011) these results point to likely weaknesses in BTs' teaching of price. In addition, they raise questions about the quality of teacher training in England and about the effectiveness of current government policy of only recruiting teachers with 'good' degrees.

Positive associations between BTs' CK and PCK were found in this study both at the pre-test and the post-test phase. This result is consistent with the theoretical

assumption that high levels of CK are a necessary condition for high levels of PCK. That the association identified in this study is relatively weak is in line with previous empirical studies suggesting that CK and PCK become more interconnected at higher levels of CK (Kraus et al., 2008).

This study demonstrates that Learning Study can focus on teacher learning as well as student learning in a way that is entirely consistent with the principles upon which it is founded, namely PVT. The main recommendation to emerge therefore is that Learning Study should be introduced more generally into teacher training in England because of its positive effects on BTs' CK and PCK.

This study makes a number of other recommendations. Firstly, the policy of only recruiting BTs with 'good' degrees should be reviewed and other measures of CK developed. One way forward could be to develop phenomenographic 'tests' of CK of the type used in this and other studies. Secondly, teacher training courses in England should revisit their approach to developing BTs CK and PCK development given that they cannot assume that BTs will arrive with high levels of either. This study has developed classifications of conceptions of price that could form the basis of a strategy to improve BTs' CK and their PCK. This is because they enable BTs and

teacher trainers to identify and focus on critical differences between qualitatively different conceptions. The classification of conceptions in relation to other key phenomena in this domain (and others) would allow this process to be more widely applied in teacher training.

In terms of recommendations for further research, the study raised four questions in relation to: i) the way in which the context (or external horizon) should be accounted for in PVT research, ii) the most effective way to develop BTs' understanding of Learning Study that is consistent with the principles of PVT, iii) the extent to which the results of the study in relation to PCK form the basis for a more generalised set of conceptions of PCK and, iv) the causes of the falls in BTs' CK and/or PCK that were observed in some BTs over the course of their training.

1.2. Personal background

Understanding more about the nature of what it means to learn something and the best ways to help people to learn have always pretty much amounted to an obsession for me. I can remember sitting in a lesson in school when I was 17, with the teacher obviously struggling to get the ideas across, thinking 'why is he having so much difficulty with this?' It was the intriguing mix of him (the teacher), us (the students)

and the subject (economics) swirling around that fired my imagination and that led me also to think 'I want to have a go at this'.

I went to Egypt for two years immediately after university in 1987 as a volunteer, and taught English Language and Literature at an Egyptian School in Alexandria. This was a tough initiation, with groups of 40-50, 14 year old students and not much else beyond a chalkboard, some chalk (usually) and my powerful sense of purpose. More fascinated than discouraged by the challenges of this experience, I returned to England to complete a PGCE at the University of Manchester. At Manchester I could not help but return again and again to the question of what I was trying to achieve as a teacher and how important developing some kind of answer to this question was for lessons that I was crafting and for the students that I was teaching. This sense of questioning and striving for clarity in my vision of teaching and learning did not leave me after I left Manchester and taught economics and business studies first in a Further Education College for five years and then in a secondary school for a further five years.

During my early years of teaching, I always had a sense that students did better if they were engaged, but my understanding of what this meant changed considerably

as my understanding of economics and business studies and my understanding of my students changed. In general terms, in retrospect, I now see this as a shift from a focus on me, the teacher, to a focus on them, the students.

In order to progress but still maintain my classroom focus, I moved to another secondary school in 2000 and became an Advanced Skills Teacher. This role gave me the scope to work with other teachers from other schools and also with trainee teachers in a local university, on the teaching of economics and business studies. This experience forced me to reflect again on what it was about my teaching that was good in order to work out how this could be shared with others. I realised that I had increasingly come to define my teaching in terms of the assessment criteria for the courses I was teaching, which was essentially based on the taxonomy developed by Bloom, Engelhard, Furst, Hill and Krathwohl (1956). This was important as it provided a more formalised framework within which I could interpret my teaching, something that I had not explicitly possessed until that point.

However, as things developed, I realised that my teaching seemed to be becoming less and less about economics and business studies and more and more about the teaching of the kinds of skills emphasised by Bloom et al. (1956). In short, it felt as if

the subjects of economics and business studies were resolving into vehicles for the teaching of 'skills'. Fortunately, in 2007, I was asked to take part in a Learning Study that involved some of my own students. This proved to be a very powerful experience. I felt the invigorating effects of the continual focus on student learning, of rethinking previously taken for granted subject content and of working closely with other teachers (something that had happened only infrequently in my teaching career). Learning Study raised many questions, but at its heart seemed to represent a special way of getting closer to the heart of teaching and learning. Here was an approach that resonated with my sense of the lesson as the fundamental building block in teaching. I saw great potential in the way in which Learning Study integrated a theory about learning, a practical approach to teaching lessons and a deep way of thinking about the subjects of economics and business studies.

In 2008, I took an opportunity to move to a university to lead a Post Graduate Certificate of Education (PGCE) course training economics and business studies teachers. This seemed like a logical move. If I could influence the learning of future teachers, I believed that I would be able to influence the learning of many more students than I could teaching students directly. Working with BTs provided another context within which to rethink my understanding of teaching and learning.

Following my exposure to Learning Study in 2007, I was set out to integrate it into the PGCE courses in the university and over the subsequent 8 years developed my approach through working with BTs from a variety of different subject domains. My direct involvement with BTs engaging with Learning Study was the main catalyst for my PhD studies, which I began in 2010.

Also during my first university position, I received recognition for my teaching ability in a university context, gaining a Teaching Excellence Fellowship in 2010. In addition, I became more deeply involved in the wider economics and business studies community, becoming the Chair of the national subject association for teachers of economics and business studies in 2012. I have also been the external examiner for teacher training courses at the University of Manchester and Queen's University in Belfast, as well as becoming a Senior Fellow at the Higher Education Academy. I have presented the interim results of this study at a number of international conferences. In 2014 I became the Junior Research coordinator for the Phenomenography/Variation theory Special Interest Group of the European Association for Research into Learning and Instruction. In 2015, in order to broaden my research interests and to experience a different context, I moved to another university.

In summary, my approach to my work as an educator has been defined by a consistent restlessness in my journey to do things better, to understand my subject better, to refine my understanding of what learning looks like and to try to develop an increasingly sophisticated understanding of how to achieve it in the classroom. In this process I have resonated between reflection and practice, between thinking about teaching and doing it, with each enriching the other. I have worked hard to relish the uncertainties that learning inevitably brings, to balance conviction and tentativeness in my beliefs and most importantly to stay alive to possibility.

This study represents another step in my journey. Completing this research has had a profound effect on my own development as a researcher and a profound effect on the way in which I have worked with BTs. I continue to gain enormous personal rewards from seeing learners make progress, but still retain a strong sense that the job is never done and that the puzzle of learning (and teaching) is never completely solved.

1.3. Scope of the study

The study drew on evidence from BTs training to gain teacher accreditation on nine month Post Graduate Certificate of Education courses at eight universities in England during 2011-12. The initial sample involved 114 BTs which represented nearly 50% of the total number of BTs training in England in economics and business studies in that year. The focus of the study was the phenomenon of price – a central topic in economics and business education. The study involved BTs from two universities taking part in a Learning Study and BTs from the other six universities acting as the control group. The Learning Study BTs were divided into six groups (three from each university) with the Learning Study lessons being undertaken in two schools. In the first school, the three groups from one university taught three separate lessons to different groups of students on price. In the second school, the three groups from the other university did the same. Mainly as a result of BTs leaving their training, the final sample of BTs was 18 in the Learning Study group and 65 in the control group.

1.4. Chapter summary

Chapter 1 – Introduction

In this chapter, a summary of the study is presented. This includes a rationale for the research followed by an outline of the main results and recommendations. Personal details about the background and motivations of the researcher are then provided as a context for the study. Next there is a brief outline of the scope of study that explains the main parameters involved before a summary of each chapter is provided.

Chapter 2 – Phenomenography/Variation Theory (PVT)

This chapter explains the theory that underpins both the methodology of the current study and the intervention that is being evaluated, namely Learning Study. It starts with a critical discussion of the ontology of PVT, what this implies for the 'location' of conceptions of a phenomena, how those conceptions can be identified and described and finally how PVT has dealt with the issue of context – particularly in relation to the phenomenon price. A summary of the main findings in relation to previous PVT into price comes next. Finally a section summarises those issues in the chapter that are of significance for the current study.

Chapter 3 – Defining Beginner Teachers' (BTs') knowledge

The main purpose of this chapter is to map the territory in relation to Shulman's (1987) notion of teachers' Content Knowledge (CK) and their Pedagogical Content Knowledge (PCK). This involves explaining why these ideas matter, the different ways in which researchers have conceptualised them and what the implications of these different conceptualisations are for measuring CK and PCK. Previous evidence in relation to CK and PCK is then summarised, looking first at the wider research in this area and then at the results of the emerging body of PVT research that has investigated CK and PCK. The chapter concludes with a description of the way in which the current study conceptualises CK and PCK through an application of PVT, the benefits of this approach and how this could contribute to the existing evidence base.

Chapter 4 – Learning Study

This chapter begins by explaining how and why Learning Study grew out of Lesson Study. This involves describing Lesson Study, presenting the results of research into the effects of Lesson Study on teacher learning and then explaining the limitations of the approach and how these might be addressed by Learning Study. A detailed description of Learning Study follows, including a summary of the differences and

similarities that exist between different enactments of it. The chapter then applies PVT to an examination of what it is about Learning Study that might promote teacher learning. Next an outline of the main findings of previous research into Learning Study and teacher learning is provided, looking at teacher learning in general and then at BTs' learning in particular. Finally, the current study is positioned in relation to previous research into the effects of Learning Study.

Chapter 5 – Method

The main purpose of this chapter is to explain how the research design in this study is directed by the principles of PVT (and therefore of Learning Study). This involves an analysis of the methodological standpoint of first Lesson Study and second, Learning Study. Both approaches draw heavily on Action Research and Design Research, so the next section examines both in detail, highlights differences between the two and suggests how the main criticisms of both might be addressed. These discussions are set in the context of previous evaluations of Learning Study to provide a basis for the method in the current study. The subsequent sections in the chapter explain the study design, the methods for gathering data, organisation of the intervention and control groups and the nature of the Learning Study intervention.

At the end of the chapter, a description of the methods of data analysis is provided, before the main ethical considerations in the study are summarised.

Chapter 6 – Results

The first section of this chapter reports on results in relation to BTs' CK and PCK. Evidence for the proposed classifications of conceptions is presented and illustrated with extracts from BTs' written or verbal responses. Following this an explanation is given of the way in which the proposed classifications of conceptions were handled in order to allow a comparison of BTs' knowledge in pre and post-tests and between Learning Study and control groups. The next section reports on results looking at the effects of teacher training on BTs' CK and PCK. This involves presenting evidence on the distribution of conceptions, associations between CK, PCK and degree classifications, comparisons between pre and post-test results and their significance and finally on general associations between BTs' CK and PCK. The chapter concludes with a summary of the main findings.

Chapter 7 – Discussion

This chapter discusses the significance of the results of the study. It does this firstly by setting the overall approach taken in the study in the context of the previous

general research into CK and PCK. Next it sets the study in the context of the previous PVT research into CK and PCK. The following sections focus specifically on the contributions to previous research that are implied by the proposed classifications of conceptions of CK and PCK developed in this study. This is repeated in relation to the level of BTs' CK and PCK that was established and then in relation to the changes in both CK and PCK that were observed in Learning Study and control groups. Finally, the importance of the findings in relation to the associations between CK and PCK are assessed.

Chapter 8 – Conclusions and Recommendations

The last chapter revisits the main research questions in the light of the evidence gathered. It summarises the findings of the study in terms of the effects of Learning Study on BTs' CK and PCK and in response to the question how can BTs' CK and PCK be described. Following this the limitations of the study are set out before recommendations are presented in terms of policy, practice and research.

2. PHENOMENOGRAPHY/VARIATION THEORY

2.1. Introduction

Phenomenography was developed in the late 1970's. It is a qualitative research methodology that originally emerged from empirical research rather than from a philosophical foundation (Åkerlind, 2005b). The focus of phenomenography is the identification of the qualitatively different ways in which people experience phenomena in the world around them (Marton, 1981). These ways of experiencing the world are known as conceptions.

Variation theory is a development of phenomenography that occurred from the late 1990's. It is primarily concerned with the application of phenomenography to instructional design. The focus of variation theory is how people come to acquire more sophisticated conceptions. According to variation theory, learning results from people experiencing differences between important characteristics of conceptions that are known as critical aspects or critical features.

In short, phenomenography is about identifying what it means to experience and learn about a phenomenon, whilst variation theory is about identifying how that learning can be bought about.

The first section of this chapter explains Phenomenography/Variation Theory (PVT) in more detail and offers a summary of its application in a teaching context. It then critically discusses a number of key aspects of PVT including: i) the ontology of PVT, ii) where the conceptions that lie at the heart of the approach are located, iii) how those conceptions can be identified and, iv) what the relationship is between conceptions of a phenomenon and the internal and external horizons (Marton and Booth, 1997) of that phenomenon. Finally, a review of the existing research on conceptions of the phenomenon of price is provided before the chapter concludes with a section on the implications of all of the above for the current study. Throughout the chapter the phenomenon of price is frequently used as an illustration. This is because price is a key focus of this study and because there is a good range of PVT research in relation to it.

2.2. What is PVT?

According to PVT, since no one has the capacity to be aware of everything at once, people are selective about those aspects of phenomena that they can discern at any one moment (Marton, Tsui, Chik, Ko & Lo., 2004). Thus when driving, it is possible to hear the noise of the engine but for much of the time the driver is unaware of it. It is not in their 'focal awareness' (Marton & Booth, 1997). This selectivity allows for the possibility that different people can experience driving (or indeed any other phenomenon) in different ways dependent on which aspects (and by implication dimensions of variation) they are aware of. It also implies that people can be aware of different aspects at different times and in different contexts. Thus a person might experience driving at night in a different way to driving in the day. Phenomenographers point to the results of over 30 years of work in a wide range of different subject domains as empirical evidence to substantiate this claim (for example, there are a least 6 studies on the phenomenon of price).

In PVT, a person's way understanding of a phenomenon (referred to as their conception of a phenomenon) is defined by the particular combination of aspects of a phenomenon that that person is simultaneously aware of. A central proposition is that some of these aspects are required in order to demonstrate a particular

conception and others are not. Those aspects that are of crucial importance are known as critical aspects. A more sophisticated conception would be one in which there is a simultaneously awareness of more critical aspects of a phenomenon than for a less sophisticated conception. This is a proposition that is said to be consistent with the findings of a number of studies into the nature of expertise (e.g. Bransford, Brown & Cocking 2000). Qualitative differences in conceptions are defined in PVT in terms of 'logical complexity and inclusiveness' (Marton & Pang, 2008, p.536). For example, in relation to price, a higher level of conception might refer to the relationship between demand and supply, a lower level of conception might refer to demand (or supply) alone.

An important factor affecting the way in which combinations of critical features are understood is the context within which they occur. An assumption of PVT is that in order to be able to experience a phenomenon, it has to be seen as distinct from its context. At the same time, the context in which the phenomenon is set affects the way in which critical features that constitute a particular way of seeing the phenomenon are discerned. According to Marton and Booth (1997) these two make up what is referred to as the 'structural aspect' of a way of seeing that is: i) the discernment of critical aspects and their relationship with each other (the 'internal

horizon') and, ii) the relationship between the whole and the context (the 'external horizon'). This study follows Marton and Booth (1997) in defining the external horizon as a holistic location or condition within which the phenomenon exists (although the external horizon has been defined in other terms elsewhere e.g. Harris, 2011). This means that in the case of the phenomenon of price, the internal horizon would perhaps comprise the following dimensions of variation: supply, demand and their interrelationship (Marton & Pang, 2008). The external horizon would perhaps be defined by whether price was set in the context of a single business, a market situation or as a result of interactions between markets (Davies, 2011b).

Originally in PVT, although evidence for conceptions was gathered from individuals, conceptions were considered to be independent of those individuals. In other words, conceptions were not seen as being synonymous with the ways of experiencing of any one person. This meant that the focus of phenomenographic research in its early days was on capturing the different conceptions *across* a group of individuals rather than capturing the conceptions of a particular individual *within* a group (Åkerlind, 2005b). On this early interpretation of PVT, since there was no need for conceptions to reside necessarily within any one individual, descriptions of conceptions were said to be based upon a 'collective anatomy of awareness' (Marton, 1995, p.171). This

implied that it was possible for any one individual at any one time in any one context to express different conceptions. It also implied that individuals could express different conceptions of the same phenomenon in different contexts. As a result of these assumptions, conceptions were considered to *some degree* to be 'generalizable across different situations in which the same phenomenon occurs' (Marton & Pang, 2008, p.536). Generalisability was constrained by the degree of difference in the contexts between where the evidence of conceptions was gathered and where the descriptions of conceptions were being applied.

As PVT developed, although the claims relating to the collective anatomy of awareness continued, the assumption that individuals could not be aligned with particular conceptions was relaxed (Pang & Marton, 2003). This change occurred largely because of the limitations it placed on the usefulness of the application of PVT in a teaching context (see Section 2.3.2).

In PVT, the purpose of teaching is to develop students' knowledge of a phenomenon (knowledge being defined in terms of the sophistication of students' conceptions). The conception that the teacher wishes students to reach is referred to as the object of learning. An object of learning consists of two integral parts: an indirect aspect (the

'how' of learning) and a direct aspect (the 'what' of learning) (Marton & Pang, 2006). The indirect object is a capability such as explaining. The direct object is that which is to be explained: in other words, it is the subject content. Both aspects of the object of learning can be analysed before, during and after any lesson. Prior to teaching, teachers identify the *'intended'* object of learning (Marton et al., 2004), that is what they wish students to learn. During the lesson, the *'enacted'* object of learning is the way in which a teacher aims to achieve the intended object of learning. The enacted object of learning is what the activities of the teacher make it possible for a student to learn (this is sometimes referred to as the 'Space of Learning' – Marton et al., 2004). Of course, these activities do not always result in students learning what it is intended that they should learn and therefore it is important to consider the *'lived'* object of learning, or how students actually experience the lesson. In the best lessons, according to PVT, the intended, enacted and lived objects of learning will all be in alignment. In other words, the lesson designed by a teacher will make it possible for students to achieve the level of understanding that it is intended they should achieve and that they do actually achieve.

In PVT, students are assumed to acquire the intended object of learning through the experience of carefully managed variation in the critical aspects of a phenomenon. It

is only when contrast between situations is experienced that it becomes possible to notice new aspects. Scholars of PVT give many examples to illustrate this. For example – 'one would not be able to discern the aspect of emotion should there only be hatred in the world, or the aspect of season should there be winter throughout the year' (Marton & Pang, 2008, p.538).

In most applications of PVT to instructional design (e.g. Pang & Marton, 2003, 2005; Marton & Pang, 2008), critical aspects are varied sequentially one at a time before being varied simultaneously. Empirical evidence from these studies suggests that this can result in significant gains for student learning. One reason for this could be that varying aspects one at a time can allow them to be more clearly highlighted against an invariant background. Then, having experienced this, students will be in a better position to understand a situation in which all critical aspects are allowed to vary. Marton et al. (2004) state that they 'believe that separating the aspects first and then fusing them together is more efficient (from the view of being able to adapt to changing conditions) than never taking the critical aspects apart' (p.17). One interpretation of this statement is that students are more likely to be able to respond to changes in the context of a phenomenon or in the nature of that phenomenon if they have experienced the effects of isolated changes in aspects of it.

PVT is distinct from many other approaches to learning in linking what is to be learned (i.e. the subject content) with how it is to be learned (i.e. the method that is to be used to teach that content). The focus in PVT is building student understanding of an intended object of learning through the identification and careful variation of the critical aspects of a phenomenon (Pang & Marton, 2005). Improvements in teaching and learning are expected to follow mainly from conformity to theory rather than from any specific arrangements for learning (such as group work or didactic instruction) or any specific arrangements for teaching (such as interaction between teachers sharing their professional expertise).

The key propositions of PVT are:

i. The same phenomenon may be experienced in a small number of qualitatively different ways.
ii. It is possible to distinguish between more and less powerful conceptions of a phenomenon on the basis of the structure of the conception.

iii. Each phenomenon has a number of different aspects, some of which are of critical importance to particular conceptions and some of which are not.

iv. To hold a conception means being aware of all relevant critical aspects at the same time (and/or of the relationship between them).

v. To become aware of a critical aspect, a person should experience the difference between a situation in which it is present and one in which it is not (i.e. they should experience variation).

The process by which more sophisticated conceptions are acquired is:

i. Critical aspects of the more sophisticated conception are individually varied whilst everything else is held constant so that differences are clearly highlighted.

ii. Then all critical aspects are varied in order to allow learners to develop a simultaneous awareness of them all.

These principles can be illustrated in relation to the teaching of price. Consider a lesson where a teacher has decided to focus on the price of a cup of coffee in a coffee shop and where the intended object of learning is that students experience price as

the result of a balance between the needs of the coffee shop as a business and customers' willingness and ability to pay. The teacher has established through empirical research that students' pre-understandings of the price of a cup of coffee are characterised by different combinations of the following aspects: i) the taste of the coffee, ii) the size of the cup, iii) a sense of exploitation because the coffee is 'too' expensive, iv) business costs and, v) customer wants.

Given the intended object of learning, points i), ii) and iii) would be classed as non-critical aspects that the teacher would not seek to highlight. These points *could* form part of the desired way of thinking, but they are not critical to it. On the other hand, business costs (as a prime constraint on business activity) and customer wants (as a prime constraint on what customers are willing to pay) would be critical aspects. A simultaneous awareness of both is integral to the target way of experiencing price.

In a lesson to highlight the critical features of the target conception (such as that described by Marton & Pang, 2008), a teacher would first design an activity that would allow students to experience variation in customer demand (whilst holding all the other aspects constant). This could be achieved through a carefully designed simulation. The teacher would repeat this with business costs. Finally they would

introduce students to a situation in which both business costs and customer demand varied at the same time. The effects of each variation would be discussed with students after they have experienced it. Should costs and demand be varied simultaneously at the outset (or indeed any two or more of the other aspects of the phenomenon), then the chances of the student having a clear awareness of the features critical to a particular form of understanding or of the relationship between them, would be greatly reduced. In short, there is a possibility that students might become confused through experiencing 'too' much variation and therefore not acquire the intended object of learning.

2.3. PVT unpacked

2.3.1. The ontology of PVT

PVT is founded in a non-dualistic ontology where attempts are made to describe how phenomena in the world are *perceived* (a second order perspective) rather than how phenomena *are* (a first order perspective). PVT aims to develop 'understanding of human experience, conceptualised as a form of human-world relationships' (Marton & Pang, 2008, p.535). A non-dualist ontology 'contradicts the common sense view that experiences are experiences of objectively and independently existing

objects' (Marton & Booth, 1997, p.105) since experience is considered to be an aspect of both the subject (the individual human) and the object (the phenomenon) at the same time. In other words, there is no difference between 'the describer and the description' (Marton & Booth, 1997, p.113). In taking this approach PVT seeks to overcome the divide between realist and relativist ontologies.

In PVT, individuals are said to experience phenomena in the way in which they understand those phenomena. In other words, an individual might understand flowers as natural objects with particular colours, smells and sizes and experience them in this way. Alternatively, they might understand flowers in terms of the function in the interaction between flowers, insects and reproduction, in which case they would be experienced in a different way. The first way of experiencing flowers might be described as 'conceptual' and the second way might be described as 'sense-related'. As PVT is concerned with uncovering the different ways in which a phenomenon is understood, both the 'conceptual' and the 'sense-related' could equally well be the focus for investigation (Marton & Pong, 2005).

In PVT, ways of experiencing (or conceptions of) phenomena are seen as relationships between the individual and a phenomenon. As a result, there is a

presupposition that there is an external world. However, this world is only accessible through the conceptions of the world held by individuals. This means that, in contrast to the natural sciences, PVT is not concerned with developing statements about the world that are judged on the extent to which they conform to material reality. PVT is about developing statements to describe individuals' conceptions that are judged on the extent to which they reflect those conceptions.

Leading proponents distinguish PVT from cognitive approaches on the basis of its non-dualistic stance (Marton & Pang, 2008). It is argued that 'the cognitive act of understanding can be described in terms of psychological entities within an individual and can be fully accounted for by the conditions of cognition or internal mechanisms' (p.535). In other words, cognition emphasises the mental structures and processes within the individual rather than nature of the external world. This interpretation assumes that the way in which an individual cognises a phenomenon can be cleanly separated from that phenomenon. Such an assumption is open to question. In addition, there is a contradiction between presenting individuals as the potential bearers of different, more sophisticated ways of experiencing a phenomenon as a result of learning and arguing that such changes are not the result of cognitive processes (Richardson, 1999).

There are other important difficulties with the assumptions underpinning PVT. First, a relational stance creates issues in explaining the existence of objective physical objects through time, independent of an individual's conceptions (Richardson, 1999). Second, if conceptions of phenomena are themselves objective entities, with the properties of being universal and generalizable, then the dualism that PVT seeks to reject would seem to have re-emerged. Both Richardson (1999) and Webb (1997) point to the tension, as they see it, contained within the attempt by phenomenography to stand astride the 'positivist desire for scientific rigor and generalizability and the hermeneutical search for authentic understanding' (Richardson, 1999, p.72). On the one hand, conceptions are 'out there' to be discovered but on the other hand, the only vehicle for accessing them is through the talk of the respondent and the interpretative filter of the researcher.

Phenomenographers have rebutted these criticisms by claiming they lie outside the scope of phenomenography. Svensson (1997) proposed that making explicit assumptions about the nature of the conception is more important than 'being concern(ed) with the ultimate base for or nature of everything' (Svensson, 1997, p.165). This echoed the argument made by Marton (1981) that the purpose of

phenomenography is the study of peoples' conceptions and that the issue of the 'realness' of an independent reality or of those conceptions is simply not the focus. In a similar vein, Bowden stated that:

> *'I don't wish to assert that I 'know' an individual's conception of a phenomenon. What I do want to be able to say is that, following a given interview context, analysis of the transcripts enables me to differentiate between a number of different ways of seeing the phenomenon that are apparent in that kind of conversation'* (Bowden, 2000, p.16).

According to these arguments the ultimate measure of the value of phenomenography is the usefulness of its outcomes for the development of teaching and learning (Marton & Booth, 1997) rather than 'its theoretical purity' (Entwistle, 1997, p.129). To put this another way, proponents of PVT argue that although difficulties exist in a providing a coherent relational account of human thinking, it offers a more fruitful way forward than the 'impoverished and abstract understanding' (Saljo, 1997, p.174) that results from Cartesian dualism.

The focus on developing pragmatic solutions to the challenges in teaching was embodied in what has been referred to as the 'new phenomenography' (Marton & Pang, 2008). This is principally concerned with operationalising phenomenography through the application of variation theory in order to improve student learning (and more recently teacher learning). One consequence of this has been that PVT research has shifted away from a debate about its ontology, after an initial flurry of studies in the late 1990's and early 2000's.

Addressing the practical issue of how to teach through the application of variation theory is extremely important, but it is also important to continue to develop a theoretical account, particularly in relation to the ontological nature of 'the conception'. This idea is at the heart of variation theory as well as of phenomenography. One potential way forward might be found in the philosophy of critical realism (Bhaskar, 1977; Lawson, 1997). In its non-dualist perspective, critical realism bears a close affinity to PVT (Davies & Brant, 2005). Critical realism is based on the assumption that reality exists independently of human perceptions but our knowledge of it (whilst not entirely arbitrary) is always contingent and subject to development. Given this, our knowledge of the world is based not on absolute proof but on informed judgement. This fits well with the notion that the work of PVT is

studying people's accounts of their experience rather than the experience itself (Saljo, 1997). Early work into critical realism in the field of Religious Education (Hella & Wright, 2008) suggests that this is a fruitful avenue to explore further.

2.3.2. The location of conceptions

In PVT, conceptions are considered to be non-psychological entities that are in some way independent of the individual. This allows PVT to account for the complex and unstable nature of individuals' conceptions observed in empirical studies (e.g. Marton & Pong, 2005). For any given phenomenon, an individual's conceptions seem to vary across time in the same context and between contexts at the same time. One difficulty this creates however, is that it greatly limits the usefulness of PVT in classroom teaching. It means that the object of research in phenomenography becomes rather 'ephemeral' (Saljo, 1997, p.179) since it is not located in a single place. Saljo (1997) argues that this difficulty is augmented if the claim is made that categories of description correspond directly to 'ways of experiencing', since one might reasonably ask the question, 'experienced by whom?'.

This raises two important practical questions: i) how do teachers establish whether the intended object of learning matches the lived object of learning, since they cannot

measure pre and post-lesson levels of individual student understanding and, ii) how can students be encouraged to be more consistent in the way in which they bring more sophisticated conceptions to bear, if those conceptions are only present in part of their own thinking (in other words, how can *they* be sure that they have acquired the intended object of learning?).

As the focus of research in PVT has shifted to the operationalising of the results of phenomenographic research through variation theory, a number of important studies have relaxed the assumption that conceptions should not be identified directly with individuals. For example, in important PVT studies in economics and business education (Pang & Marton, 2003, 2005), conceptions are treated as if they were aligned with individuals. The same principle has been applied to teacher learning (Pang, 2006). In all of these studies, individuals are categorised according to the highest level of conception expressed and other conceptions are ignored. Statistical comparisons are made on the basis of this evidence.

This approach has significant practical benefits since it provides students and teachers with an explicit description of what it means for an individual student to make progress in a lesson (that is moving from a less sophisticated conception of a

phenomenon to a more sophisticated conception). In addition, since lower level conceptions are nested within high level conceptions, there is a logic to 'crediting' individuals with the higher level. This would be in line with the application of frameworks for assessment commonly used in the English education system (such as Bloom et al.'s (1956) taxonomy).

The difficulty with this approach is that it runs the risk of over-stating the coherence and stability of a particular individual's conceptions of a phenomenon. If conceptions are highly fluid and/or context dependent (Marton & Pong, 2005), then it is difficult to see how they could be relied upon to provide an accurate measure of student understanding. Research in PVT has not focused on what determines the range of conceptions expressed by an individual at any one time or over time. However, there do not seem to be either a priori or (at present) any empirical grounds for taking the view that phenomenographic conceptions are any less stable than other forms of understanding commonly measured in the English education system (e.g. through the application of Bloom et al.'s (1956) taxonomy). In addition, there is a possibility that regularly exposing students to teaching based around PVT might result in an increase in the stability of expressed conceptions because of the focus on clearly defined expressions of increasing conceptual sophistication.

2.3.3. Identifying conceptions

The outcome of PVT research is descriptions of qualitatively different conceptions of phenomena and their critical aspects. Differences between conceptions are said to occur on the basis of logical complexity and inclusiveness (Marton & Pang, 2008). This is because qualitatively different conceptions all relate to the *same* phenomenon. Typically this means that conceptions are arranged hierarchically (although this is not a logical necessity).

Identifying conceptions involves analysing evidence gathered from people and focusing on both the meaning and the structure in order to develop descriptions of qualitative differences. This evidence is often in the form of semi-structured interview transcripts or written responses to test items. The research process in PVT is iterative. It involves researchers in repeatedly reading and re-reading interview transcripts with a focus on the similarities and differences between them. Through this process of continual review, the researcher moves towards the development of a stable set of descriptions of conceptions. The researcher is required to be as open minded as possible (particularly in the early stages of the research) and willing to constantly adjust and review their thinking. In doing this, they will move back and

forth between the emerging descriptions of conceptions and the evidence, at one time using the evidence to develop the descriptions and at other times using it to check developing descriptions.

Within this broad approach, there is some variation amongst PVT researchers (Åkerlind, 2005b). These variations are:

i. The extent to which researchers break up the transcript and focus on sections of it in isolation or whether they analyse each section in context.
ii. The number of researchers involved in PVT.
iii. The way in which the evidence is approached from different perspectives at different times, including the timing, method and sequencing of each iterative cycle.
iv. The balance between ensuring that descriptions of conceptions emerge as directly as possible from the evidence and the involvement of researcher's judgement.
v. Variation in the emphasis placed on communicative and pragmatic validity (Marton & Booth, 1997).

vi. Variation in approaches to reliability according to whether findings are independently coded (coder reliability) or whether they are reached through discussion and joint review (dialogic reliability).

A criticism that has been levelled at studies in PVT is that they only tend to offer sketchy methodological detail (Hasselgren & Beach, 1997; Åkerlind 2005b). This can be observed in the general nature of some of the descriptions of methodology that are provided. For example, in their influential study, Pang and Marton (2003) state that 'the data analysis followed the conventions of phenomenography' (p.186) – without directly explaining what these are - and also that the 'following categories were found to capture the variation' (p.189) – without directly explaining how. Other issues of methodological detail can be identified in: i) the use of only a small number of quotations from transcripts to illustrate proposed descriptions of conceptions (thus in the Pang and Marton study above, one example is given of each conception) and, ii) the way in which quotations are left to speak for themselves (this is particularly starkly seen in the above study, where illustrative quotations are simply listed under proposed conceptions without a detailed textual analysis of the quotations, linking them to the conception).

These difficulties can be further illustrated by examining another study into price (Marton & Pang, 2008). In this study, the following quotation from a student is classified as belonging to a conception where price is seen to be a function of 'supply':

> *'I would sell it for $15 because I could earn more money……..The biscuit stick is a new product on the market. If I reduced the supply (of biscuit sticks)…..I would just supply 10 boxes a day, then the students would rush for it. If I increased the supply by 50 boxes, then the students might not go for it. So, I would reduce the supply so that I could earn more'* (Pang & Marton, 2008, p.545).

Standard economic theory would predict that reducing supply (either at all possible prices or just at a given price) would result in a *fall* in the amount demanded rather than an increase, as seems to be implied in the extract above. Restricting supply would be likely to result in a higher price in the market, it is true, but the middle part of the quotation above seems more concerned with demand than supply. There is the suggestion first, that because the product is new it is likely to be in higher demand and second, that its exclusivity is likely to boost demand. This meaning is

evident in spite of the fact that the word 'supply' is used three times in this relatively short quotation. Therefore, classifying this statement as 'supply' does not appear to be as straightforward a matter as is perhaps implied. On the basis of the evidence provided, this answer might potentially be classified as 'supply and demand'.

The difficulty that this creates for a reader is that it is hard to have a view on whether it is the description of the conception that requires revision or whether it is the classification of the quotation that is open to question. This is potentially a challenge for PVT studies that associate particular students with particular conceptions and make claims about learning based upon them (such as in the above 2008 study by Marton & Pang). Although these issues may be partly a result of the restricted word count available for descriptions of these studies, they do create significant difficulties in terms of communicative validity.

These difficulties can be addressed by providing more detailed descriptions of the methodological approaches used. Åkerlind (2005b) provides a helpful checklist of issues that should be covered in such descriptions. Sandberg (1997) also offers a five step 'phenomenological reduction' process for improving PVT research that also offers benefits.

2.3.4. Describing conceptions

One criticism of PVT is that it tends to result in the reproduction of the 'authorised conceptions' in a subject domain (Webb, 1997; Ashworth & Lucas, 1998). Webb refers to Popper and Derrida to argue that it is impossible for any researcher to 'bracket' their prior understandings. As a result, 'one is left with the feeling that phenomenographic research will continue to find confirmation of its suspicions, as it continues to reproduce the discourses within which it is embedded' (Webb, 1997, p.205). An implication of this is that data will be ignored by researchers who give too much prominence to their own preconceptions (Walsh, 2000).

However, it is hard to see an alternative to locating an interpretation of peoples' conceptions within the current terms of understanding held by the researcher (Walsh, 2000). If there is no limit on the ways in which it is possible to communicate about a phenomenon, surely it is logical to apply some structure to an understanding about it (Saljo, 1997). Conventions developed within subject domains act as a 'symbolic code' (Saljo, 1997, p.185), allowing accounts of people's experience to be provided. If PVT cannot make use of the tools of current academic analysis for fear

of clouding the 'real' picture emerging from research, it may be of very little utility (thereby failing a pragmatic validity test).

The implication that PVT is inherently conservative is contradicted by the occurrence of revisions in the mapping of conceptions. For example, there have been significant modifications made over time in relation to the description of conceptions of price. In line with a critical realist approach it may be helpful to think of descriptions of people's conceptions as being better or worse rather than correct or not. Finally, the implication that data will be ignored in developing logically related conceptions is not a necessary outcome of PVT. Evidence that does not appear to fit into logically related conceptions might be reported as non-critical or as a subsection of a more sophisticated conception. There is no a priori reason why branching structures or hierarchies are not also possible either (Åkerlind, 2005b).

2.3.5. The external and internal horizons

An important feature of PVT is that it provides a theoretical account (Marton and Booth, 1997) of the distinctness of a phenomenon (the 'internal horizon') whilst simultaneously acknowledging its connectedness with the context (the 'external

horizon'). As a result it might be assumed that the external horizon would have a good deal of prominence in PVT research.

Drawing on the principles of variation theory, there are at least three ways in which the external horizon or context might be expected to feature: i) in variation in the context during the collection of evidence of conceptions, ii) in variation in critical and non-critical aspects of the external horizon (this would seem to be a logical extension of the focus in the internal horizon on the difference between critical and non-critical aspects) and, iii) in the descriptions of conceptions that emerge from the evidence.

This section explores the extent to which these three types of variation are present in previous PVT research by examining two important studies into the phenomenon of price. The first of these (Study 1 – Marton & Pang, 2008) has been chosen to typify PVT studies that focus on identifying conceptions of price with a view to improving the teaching of it. The second (Study 2 – Marton & Pong, 2005)) has been chosen since it represents one of the very few PVT studies that focus explicitly on the external horizon.

A description of these studies is provided below followed by a summary of the way in which they treat the external horizon (Table 2.1).

Study 1 (Marton & Pang, 2008)

In this study, a single question is used to gather evidence of conceptions of price from 10 year old students. The question asks what price students would set for a hot dog in the school tuck shop. The rationale provided for this choice of context is that it is appropriate for 10 year olds. No explicit mention of the external horizon is made in the study. Context does not appear in the description of the conceptions that are developed.

Study 2 (Marton & Pong, 2005)

In this study, an interview schedule of 4 questions in relation to price is presented. The first of these sets price in the context of an individual decision whilst the others are in the context of a market. Although no explicit rationale is given for this variation, later in the study the role of variation in the product is highlighted in explaining why an association was found between certain types of question and certain conceptions of price. The study reports that 'not all the (four) questions were asked in every interview' (Marton & Pong, 2005, p.337). One important finding is

that there is an association between the question focusing on price set in the context of an individual business decision and lower conceptions of price. Again, there is no explicit reference to the context in descriptions of conceptions of price.

Table 2.1 - The treatment of the external horizon in two PVT studies

Study	Explicit variation in context	Identification of critical aspects of the external horizon	Inclusion of context in descriptions of conceptions
1	No	No	No
2	Yes (no rationale)	Implied (but not critical)	No

As can be seen in Column 1 of Table 2.1, Study 1 only focused on one context (a decision by a tuck shop owner). Whilst this may seem to be important for the quasi-experimental nature of the research design that was adopted in this study, it is likely to have limited the range of responses that were elicited. Students were not given the opportunity to demonstrate an understanding of how prices are set in a market context, for example. The possibility exists in Study 1, that variation in the context was introduced by researchers as part of the semi-structured interviews that were used to supplement written evidence. However, no explicit reference is made to this and no critical aspects of the external horizon are identified (Column 2, Table 2.1).

In Study 2, although the context is varied, two issues arise: i) variation does not seem to have been undertaken in a systematic way, since not all the questions were asked of each participant in the study and, ii) prominence seems to have been given to variation in the nature of the product rather than variation in other aspects of the context (this is indicated by one question where the association between price as a result of individual business decisions and less sophisticated conceptions of price is attributed to the nature of the product).

Evidence from other research suggests that a focus on price set in the context of one product compared to another is much less powerful than a focus on price set in the context of a market compared to price set in the context of a single business (Davies, 2011b). Davies (2011b) presents evidence of an association between the complexity in the context and the complexity of understanding that individuals are able to develop. In other words, the degree of sophistication contained within the contextual frame acts as a cap on the degree of sophistication in the level of conception that it is possible to experience. This finding is consistent with the association that was found in Study 2 between a question focusing on price in the context of a single business decision and lower level conceptions of price.

Neither Study 1 nor Study 2 makes explicit reference to the external horizon in the final description of conceptions that are developed. On the basis of this and the analysis above, it might be concluded that PVT research (at least in relation to price) has focused on the internal rather than the external horizon. At the very least, there is a tension between this position and the non-dualist, relational stance of PVT. This tension could be addressed by incorporating the external horizon more fully into PVT research. This could be achieved by: i) identifying critical aspects in the context of a phenomenon, ii) systematically varying those critical aspects during the research process and, iii) explicitly making reference to these critical aspects in descriptions of conceptions (or at least in descriptions of the research process).

2.4. Conceptions of price

This study focuses on the phenomenon of price. One reason for this is that it is recognised as being central to subject understanding in the domain of economics and business studies teaching (Pang & Marton, 2005; Pang, Linder & Fraser, 2006; Davies, 2011a; Davies & Lundholm, 2012). Its profile in the curriculum more or less ensures that any teacher of these subjects would be asked to teach it. In addition, there is an extensive amount of previous research on conceptions of price which provides an evidence base on which to draw.

There have been a number of studies into the conceptions of price of school and undergraduate students (e.g. Dahlgren & Marton, 1978; Pang & Marton, 2003, 2005; Leiser & Halachmi, 2006; Marton & Pang, 2008). The resultant classification of conceptions has developed with each addition to the body of evidence. In order to provide a point of comparison to illustrate these changes, Pang and Marton's (2005) categorisation of conceptions of a change in price is set out below (in order of increasing sophistication):

i. Price change as a fundamental characteristic of a product (varying only as a consequence of its intrinsic value).
ii. Price change as a function of demand (that is consumers' purchasing power and willingness to pay).
iii. Price change as function of supply (that is producers' willingness to provide products at a particular price).
iv. Price change as a function of changes in both supply and demand (as a result of the interaction between supply and demand).
v. Price change as a function of changes in both supply and demand (taking into account the relative magnitudes of the changes).

An early study (Dahlgren & Marton, 1978) had only distinguished between Category (iv) and Category (i). This is the difference between price as 'an entity determined by a system' (Dahlgren & Marton, 1978, p.34) where price is an outcome of market conditions or supply and demand, and price as a 'property of an object, comparable with its colour, size or weight' (p.34) where price is a function of the inherent value of a product. A later study (Meyer and Shanahan, 2002) found statistical evidence in support of this twofold distinction but was not able to separate Categories (ii) and (iii) above. In two subsequent studies (Pang et al., 2006; Marton & Pang, 2008), further refinement took place in presenting evidence that Categories (ii) and (iii) are of equal sophistication. A reason given for this is that since both Categories (ii) and (iii) are related to one aspect of the context, either supply or demand, they should be assigned the same level of complexity (Pang et al., 2006).

The distinction between made by Pang and Marton (2005) between Categories (iv) and (v) above represented an addition to the previous literature. It highlighted a difference between explanations of a change in price which referred to supply and demand when compared with explanations of a change in price in terms of the relative size of changes in supply and demand. In later work by the same authors

(Marton & Pang, 2008), Categories (iv) and (v) were replaced with a single category focusing on changes in supply and demand.

In relation to the external horizon, Dahlgren and Marton (1978) drew an important early distinction between a conception (A1) where 'the price of the bun is determined by the market price of its constituents: in other words, the price depends on the supply and demand situations for e.g. wheat, flour and transport services' (p.34) and conception (A2) where 'the price of the bun is determined by the supply of and demand for buns' (p.34). A1 treats price as an outcome of interaction between markets whilst A2 restricts its scope to a single market for buns. A1 thus refers to a broader context for price formation than A2. A later study (Davies, 2011a) added to this distinction by providing evidence that conceptions vary according to whether price is seen as a decision made by an individual business, as an outcome of activity within the market for a particular product or as an outcome of interaction between different markets. In a further study, Davies (2011b) provides evidence that the level of sophistication within which discussions of price are placed has an important bearing on the complexity of understanding it is possible to gain. This is consistent with the findings of Pong and Marton's (2005) study.

The developments in the categories describing conceptions of price can be explained in terms of the Structure of the Observed Learning Outcome (SOLO) taxonomy (Biggs & Collis, 1982; Biggs, 1996). The SOLO taxonomy is a way of describing the increase in structural complexity that a learner experiences when they learn about a phenomenon. This approach chimes well with PVT since it focuses on the meaning of learning in relation to a particular learning situation, rather than in relation to general development stages (as might be the case, for example, with a Piagetian approach). The SOLO taxonomy consists of 5 levels: i) pre-structural, ii) uni-structural, iii) multi-structural, iv) relational and, v) extended abstract.

The first three levels represent an increase in structural complexity in terms of a consideration of an increasing number of the factors that bear on a phenomenon. This moves from no factors at the pre-structural level to many factors at the multi-structural level. Levels (iv) and (v) are qualitative restructurings of level (iii). 'Relational' refers to the integration of different concepts with each part contributing towards the overall meaning. 'Extended abstract' refers to the reframing of the relational at a higher level to ensure generalisation to new topic areas.

The distinction between Categories (iv) and (v) identified by Pang and Marton (2005) appears structurally similar to that between the 'multi-structural' and 'relational' levels identified in the SOLO taxonomy. Categories (ii) and (iii) seem to have been placed at the same level because they are 'uni-structural' in nature - that is they relate to only one aspect of the market (earlier studies that placed supply above demand do not provide a detailed rationale for this decision e.g. Pang & Marton, 2005). On this basis, a consideration of both aspects of the market should be assigned a greater degree of sophistication. However, the next level of sophistication is based on the identification of a *relationship* between supply and demand and not simply on the basis that both aspects are included. This opens up the possibility of an additional conception where supply and demand are referred to, but there is no sense of interaction between the two. To date, such a conception has not been presented in the research into price.

Following this logic through, it might be expected that PVT would have discovered other conceptions similar to those specified in the SOLO taxonomy. The 'extended abstract' level is one where connections are made between a phenomenon and its wider context, placing it within a more elaborate and general way of thinking. One area where this might be expected to be seen is in relation to the degree of market

power that is present within a particular market. Market power results from the restriction of consumer choice and means that demand is much less responsive to a change in price than in more competitive situations (ceteris paribus). The degree to which demand varies with price is known as price elasticity of demand. In situations of significant market power, demand is said to be relatively price inelastic. A conception of price that includes price elasticity has yet to be found in the research on price. One reason for this could be that most of this research has focused on school students and undergraduates. Graduates of economics and business studies, who would be expected to have more sophisticated conceptions, might be more likely to provide such evidence.

2.5. Conclusion and implications

The critical benefit of PVT for teaching is that it seeks to integrate subject matter with what it means to learn about that subject matter. It has an inherent focus on teaching as developing a particular type of understanding of a phenomenon. This is in sharp contrast to those generic approaches that focus on the arrangements for teaching (e.g. cooperative learning or self- regulated learning) and frequently ignore the intended object of learning (or take it as self-evident). In terms of teacher development, these approaches are often introduced to teachers who are then expected to 'overlay' them

on the particular subject content that they are teaching. Whilst it is possible that the application to a particular subject context can be successful, the need for this application greatly increases the chances of a misalignment occurring between the intended object of learning and the enacted object of learning. It is also likely to only result in short term changes to teachers' practice, since it does not directly tackle teachers' understanding of what it means for students to learn about their subject. In other words, because it does not address teachers' understanding of the intended object of learning, habitual patterns of teaching are likely to quickly resurface and any benefits to student learning will only be brief.

There are however tensions in PVT that have yet to be fully resolved. Some of these stem from the attempt to stand upon a relational, non-dualist ontology. In this chapter, it has been briefly shown how a critical realist approach may offer a way forward in relation to some of the underlying tensions. For example, critical realism can provide a theoretical account of the provisional nature of descriptions of conceptions. This helps support the evidence of a changing picture in relation to the understanding of conceptions of price evidence in PVT studies over time and allows effective rebuttal of criticisms centred on the conservative nature of PVT.

On a strict interpretation of PVT, descriptions of conceptions cannot be aligned precisely with individuals. This is consistent with the empirical evidence to the extent that only relatively rarely do individuals seem to present clear and coherent single conceptions of a phenomenon. According to this view, descriptions of qualitatively different conceptions could inform the development and enactment of teaching strategies. However, they could not be used to measure the progress of individual students. Taking this approach dramatically limits the power of the PVT in relation to the planning and teaching of lessons. The clear, progressive statements that reflect different levels of understanding, offer tremendous potential for the assessment of students (and for the evaluation of different teaching strategies). In addition, they fit well with teachers' conventional assessment practices. As a result, this study will follow the leaders in the field (Marton and Pang) in categorising students according to the highest conception they express.

The role of the external horizon (context) is given prominence in theoretical discussions about PVT but, as has been shown, does not generally appear in an explicit way in the studies on price. PVT's assumption that conceptions are made up of awareness of a number of critical aspects and the relationships between them has not been explicitly applied to the external horizon. Where it does appear in studies

of price, the context is often identified simply with the type of product. Eliding the product with the context runs the risk of ignoring other aspects of the context that might be important. One of these is the distinction between a conception of price in the context of an individual business decision and a conception of price in the context of market outcomes. This study seeks to give a greater prominence to context in the way in which evidence of conceptions is collected. This will involve introducing systematic variation in the nature of the context. It will also involve the inclusion of specific reference to variation in the context in the descriptions of conceptions that are developed.

As has been shown in this chapter, some PVT studies of price have lacked detailed descriptions of methodology and most provide only a small number of illustrative examples. This may be partially a result of constraints on the length of published articles. However, one result is it can then be difficult to judge the degree to which the categories being proposed accurate capture the range of conceptions expressed by individuals. It is also difficult to judge whether the categorisation of individual responses is accurate. To counter these difficulties, this study adopts a more detailed approach to the description of evidence, along the lines suggested by Åkerlind (2005b) and Sandberg (1997).

Finally, the review of studies into conceptions of price in the previous section suggested that these have largely defined the differences between conceptions in terms similar to those in the SOLO taxonomy. Proceeding by logical extension, applying the SOLO taxonomy implies that it is possible that at least two other conceptions of price might exist – one based on supply and demand without interaction and one based on the 'extended abstract' notion. This is a possibility that will be explored in the current study.

3. DEFINING BEGINNER TEACHERS' KNOWLEDGE

3.1. Introduction

This study examines the effects of Learning Study on BTs' knowledge. It defines BTs' knowledge in terms of Shulman's (1986a) notions of Content Knowledge (CK) and Pedagogical Content Knowledge (PCK), interpreted through the lens of PVT. The purpose of this chapter is to explain this interpretation by mapping out the relationships between PVT and CK/PCK.

The chapter begins by outlining the rationale for adopting Shulman's concepts of CK and PCK. It then moves on to explain these ideas in more detail. First, the origins and wider significance of the notions of CK and PCK are explored. Next follows a discussion of conceptualisations of CK/PCK that have been prominent in the literature. A summary of the main findings of CK/PCK research is then provided alongside an overview of the small, but emerging body of research into CK/PCK based in PVT. The final section draws upon the rest of the chapter to provide a context for the current study.

3.2. Why CK and PCK?

In PVT, learning is described in terms of the acquisition of more sophisticated conceptions of an object of learning. PVT studies in relation to teacher learning have tended to define that object of learning broadly, either in terms of the general nature of teaching in a particular context (e.g. Davies & Dunnill, 2008) or in terms of the nature of teaching a particular subject (e.g. Pang, 2006). These studies are helpful in providing an overall direction of travel for teacher learning. However, they do not explicitly identify the critical aspects of conceptions of teaching. This limits their application in teacher education programmes since appropriate patterns of variation cannot be established. In addition, they do not provide a particularly fine grained description of the types of understanding that teachers need in order to successfully teach a lesson on a particular topic.

As argued in Chapter 2, it is appropriate in PVT research to make use of existing knowledge within a discipline in the interpretation of conceptions of a phenomenon (this is seen for example in the way in which economists' ideas of supply and demand are used in descriptions of conceptions of price). As a result, in the case of teaching it seems appropriate to look to existing research into teachers' knowledge

for clues as to the critical aspects that are likely to make up a sophisticated understanding of teaching.

Two aspects of teachers' knowledge that have been given prominence are Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) (Shulman, 1986a). One reason for this is the strength of the association that has been established between teachers' CK and PCK and student learning. Evidence comes from both small-scale qualitative studies (e.g. Escudero & Sanchez, 2007; Speer & Wagner, 2009; Griffin et al., 2009) and larger-scale quantitative studies (e.g. Hadfield et al., 1998; Baumert et al., 2010; Tirosh et al., 2011). Some researchers have found that PCK is of greater significance for student learning than CK (Griffin et al., 2009; Baumert et al., 2010).

This evidence suggests that, as important forms of teachers' knowledge, CK and PCK could be interpreted as being critical aspects of the phenomenon of teaching. As a result, finding effective ways of developing both can be seen as being important in improving the quality of teaching. An examination of the extent to which Learning Study might provide a vehicle for such improvement provides a key impetus for the current study.

3.3. CK and PCK unpacked

3.3.1. The origins and significance of CK and PCK

The distinction between CK and PCK is rooted in the idea that knowing about a topic (CK) is completely different to knowing about teaching and learning that topic (PCK) (Bucat, 2005). According to Shulman, PCK is teachers' 'own special form of professional understanding' (Shulman, 1987, p.9). It is the knowledge base of the scholarly teacher in contrast to the knowledge base of the scholar (Trigwell, 2004).

In Shulman's first conceptualisation (Shulman, 1986a), PCK is defined as a topic specific, sub-category of CK. It is the 'particular form of CK that embodies the aspects of content most germane to its teachability' (Shulman, 1987, p.9). PCK itself was said to consist of two further sub-categories: i) knowledge of 'the ways of representing and formulating the subject that make it comprehensible to others' (Shulman, 1986a, p.8), referred to as 'instructional strategy' in the research and, ii) an understanding of 'what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons…….'(Shulman, 1986a, p.9), often referred to as 'student's learning difficulties' in the research.

Subsequently Shulman (1987) revised his description of PCK and presented it as a discrete category of knowledge alongside six other categories (content knowledge, general pedagogical knowledge, curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational contexts and knowledge of educational ends, purposes and values).

Shulman's concepts of CK and PCK have significant intuitive appeal as a heuristic (Ball, Thames & Phelps, 2008). This may be because of peoples' common experience of subject 'experts' (with high CK) who are nevertheless more or less ineffective as teachers (as a result of having low PCK). Or it may be because of peoples' experience of 'good' teachers, with an understanding of students and an ability to teach well (with high levels of PCK), who are nevertheless constrained in how far they can take their students because of their lack of subject expertise (or CK).

These experiences have a particular poignancy for those who have been teachers or have been involved in working closely with teachers. For these people, the distinction between CK and PCK feels like a powerful way of conceptualising something fundamental and distinctive about the act of teaching (Abell, 2008). The

idea of PCK appeals to teacher educators, who see it as an important way of thinking about how to improve the quality of teaching (Kind, 2009).

As a result, the concepts of CK/PCK have sparked a considerable number of studies in education research - most notably in mathematics and science education (Ball et al., 2008). Some idea of the scale of this interest is indicated in the review of CK/PCK research in mathematics education undertaken by Depaepe, Verchaffel and Kelchetermans (2013). This review analysed 51 studies that focused on CK/PCK, after initially identifying a total of 811. Over half of the 51 studies were concerned with teacher training.

3.3.2. Conceptualisations of CK and PCK

There is some common ground amongst researchers into PCK. It is generally agreed that PCK connects subject content and pedagogy in some way, that it is specific to teaching particular subject content and that it is therefore critically underpinned by CK (Depaepe et al., 2013). However, there is much disputed territory beyond this.

One viewpoint on PCK emphasises its role in the classroom. According to this conception, PCK is inextricably embedded in the act of classroom teaching and is a

highly dynamic form of knowledge in action (e.g. Marks, 1990; Cochran, Deruiter & King, 1993; Fernandez-Balboa & Stiehl, 1995; Seymour & Lehrer, 2006). Here the object of learning is mainly co-constructed through the interactions between teacher and students *in* the lesson. Gess-Newsome (1999) described this as an 'integrated' model, in which PCK is conceived as a 'mixture' of different, yet separate, types of knowledge. This model suggests that the teacher will need to 'think on their feet' regarding which parts of their knowledge will be relevant and which will not, and that the enacted object of learning in any lesson is highly likely to turn out to be something that they did not know beforehand. In seeing PCK as a mixture of different forms of knowledge, this model tends to place as much emphasis on developing generic types of teachers' knowledge as on developing their subject specific knowledge.

An alternative viewpoint (e.g.Krauss et al., 2008, Baumert et al., 2010), emphasises the role that PCK plays *before* the lesson. Here teachers draw upon a number of different types of knowledge to develop an intended object of learning in advance of the lesson. These are likely to include their subject specific CK, their knowledge of students' current thinking (sometimes described in terms of misconceptions) and their judgement about the progress students can make in the time available

(although other forms of knowledge may be relevant too). This model suggests that teachers can accurately predict which aspects of CK and PCK will be relevant during a lesson. Gess-Newsome (1999) described this as a 'transformative' model of PCK in which PCK is a distinct form of knowledge created out of CK and other types of knowledge. According to this perspective, PCK, once established, acts reciprocally on other forms of knowledge, transforming them.

3.3.3. Capturing CK and PCK

The way in which researchers have sought to capture CK and PCK has been determined by the way in which CK and PCK have been conceptualised (Kind, 2009; Depaepe et al., 2013). Thus, those emphasising teachers' knowledge outside of the classroom have tended to measure CK/PCK using a test, whereas those emphasising teachers' knowledge in the classroom attempt to capture PCK 'in action' (e.g. by drawing upon evidence from classroom observations, reflective journals, video excerpts or semi-structured interviews). The potential for triangulation gives those studies based in the classroom good reliability, although they are time consuming and resource intensive. By contrast, 'tests' conducted outside of the classroom have faced challenges in terms of test design, validity and in managing the type of multidimensionality that emerges (Hill, Ball & Schilling, 2008). However, these have

the potential to be less resource intensive and give access to larger samples (Rohaan & Taconis, 2009).

Some researchers have adopted approaches that attempt to capture the relationship between the PCK teachers use in the classroom and the PCK they use outside it. For example, Loughran, Mulhall and Berry (2003) developed two rubrics to capture CK/PCK. One rubric sets out the significance of the ideas contained within a particular lesson (CoRes - Content Representations) and the other offers a structure for detailed reflections on those ideas as they are revealed in practice in lessons (PaP-eRs - Pedagogical and Professional experience Repertoires). As rubrics are completed, they are validated through a process of reviewing and redrafting undertaken by both teachers and researchers. CoRes are used as an interview tool outside of lessons to 'elicit……understandings of important aspects of the content under consideration (Loughran et al., 2003, p.376). PaP-eRs are intended to 'offer a window into a teaching/learning situation wherein it is the content that shapes the pedagogy' (Loughran et al., 2003. p.377). According to Loughran et al. (2003), one important way in which teacher knowledge develops is through an interaction between the outcomes and thinking underpinning CoRes and PaP-eRs. The two rubrics proposed by Loughran et al. (2003) act as an invariant background against

which to observe variation in the planning, enactment and review of lessons. In PVT terms, this invariance is an essential precondition for teacher learning since it has the effect of clarifying the complexities of CK/PCK by making them implicit explicit. This is an approach supported by other researchers in PCK (e.g. Kind, 2009; Kellner, Gullberg, Attorps, Thoren & Tarneberg, 2011).

3.3.4. Evaluating different models of PCK

What conclusions might be drawn about the relative merits of the approaches to PCK outlined above? On the one hand, models of PCK that focus on classroom interactions could be said to have the potential to capture more of the full complexity of teaching, including affective aspects such as teachers' self-efficacy, identity and personal interest in the subject and students (Hodgen, 2011), or cultural aspects (An, Kulm & Wu, 2004). However, the complexity that they seek to capture means they run the risk of being able to develop only 'elusive descriptions of what PCK entails' (Depaepe et al., 2013, p.23) that are unwieldy. In addition, approaches to capturing PCK in situ are likely to be less helpful to BTs (particularly during the early stages of their training) because they lack a well-developed ability to identify the critical aspects of their teaching in comparison to more experienced teachers (Kind, 2009).

In terms of BT's knowledge development, on the one hand, the adoption of models of PCK that focus on its role and development in the classroom might result in BTs being left alone to integrate discrete forms of knowledge in the classroom. This is highly likely to result in them falling back on transmission approaches to teaching (Gess-Newsome, 1999). One the other hand, an approach to PCK that focuses on its development outside of the classroom presents BTs with the challenge of successfully integrating this knowledge into their teaching.

This suggests that a model of PCK combining both perspectives could be beneficial. This might occur through BTs reflecting upon both their knowledge in action as well as upon their knowledge about that action (Petrou & Goulding, 2011). This approach would avoid the risks of downplaying the impact of the pre-existing knowledge that teachers use in the planning and preparation of their lessons (Hashweh, 2005). It would also ensure that BTs would develop their PCK in the context of classroom practice. This is important since it has been shown that improving PCK on its own is unlikely to be sufficient to improve teaching (Cochran et al., 1993).

Finally, placing an emphasis on different approaches to the development of PCK might be appropriate at different stages in a teachers' career. In the early stages, BTs

might benefit more from a greater focus on the development of PCK away from a classroom context than they might later on in their development. This would be in line with evidence from studies (e.g. Krauss et al., 2008) suggesting that those teachers with higher levels of subject expertise, developed as a result of teaching experience, may have more integrated knowledge that those with lower levels.

There is still considerable work to be done in relation to models of PCK. In fact Kind (2009) has argued that it may be best to view research in this area as being in the 'pre-science' phase in Kuhnian terms. First, approaches to PCK have yet to fully develop an account of how different forms of teacher knowledge interact to form PCK (Abd El-Khalick, 2006). In particular, transformative models need to explain the reciprocal mechanism by which PCK 'transforms' other types of knowledge, particularly CK, and is in turn transformed by it (Kind, 2009). Second, different models of PCK cannot yet effectively define what the nature of the knowledge is in the sub-categories of teacher knowledge that are identified (Depaepe et al., 2013). For example, evidence from a range of studies indicates that the definition of CK may not be a straightforward one (e.g. Kind & Taber, 2005; Deng, 2007). This represents a challenge to transformational models since it may not be clear what is to be

'transformed' (Ellis, 2007), and a challenge to integrative models since it is not clear what is to be 'integrated'.

These are important considerations and could help explain the fact that it is not yet universal practice in the field of PCK research for researchers to clearly articulate their assumptions in relation to PCK. In their review of 51 CK/PCK studies for example, Depaepe et al. (2013) found that nearly 25% did not specifically define the components of PCK at all.

One way forward concerning the relative merits of different approaches to PCK is to frame the debate in new terms. This study does this by defining CK and PCK in terms of PVT.

3.4. Evidence in relation to CK and PCK

3.4.1. Findings of non-PVT research

This section summarises some of the main findings of the existing non-PVT research into PCK and CK that are relevant to the current study. It focuses on those findings for which there is a considerable consensus across the field. This helps to take

account of the variation in interpretations of PCK and CK and the different methods for capturing these that are present in the wide range of studies considered. Support for this approach comes from comparison of two major studies that comprehensively review previous research into CK and PCK in science and mathematics education (Kind, 2009; Depaepe et al., 2013). These reveal that the central themes in different subject domains are broadly similar. As a result, this study will draw heavily on research in mathematics and science in the absence of specific research into CK and PCK in economics and business studies (the focus of this study).

With this in mind, the key findings are:

i. High levels of CK are a necessary but not sufficient condition for developing high levels of PCK.
ii. BTs often possess weak CK and PCK.
iii. Classroom experience is critical in developing PCK.
iv. Domain specific PCK is different to topic specific PCK.
v. A wide variety of methods can be used to develop PCK.

In relation to point (i), evidence for the logical assumption that PCK is inconceivable without CK is found in a large number of studies. In science education, small scale,

qualitative research (e.g. de Jong & van Driel, 2004; Sperando-Mineo, Fazio & Tarantino, 2006) has shown how BTs replicate their own misconceptions of subject content in their teaching and are thus not able to move their students beyond the level of their own understanding. This strongly suggests that PCK development is limited by CK. Larger scale, quantitative studies in maths education, based on distinct test items designed to measure CK and PCK, have provided supporting evidence for this (Krauss et al., 2008; Baumert et al., 2010).

However, whilst a high level of PCK does not seem to be possible independently of CK, high levels of CK do not automatically lead to the development of high levels of PCK (Davis, 2004; Bond-Robinson, 2005). Further indirect evidence of the distinct nature of PCK was provided by Baumert et al. (2010). They found that teachers' educational level had a greater impact on CK than on PCK. These studies suggest that factors other than CK may be at play in the development of PCK. One such factor could be BT's self-confidence. Some researchers have found that high levels of CK give BTs the self-confidence to develop more student focused activities that take account of student's learning difficulties, thus allowing them to develop higher PCK (Childs & McNicholl, 2007).

Turning next to point (ii), Depaepe et al. (2013) refer to a large number of studies in mathematics education indicating significant gaps in BT's PCK in relation to a variety of topics. Studies in science education have come to similar conclusions (e.g. Sperandeo-Mineo et al., 2006). In the light of the evidence in point (i) above, this is most likely to be as a result of low levels of CK in these areas. This might appear surprising given that in England, at least, teaching is a graduate entry profession.

However, studies exploring the link between teacher qualifications (a distal measure of CK) and teacher quality have not consistently found a strong association between the two. In England, for example, Slater, Davies & Burgess (2012) drew on evidence from over 7300 16 year old English students and the teachers who taught them, but could find no significant associations between teacher qualifications and teacher quality. In the US, the evidence is mixed. Clotfelter, Ladd & Vigdor (2010) found that teacher qualifications do have a significant effect on teacher quality in comparison to class size or parental education whilst although other studies (e.g. Kane, Rockoff & Staiger, 2008) point to more modest effects in relation to BTs' credentials. Taken as a whole, these findings suggest that further research may be required in this area (Slater et al., 2012). However the existing evidence would at least seem to indicate that there is no straightforward connection between teacher

qualifications and teacher quality, and that in the context in which this study is set, namely England, little firm evidence of a link has yet been established.

One reason for this could be that the types of knowledge required to perform well in a degree could be different to that required to teach successfully in a school. Some researchers have suggested that 'school' CK is not the same as 'academic' CK (Banks, Leach & Moon, 2005; Kind & Taber, 2005). Deng (2007) provides a series of convincing examples of the difference between 'school' based physics and 'academic' physics and concludes that BTs' PCK depends more on their understanding of the former than the latter. Indeed, Banks et al. (2005) suggest that in learning to transform their 'academic' CK into 'school' CK, BT's are more likely to attend to the needs of students and therefore develop their PCK. This is a theme identified by other researchers (e.g. Angell, Ryder & Scott, 2005).

Another perhaps less palatable possibility is that graduate qualifications equip BTs with better 'surface' CK than 'deep' conceptual CK. Qualitative evidence suggests that a deeper conceptual understanding can have a significant effect on the quality of teaching. For example, in comparing teachers in the US and China, Ma (1999) showed how the depth of Chinese teachers understanding allowed them to deploy a

much more diverse range of strategies in the teaching of mathematics. If BTs lack a deep conceptual understanding of subject matter it may be that they are unable to develop high level PCK. One implication of this is that teacher training programmes will need to deepen BTs' CK in order to enhance their PCK.

In terms of point (iii) above, there is broad agreement across CK/PCK research that the quality of teachers' PCK can best be developed through classroom experience. On average, for BTs, PCK tends to be more procedural than conceptual (Depaepe et al. 2013). For example, Angell et al. (2005) note little difference in the CK of the novice and expert teachers they studied, but found great differences in their PCK. This was observed in the transmission focus of the novices and the richer pedagogical skills demonstrated by the experts. These studies suggest that PCK is not something that can be taught solely in isolation from the experience of teaching. Lederman, Gess-Newsome and Latz (1994) provide evidence of the transformational effect of classroom practice on BTs' understanding of the structure of their subject and the move towards an integration of pedagogy and subject matter. De Jong, Van Driel and Verloop (2004) show that BTs exhibited much stronger development in their understanding of students' specific learning difficulties after teaching lessons in those topics, in comparison to those that they had not taught. The implication of all

these studies is that methods to improve PCK should be strongly centred on the interpretation of classroom experience.

Turning next to point (iv) above, some researchers have found that BTs' PCK differs according to the topic area within a subject domain. For example, Lee (2010) found variation in kindergarten teachers' PCK across six areas of mathematics. This finding was echoed in Watson and Nathan's (2010) work on how teachers' PCK differed between statistics and mathematics. Since teachers' knowledge is unlikely to be evenly spread across their subject domain and given the association between CK and PCK, these results are hardly surprising. However they suggest that PCK is not automatically 'transferable' even within a subject domain and thus emphasise that PCK is deeply connected with the nature of the particular topic at hand. This is a conclusion supported by Sperandeo-Mineo et al. (2006).

One implication of this is that the most effective way to develop PCK is likely to be through discussion that most closely links topic specific CK and pedagogy. Daehler and Shinohara (2001) note that this is helpful in counteracting BTs' natural inclination to discuss how to teach a topic without consideration of their own understanding of it. Since a number of studies in CK/PCK have focused on

producing aggregate measures of PCK (e.g. Krauss et al., 2008), care needs to be taken in the interpretation of these measures for individual teacher performance in a particular lesson (although such measures may have other uses in relation to an overall assessment of teacher quality).

Finally, in reviewing the literature, there are many examples of different types of training that claim to have resulted in the development of PCK and in some cases CK. Depaepe et al. (2013) provide an extensive set of examples. These include: collaborative learning, mentoring, using particular text books and analysing video-case studies and field experiences. Conducting comparative tests of these alternatives in order to decide on the most effective approaches has not been a significant feature of research into PCK and CK, perhaps because of the absence of standardised definitions of PCK and CK.

3.4.2. Findings of PVT research

A small and emerging body of research has made use of PVT to explore CK/PCK. This research can broadly be divided into: i) those studies that have used PVT as a methodology for categorising conceptions and, ii) those that have used it as a way of contributing directly toward the development of teachers' PCK (through such

interventions as Learning Study). Examples of the first type are studies that have identified BTs' understanding of students' learning difficulties (PCK) (e.g. Kellner et al., 2011) and those that have identified BTs' CK (e.g. Sperandeo-Mineo et al., 2006). Examples of the second are studies that have sought to define critical features in conceptions of teaching a particular subject (e.g. Paakari, Tynjala & Kannas, 2011) and those that have explored how PVT, through the vehicle of Learning Study, can have an impact on PCK (e.g. Nilsson, 2014). A consideration of the effects of Learning Study on PCK is left until Chapter 4. This section will address each of the other strands of PVT research in turn.

Kellner et al. (2011) explored BT's conceptions of student's learning difficulties. They used phenomenographic analysis to categorise 32 primary and lower secondary BTs' understanding of the misconceptions held by students in relation to four hard to learn topics in science and mathematics. They concluded that BTs' initial conceptions are an 'important potential resource when planning teacher education courses at the topic-specific level' (Kellner et al., 2011, p.860). Improving PCK (and CK) is a matter of surfacing BTs' personal views and interweaving those with other BT's conceptions and the results of previous research in a 'dynamic discourse' (Kellner et al., 2011, p.860). This argument is founded on the assumption that

presenting BTs with information on students' (mis) conceptions is much less likely to change their approach to teaching than presenting them with information on their own conceptions.

Other studies have focused more on using phenomenography to map BTs' understanding of subject matter (e.g. Attorps, 2003; Sperandeo-Mineo, 2006). Sperandeo-Mineo et al. (2006) made use of phenomenographic analysis to describe 28 BTs' explanations of thermal processes in physics. Unlike Kellner et al. (2011) they rank the sophistication of explanations and compare them in pre and post-tests in order to evaluate an intervention designed to improve CK. This intervention included briefings on the current research into student misunderstandings, collaborative discussions and highly detailed written reflections on classroom experiences. The study highlighted the importance of CK in underpinning PCK development as well as general weaknesses in BTs' CK. It also pointed to the success of the workshop oriented intervention (particularly for BTs with lower CK).

In a smaller scale, less complex study, Attorps (2003) identified BTs' conceptions of an equation in mathematics. Although no detailed quantitative evidence is provided, Attorps concludes that many BTs have a low level of conceptual

understanding and that as a result spend much of their time with students developing procedural skills. The role of conventional textbooks in not revealing critical differences between aspects of subject content is suggested as one possible reason for this.

A second group of studies has focused more on the way in which the underpinning theory of PVT might be employed to develop BT's CK and/or PCK. This research seeks to identify critical aspects of these conceptions that will potentially help teacher educators in the design of effective training programmes. A key study in this vein was undertaken by Paakari et al. (2011). They investigated the ways in which BTs' understand learning in health education and arrived at six categories and a number of critical aspects. One such critical aspect is whether knowledge is viewed as non-problematic or problematic. This study adopts a strict interpretation of phenomenography in that it does not categorise individual BTs according to their conceptions but produces generalised conceptions around which it is suggested teacher education programmes might be structured.

3.5. CK and PCK in the current study

This study adopts Shulman's (1986a) original definition of PCK (interpreted through the lens of PVT). This is because, although there has been significant disagreement amongst researchers about what to include and what not to include in any definition (Depaepe et al. (2013), for example, identified eight potential components in their survey of PCK research in mathematics teaching), at the core of most conceptualisations of PCK are Shulman's (1986a) two original components: i) knowledge of student (mis)conceptions and, ii) knowledge of instructional strategies and representations.

In the review by Depaepe et al. (2013) there is a near unanimous agreement on their inclusion, with over half of the 51 studies examined exclusively adopting Shulman's definition of PCK. This may result from the fact that Shulman's two components are necessarily deeply embedded in the practical act of planning and teaching a lesson on a subject to students. It is difficult to conceive how a lesson could be successful without these two elements. With the possible exceptions of aspects of context knowledge and cognitive demand, the potential eight components of PCK that were identified by Depaepe et al. (2013) tend to be more concerned with generic aspects of

teaching than they are with teaching a particular lesson within a particular subject domain.

This study interprets one aspect of Shulman's original definition of PCK, namely students' learning difficulties, in terms of PVT. The study does not directly focus on the other aspect of Shulman's definition, namely knowledge of instructional strategies (although there is a possibility of interpreting this in terms of PVT in future research). The extent to which the depth of a BTs' knowledge of students' knowledge can be said to represent their PCK therefore depends on the relative importance of Shulman's two components. Unfortunately there do not seem to be any studies that provide firm evidence in relation to this. Examining the association between the quality of BTs' teaching and the quality of their understanding of students' understanding would be one way forward, but this work was not undertaken in this study. As a result, this study is built on the assumption that BTs' knowledge of students' understanding is the predominant influence on BTs' PCK. One possible argument in support of this assumption is that knowledge of teaching strategies is more straightforward than knowledge of students' learning difficulties. This may be partly because BTs (and perhaps some more experienced teachers) find it easier to focus on themselves and their role as teachers rather than on students and

their role as learners. It may also be a result of BTs having considerable direct experience of teaching strategies during their own education. This means that whilst it is possible to conceive of a BT that has a good awareness of students' thinking but a poor awareness of teaching strategies, these BTs are likely to be much fewer in number than those with a good awareness of teaching strategies and a relatively poor awareness of students' thinking.

In interpreting Shulman's definition of PCK in terms of PVT, this study makes use of the potential of PVT to lend theoretical unity to the understanding (and measurement) of both CK and PCK and to the way in which these can be developed. PVT allows for the operationalisation of CK and PCK in the following ways: i) CK can be defined as the level of sophistication in a BTs' conception of a phenomenon providing the researcher with a method of differentiating between qualitatively distinct levels of understanding, ii) the 'students' learning difficulties' element of PCK (originally described by Shulman 1986) can be defined in terms of BTs' understanding of the different conceptions of a phenomenon that students might hold, and, iii) the 'design of instructional tasks' element of Shulman's original formulation of PCK is specifically addressed by variation theory. Here the principles of PVT have been developed into a theory of instructional design which asserts that

conceptual change is prompted when learners are presented with comparative examples in which features which are critical to a more sophisticated conception are varied whilst all other features of the phenomenon are kept invariant.

This study is built on the assumption that high levels of CK and PCK are a necessary but not a sufficient condition for effective teaching. Other forms of teacher's knowledge (such as knowledge of curriculum) are therefore highly likely to play a part, as will affective aspects such as teacher's self-efficacy and motivations. Indeed in identifying that there may be a difference between the intended, enacted and lived objects of learning, PVT explicitly acknowledges the complexity of the interplay between factors that is possible within a classroom. So, for example, even if a BT has high levels of CK and PCK, this does not guarantee that the intended and lived objects of learning will coincide. However, it is highly likely that the presence of high levels of CK and PCK will increase the chances of this happening because they are of such crucial importance to the teaching of a lesson. Hence, finding effective methods for developing CK and PCK remains highly desirable.

As indicated in Section 3.4., previous research has investigated PCK and CK at either a topic specific or a subject domain level. However, it is not clear which of these is

the most significant for the quality of teaching. No research exploring the link between subject domain PCK and topic specific PCK could be found, even though both are likely to be important in the teaching of any individual lesson. However, subject domain measures, particularly aggregate ones such as those constructed by Baumert et al. (2010), are much less likely to be of immediate concern to a BT trying to plan to teach a particular lesson on a particular topic. Subject domain PCK is limited to providing a useful context for decisions about the structure of individual lessons, and is unlikely to be able to provide much direct guidance on lesson planning. On this view, subject domain PCK is more likely to be a focus for the longer term development of BT knowledge and is therefore particularly useful in the design of teacher training programmes. Since the focus of this research is the effects on PCK and CK of teaching a lesson on a particular topic, this study will adopt a topic specific focus. This fits closely with the methodology adopted in previous PVT studies researching price and Learning Study.

This study builds on and adds to previous work linking PVT and CK/PCK. The study by Kellner et al. (2011) provides an important underpinning in terms of: i) defining one aspect of PCK (students' learning difficulties) in terms of BTs' conceptions of students' understanding and, ii) recognising the potential of this as

the driver for improving PCK (rather than focusing on student (mis)conceptions alone). The work by Sperandeo-Mineo (2006) and Attorps (2003) emphasises the benefits of taking a topic specific approach to the development of CK and PCK, as in this study. In addition, they point to the importance of: i) collaboration between BTs for highlighting differences in conceptions and, ii) using previous research into student (mis)conceptions as a point of comparison and stimulation for productive discussions amongst BTs. Learning Study is a collaborative approach that is based on empirical research into student understanding of topic content and so this fits very logically with this previous research. Finally Paakari et al. (2011) have shown how PVT can be used to identify critical aspects of a form of PCK (i.e. conceptions of student learning) in a particular subject domain and have emphasised their potential for developing BTs' PCK. This study applies these principles to a specific topic and adds to the research of Paakari et al. (2011) by providing a more detailed description of instructional design (Learning Study).

3.6. Conclusion

There are strong a priori grounds for emphasising the importance of teachers' CK and PCK. This is supported by a considerable body of research evidence suggesting they are critical aspects of knowledge that impact significantly on teachers'

effectiveness. However, in attempting to tie down the meaning of CK and PCK and move beyond using them simply as heuristics and broad guides to interpreting teachers' knowledge, there is a good deal of controversy. Key questions introduced in this chapter have been, what the constituents of CK and PCK are and how these forms of knowledge should be captured and measured. Debate in relation to these issues is not yet concluded and one significant outcome of this is that it is not clear what the implications for teacher training should be. In other words, what is the best way to develop BTs' CK and PCK?

This study proposes a new way of conceptualising CK and PCK through an application of PVT. This approach can address some of the issues noted above as well as allowing an examination of the results of previous research from a different perspective. In addition, this study extends the evidence base in relation to BTs' knowledge in a subject domain for which there is little previous research – namely economics and business studies.

Defining CK and PCK in terms of descriptions of qualitatively different conceptions has a number of benefits. To begin with, PVT adopts a perspective that claims to be neither situated nor cognitive and thereby potentially avoids the disadvantages of

both outlined earlier in the chapter. It also offers a framework for understanding BTs' knowledge and an associated language for talking about it through such vocabulary as 'conceptions', 'qualitative differences', 'critical aspects' and 'variation'. In this way, PVT performs a similar function to the CoRes and PaP-eRs developed by Loughran et al. (2003). These rubrics helped ensure that the complex and fluid ideas of CK and PCK can be more 'concretely represented to others' (Loughran et al., 2003, p.371) and the development and use of a shared language based on these rubrics allowed teachers to identify and articulate the differences between lessons.

However, PVT offers significantly more than the rubrics suggested by Loughran et al. (2003) because: i) it expresses CK and PCK in the *same* theoretical terms and, ii) is explicit in describing what a more or less sophisticated understanding of each looks like. This means that: i) different levels of understanding can act as points of comparison and provide target levels of understanding that could be of use to both BTs themselves and to their trainers, ii) CK and PCK can be directly compared, allowing relationships to be more quickly and accurately discerned and, iii) there is likely to be considerable economy of effort if BTs only have to learn and work with one framework for understanding CK, PCK and associated methods to improve both.

All of these benefits depend on the extent to which descriptions of conceptions of CK and PCK are accurately identified. However, even if subsequently proved to be inaccurate, such descriptions can offer an invariant background against which to highlight the need for revision.

Finally, one of the most significant benefits of PVT is that it offers a method of developing both CK and PCK that interweaves teacher-led research in the classroom, theory and classroom practice, known as Learning Study. Thus the opportunity for ensuring theoretical clarity goes beyond just definitions of CK and PCK and extends to a practical way in which such knowledge might be developed. The purpose of the next chapter is to provide an explanation of Learning Study and explore how it can contribute to BTs' learning.

4. LEARNING STUDY

4.1. Introduction

PVT is most commonly operationalised through an approach to planning, teaching and reviewing lessons known as Learning Study. Since Learning Study developed from a related approach known as Lesson Study, this chapter begins by explaining what Lesson Study is and the benefits that it might have – particularly for teachers. Following this, a critical analysis of the research into Lesson Study and the effects on teachers' knowledge is presented. This highlights the small scale, largely qualitative nature of the existing research, as well as suggesting that the treatment of CK and PCK has been under theorised. Building on this, the origins of Learning Study are then outlined along with a description of the Learning Study process. A section follows examining how Learning Study might contribute to the development of teachers' knowledge through their experience of variation. This section identifies possible sources of variation that teachers are likely to encounter in a Learning Study which might promote learning. Next, the existing evidence into Learning Study and teachers' learning in general is examined. The chapter ends by outlining the implications of all of the above for this study in terms of underpinning theory and methodology.

4.2. Lesson Study

4.2.1. What is Lesson Study?

Lesson Study is an approach to teachers' professional development that originates in Japan. Its defining characteristic is that it involves 'observation of live classrooms by a group of teachers who collect data on teaching-learning and collaboratively analyse it' (Lewis, 2009, p.96). Teachers work over long periods of time (ranging from several months to a year) on the design, implementation, testing and improvement of one or several 'research lessons'. The end result is a clarification of the recommendations for future teaching practice, shared through short written papers, presentations or demonstration lessons.

Stigler and Hiebert (1999) map out the following stages for a group of teachers undertaking a typical Lesson Study:

i. Define an educational problem.

ii. Plan a lesson making use of previous approaches to tackling that problem.

iii. Teach the lesson (one teacher teaches whilst others observe and gather other evidence – often through video).

iv. Evaluate the lesson by discussing all the evidence gathered.

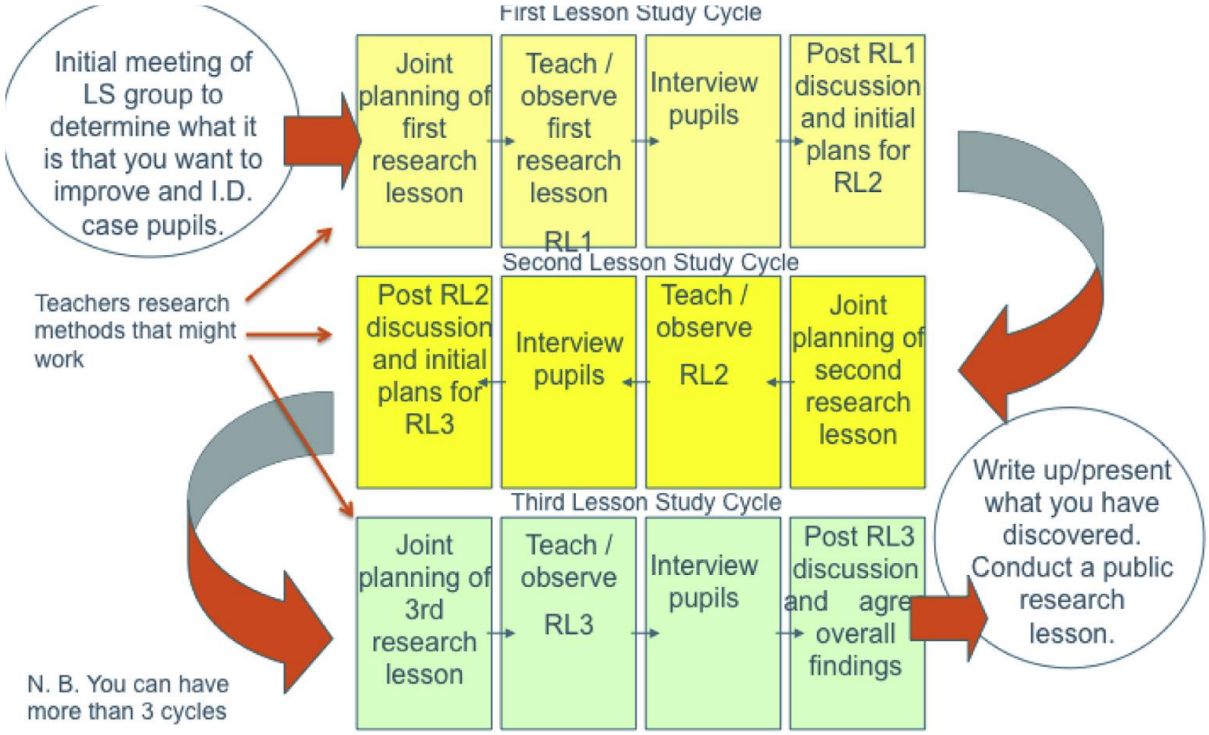
v. Develop a revised lesson.

vi. Reteach the lesson (again with one teacher teaching and others observing and gathering of evidence).

vii. Sharing the outcomes of the process with teachers both within the school that the study was undertaken in and beyond it.

Although Lesson Study groups vary in the extent to which they emphasise different aspects of the Lesson Study process (Lewis, Perry & Hurd, 2009), a common feature is the inclusion of repeated cycles of planning, teaching and reviewing lessons (Lewis, Perry & Murata, 2006). Figure 4.1 illustrates a typical lesson study process (Dudley, 2013, p.108).

Figure 4.1 – A typical Lesson Study



In a Lesson Study, teachers theorise about the educational problem that they have decided to focus on and develop hypotheses about what constitutes a good way to address it in their teaching (Lewis, 2009). In doing this Lesson Study explicitly places a high value on teachers' practical knowledge and experience. This is likely to increase their sense of ownership of the Lesson Study process as well as their self-efficacy (Lieberman, 2009). In Lesson Study, teachers are also expected to inform their analysis by drawing on wider educational theory and previous research (Stigler

& Hiebert, 1999). They are usually supported by researchers in this process. Lesson Study of itself does not specify what the critical aspects of good student learning are and therefore leaves the choice of theory to the participants in the Lesson Study. This means that different Lesson Studies are likely to draw on different educational theories. An important advantage of this is that theory can be selected that is appropriate to the nature and context of the educational problem under review and can therefore complement teachers' existing practical knowledge and experience. This is a powerful combination that can help avoid the problems inherent in translating 'theory' into 'practice'. Another advantage is that in adopting a research informed approach to the analysis of problems in teaching, where lessons are designed, taught, reviewed (in the light of gathered evidence) and then re-taught, there is significant potential for teachers in a Lesson Study to develop their understanding of important aspects of the topic that is being taught, namely the object of learning.

These advantages help explain why Lesson Study has been presented as a key factor in Japan's educational success (Stigler & Hiebert, 1999). Lesson Study has also gained popularity in the US, more widely in Asia and in other countries, including England. The establishment of the World Association of Lesson Study in 2007, with

biennial conferences and an associated international journal, is indicative of its increasing prominence.

4.2.2. Lesson Study and teacher learning

Advocates of Lesson Study draw on both situated and cognitive theories of learning to explain teacher learning in Lesson Study (Lewis et al., 2009). Firstly, with reference to situated learning theories, Lesson Study is presented as being an effective way of developing communities of practice (Lave & Wenger, 1991). A community of practice involves groups of teachers in the development and use of shared cultural 'tools' such as language, norms, customary practices and common frameworks for the analysis of teaching practice. Becoming a member of such a community therefore goes beyond relatively passive, superficial 'sharing' (for example, where one teacher simply passes a teaching resource to another) to the development of a deeper, more active form of 'participation' that shapes the identity of individual teachers. In a community of practice, teachers therefore develop their skills and their understanding of teaching and learning as part of the same process as becoming a fully-fledged member of their professional community (Lave & Wenger, 1991). Although learning can occur in any community of practice, the structured collaboration offered by Lesson Study significantly increases the chances of the

successful development of the cultural 'tools' identified above. This is demonstrated in the opportunities in Lesson Study for teachers to share not only their classrooms (materials and practices) but also their minds (beliefs and reasons) and their vulnerabilities (uncertainties and failures) (Vescio, Ross & Adams, 2008). Lieberman (2009) gives many of examples of the way in which Lesson Study can work along these three dimensions to break the individualism that so often characterises teachers' experience of teaching.

Secondly with reference to cognitive theories of learning, Lesson Study is presented as a good way to bring about changes in the mental schemata of teachers. This is explained largely as a result of the potential of Lesson Study to make tacit aspects of teachers' knowledge explicit (Eraut, 2004). A wide range of studies have conceived of this knowledge in terms of CK and PCK (e.g. (Lewis, 2009; Fernandez, 2009; Lewis, Perry, Friedkin & Roth, 2012). The mechanism to activate CK and PCK development is the way in which Lesson Study gives teachers the opportunity to experience and confront ideas that are different to their own. For example, in jointly examining students' work or their own teaching practice, teachers may surface aspects of their thinking that were to that point assumed and implicit (Lieberman, 2009). In clarifying their assumptions, individual teachers then have a firm basis on which to

examine their own thinking and potentially revise it (Linn, Eylon &Davis, 2004; Lewis et al., 2009; Dudley, 2013).

4.2.3. Challenges for Lesson Study

Lesson Study faces a number of challenges. Firstly, since it requires teachers to draw on their own theorising about education and on the theories of others (either from other Lesson Studies or from wider education research), Lesson Study places demands on the teachers to distinguish between 'good' educational theory (and research) and 'bad' educational theory (and research). Teachers may lack the expertise to make these kind of decisions (Chokshi & Fernandez, 2004). Secondly, it may be difficult for teachers to build up good research knowledge and skills in a particular area since they may take part in different Lesson Studies that are based on different theoretical principles. This could reduce the quality of some Lesson Studies below that which might be achieved. Thirdly, since a single theoretical approach is not seen to be an underlying feature of Lesson Study (Pang & Marton, 2003), it is more challenging for Lesson Study to demonstrate that the approach has benefits to student learning. This is because if student learning is defined in different terms in different Lesson Studies, then it is not clear what the basis for comparison between Lesson Studies should be.

One approach to this final problem has been to define student learning in terms of performance in standardised tests (e.g. Murphy, 2013). This allows large, scale randomised control trials to be undertaken where test scores can be compared in Lesson Study and control groups across subject domains (such as English or Maths). However, because these tests are generalised measures of outcomes, they are not able to identify what it is about the Lesson Study lessons that were enacted that was crucial to learning taking place. Furthermore, it is unclear in such studies what the relationship is between individual objects of learning and the way in which individual Lesson Studies are conducted. This is because Lesson Study per se, does not contain within it the mechanisms to make such a link. Its primary focus is on the process by which teachers organise student learning and evaluate its effectiveness, rather than on the object of that learning.

Research examining Lesson Study and CK and PCK is characterised by two main features. Firstly, a large number of studies rely on small scale, qualitative research (e.g. Lewis, 2009; Lewis et al., 2009; Fernandez, 2009; Dudley, 2013). These generally adopt a case study approach involving a small number of teachers participating in a small number of Lesson Studies from which a small number of examples of changes

in teacher knowledge are drawn. For example, in an often quoted study by Lewis et al. (2009), only three examples of changes in CK and three examples of changes in PCK are presented in a study of six teachers in a Lesson Study. A limitation of the case study approach, is that it is hard to identify with any certainty whether it was Lesson Study that caused the recorded changes to occur.

Secondly, studies have tended to treat CK and PCK in a binary way, where teachers either possess or do not possess each type of knowledge. For example, Lewis et al. (2009) make the following statement in their explanation of how Lesson Study improved teachers' CK:

> *'Initially teachers suggest it does not make a difference how the triangles (in a triangle-perimeter function) are arranged or are wondering; after solving and discussing, all agree it makes a difference'* (Lewis, et al., 2009, p.295).

In the quotation above, it is not clear what kind of difference the arrangement of triangles makes or what the reasons for this are. It is also not clear to what extent teachers do or do not possess this kind of understanding. The limitation of presenting changes in teachers' knowledge in this way is that it does not involve

defining or reporting on qualitative differences in CK. In other words, the size, nature and distribution of any changes in teacher knowledge that might have occurred are not specified. This is something that has been recognised by Lewis elsewhere (see Lewis, 2009).

The following quotation (Lewis, 2009) provides a further illustration of these points in relation to PCK:

> *'The teachers learned for example, that introducing levers by putting a 220 pound sack in the middle of the gym floor catalysed more student investigation than previous methods of introducing the levers unit. They also learned about student thinking: when experimenting with the levers, some students attended more to the material of the lever (wood versus metal) or to its height than to its position relative to the fulcrum and object to be lifted. Pedagogical content knowledge developed by the teachers included the realization that how teachers presented the levers problem dramatically affect the lifting strategies imagined by students.'*(Lewis, 2009, p.100).

Again, it is not immediately apparent from this quotation exactly what teachers did learn. It was presumably not that teachers should always use 220 pound sacks! It is

not clear whether teachers have gained new PCK relating to the principles underlying the benefits of using the 220 pound sack or whether they already had the PCK and had simply not thought of using a sack. It is also hard to tell which teachers the above quotation relates to or what proportion of the group. The quotation however is interesting in the reference to the way in which students focused on non-critical aspects of the science (such as the lever's material). This would seem to offer support for the central proposition of PVT, that in order for students to acquire the intended object of learning, teachers should vary critical aspects whilst holding non-critical aspects constant.

Taken as a whole, the relatively large number of studies that make reference to the positive effects of Lesson Study on teachers' knowledge suggest that *some* changes in teachers' knowledge are likely to be occurring in association with the approach. However, research into teacher knowledge development in Lesson Study seems to be more concerned with establishing the existence of *any* effects rather than on establishing the distribution and scale of those effects. This is illustrated in Fernandez's study (2009), where a stronger emphasis is placed on Lesson Study as an *opportunity* for the development of PCK and CK rather than on the actual development of PCK and CK that occurred.

The challenges outlined in this section constituted the impetus for the development of Learning Study (Pang & Marton, 2003). The next section provides an introduction to Learning Study.

4.3. Learning Study

4.3.1. What is Learning Study?

Learning Study, as first proposed (Pang & Marton, 2003), combined Lesson Study with elements of Design Research (DR) (Collins, 1992). DR was interpreted as contributing two key aspects to the Lesson Study process: i) a theoretical dimension and, ii) an experimental methodology. Although Pang and Marton (2003) presented Learning Study as being appropriate for any theory of learning, they adopted PVT as a framework within which to operate. This has subsequently become the norm in the field.

The aim of the initial Pang and Marton study (2003) was to compare the relative merits of Lesson Study and Learning Study in the context of secondary schools in Hong Kong. In this study, some students were exposed to a lesson designed using a

Lesson Study approach and some students were exposed to a Learning Study approach. Teachers were randomly allocated to either Learning Study or Lesson Study groups, but students were not. This means that the study was quasi-experimental in design.

According to Pang and Marton (2003) a Learning Study involves a group of teachers undertaking five stages. These stages are set out below and are then described in more detail:

i. Choosing an intended object of learning (usually based around a phenomenon that is central to the curriculum or a particular challenge to students - examples include 'the concept of price, proficiency at essay writing, or developing empathy with people from other cultures' Pang & Marton, 2003, p.179).

ii. Ascertaining students' pre-understandings (usually completed through a pre-lesson test in order to identify students' conceptions of the phenomenon being taught).

iii. Planning and implementing the lesson(s) with teachers working together to highlight the critical features for the desired way of understanding the phenomenon.

iv. Evaluating and revising the lessons: analysing evidence from the lesson focusing on 'how the object of learning is handled' (Pang & Marton, 2003, p.179).

v. Reporting and disseminating the results.

Stage (i) – Choosing an object of learning

A distinctive feature of the object of learning is that it does not relate to particular ways of teaching, it is expressed purely in terms of a domain specific capability that teachers are aiming to develop in their students. In their study, Pang and Marton (2003) decided on the object of learning that the teachers were to work on, although they report that it was quickly recognised by teachers as being: i) a difficult topic and, ii) an important topic. This ensured that the object of learning was a matter of personal concern to the teachers involved, as well as being directly related to the context within which they were working. These factors could increase the 'buy in' of teachers to the Learning Study and the effectiveness of the resulting lessons.

Stage (ii) – Ascertaining students' pre-understandings

In the Pang and Marton (2003) study, a 'pilot' study was conducted to establish two things: i) the qualitatively different ways in which students *could* understand a

phenomenon and, ii) the qualitatively different ways in which they *did* understand a phenomenon. This involved two distinct steps. First, phenomenographic research methods were used to establish a scale measuring the different levels of sophistication in students' conceptions. Second, data from individual students was reviewed in order to categorise their conceptions according to that scale. In this way the theory that underpinned the design of the intervention (i.e. PVT) could also be used to underpin the method of evaluation of that intervention. The methods used to gather data for the pilot study (or pre-test) were a written test in response to a domain specific problem (completed by all students) and a series of phenomenographic interviews (undertaken with a much smaller number of students). The purpose of the interview data was to 'facilitate' (Pang & Marton, 2003, p.186) the analysis of the written data and thereby confirm its validity.

Stage (iii) – Planning and implementing the lessons

Two groups of five teachers were involved in this study – a Lesson Study group and a Learning Study group. The Learning Study group was 'introduced' (Pang & Marton, 2003, p.186) to the idea of PVT by a researcher. The only details that are provided about the nature of this introduction is that use of examples drawn from other topics in the subject domain was made. Both groups of teachers met three

times for six hours in total in the planning phase. Session 1 focused on sharing teachers' experiences of the object of learning, session 2 continued this process in the light of the evidence drawn from the pre-test and session 3 was concerned with planning the lessons to be delivered to students. Lessons were then taught to students that were based upon the plans that had been jointly developed. However, teachers implemented these plans 'in line with their own personal styles and any modifications that they considered necessary' (Pang and Marton, 2003, p.188).

Stage (iv) – Evaluating and revising the lesson

Data to evaluate the enacted lessons was said to have been drawn from three main sources: i) classroom observation and accompanying field notes, ii) video-recordings of lessons (along with verbatim transcripts) and, iii) pre and post-test results (based on students' written responses and confirmed through phenomenographic interview data). These data were supplemented by additional data from the preparatory meetings, lesson plans and interviews with teachers. The post-tests were constituted in the same way as the pre-tests involving the same combination of written responses and phenomenographic interviews. Both pre and post-tests were based on the same domain specific problem. The framework for the analysis and the evaluation of the data collected was PVT and was therefore focused on identifying what features of the

object of learning varied, varied simultaneously or remained invariant in the lesson. The evaluation drew mainly on evidence of qualitative differences in students' understanding of the phenomenon. Little detail is given about the revisions to the lessons that took place as a result of an examination of the data or about the time that was allocated to this phase of the study.

Stage (v) – Reporting and disseminating results

Pang and Marton (2003) emphasised the difference between the distributions of post-intervention conceptions in the groups of Learning Study and Lesson Study students. The study claims that the Learning Study was more successful because a greater proportion of students in this group demonstrated more complex conceptions in the post-test. The Pang and Marton (2003) paper itself seems to be the main vehicle for the dissemination of these results, as no other information on dissemination is provided.

Following on from the first study in 2003, Pang and Marton completed a second study (Pang & Marton, 2005). This addressed a number of methodological issues that had arisen in the initial study. In the 2005 study:

i. Results were expressed as a comparison between pre and post-testing data whereas in the 2003 study, results from the pre-test were used only to support the planning of the lesson. The basis of this comparison was still the proportion of students demonstrating each level of conception but the study included pre and post-test evidence of the distribution between *both* Learning Study and Lesson Study groups.

ii. The experimental design was improved through: i) drawing on a more homogenous sample of students (from Band 1 in the Hong Kong secondary school system rather than from Bands 1, 2 and 3 in the initial study), ii) interviewing the same students in the pre-test and the post-test and, iii) confirming the validity of the categorisation of students' conceptions by an experienced teacher who examined a proportion of student responses.

iii. More methodological detail was provided in relation to: i) how PVT was introduced to teachers by explaining the link between discernment and variation, ii) how interviews were structured to initially thematise participant responses before proceeding in an unstructured way, iii) how the phenomenographic research process led to the emergence of

stable categories of description that were logically structured through iterative cycles and, iv) how the highest conception demonstrated by a students was to be taken to be the basis of the categorisation.

4.3.2. Similarities and differences in approaches to Learning Study

Learning Study was originally conceived as being flexible in execution (Pang & Marton, 2003). For example, Pang and Marton (2003) suggest that it could involve teachers working in the same or different schools, it could involve outside experts or researchers and it could be used to enhance teachers' professional development either in service or pre-service.

Pang & Linder (2012) distinguish two types of Learning Study. Firstly, there are those that have specifically set out to evaluate the effectiveness of Learning Study as an approach, usually through conducting a quasi-experiment in which a control group is used (e.g. Pang & Marton, 2003). Secondly, there are those that involve repeatedly working on the same lesson and refining it in the light of experience (e.g. Lo, Pong & Chik, 2005; Andrew, 2012; Pang & Ling, 2012). Their purpose is to try and improve the teaching of a particular topic. The former (of which there are a relatively small number) have in the main emphasised quasi-experimental controls

and the use of PVT in the assessment of the effectiveness of lessons, whereas the latter have emphasised the importance of action research cycles in the improvement of teaching. In the emphasis given to PVT, Learning Study naturally contains within it a theoretical framework for its own evaluation. What therefore could explain why this latter type of action research focused Learning Study has been so prevalent?

One important reason for this is likely to be resource constraints. As outlined above, Learning Study is already a lengthy and resource intensive process. The requirements to instigate control groups and conduct phenomenographic analysis place considerable demands on the time and skills of both teachers and researchers. A good example where high level research skills are needed is in the design of pre and post-test questions. In these questions, there is a challenge in striking a balance between the narrowing effects of providing a context within which the response can be formulated and the need to make things open ended enough not to close off any options. Another aspect that demands considerable skills is in developing categories of description that accurately reflect the data that has been collected. Identifying the underlying patterns in large amounts of evidence requires patience, time and arguably a high level of subject knowledge. Another reason could be the shift in the focus of PVT research from phenomenography towards variation theory. Some more

recent reports of Learning Studies (e.g. Andrew, 2012) are concerned with the identification of critical features and contain hardly any explicit reference to conceptions of a phenomenon or the measurement of learning in this way.

The difference in approaches to Learning Study might reflect the distinction between Learning Studies that are led more by practitioners and those that are led more by researchers (although this need not necessarily be the case - see Pang & Ling, 2012, for example). It is not reasonable in resource terms (and perhaps not necessary) to expect that every instance of Learning Study should be concerned with an evaluation of the efficacy of the whole approach (although this is not to say that this should not be a major strand of research in the field). Therefore, in an individual Learning Study it is more important for teachers to know that the intervention has had *some* positive effect on the sophistication of students' understanding (which could be measured in a number of different ways other than in PVT terms) without necessarily establishing that it has more effect than another approach. It may therefore be less relevant to teachers trying to develop their routine practice to establish experimental controls than to those trying to establish the efficacy of the overall approach.

Learning Study has varied in practice in a number of other ways. These are outlined below:

i. The method of measuring the outcomes. For example, whilst Lo et al. (2005) and Pang (2010) make use of qualitatively different student conceptions of a phenomenon, Cheung and Wong (2014) employ an externally validated scale to assess student learning and others (e.g. Andrew, 2012) use fairly standard domain based questions where students' responses are assessed in terms of whether they are correct or not.

ii. The time allocated to the process. For example, Lo et al. (2006) completed two rounds of Learning Study in the same day whereas by contrast Pang's (2010) study ran for a year.

iii. The number of meetings and lessons. Pang and Marton (2003), for example, used 4 lessons to analyse student performance compared to Pang (2010) who analysed 16 lessons.

iv. The number of teachers involved. In a comparative study of different Learning Studies undertaken by Cheung and Wong (2014) the number of teachers taking part ranged between 2 and 70.

v. The number of students involved. Lo et al. (2005) gathered data from 71 students, Pang and Marton (2003) from 181 in the Learning Study group and 175 in the Lesson Study group and, Pang and Ling (2012) from 28 in the Learning Study group and 31 in a comparison group.

vi. The way in which PVT and Learning Study is introduced to teachers. Pang and Ling (2012) suggest this should last at least 12 hours but in general, only very sketchy detail is provided in descriptions of Learning Study in relation to this. It seems reasonable to assume therefore that it is done in different ways.

In spite of these differences there are a number of features that are common across Learning Studies. These include:

i. The focus throughout on student learning in relation to the object of learning.

ii. The collaborative nature of the research process involving joint planning and review of a lesson.

iii. The ownership of the research process in general by teachers including the object of learning.

iv. The use of 'live' lessons to test lesson designs.

v. The gathering of data from 'live' lessons in order to inform the analysis of student learning.

vi. The combination of teachers' experiences of teaching with evidence drawn from students in order to inform lesson planning and evaluation.

vii. The use of pre and post-testing of students in order to examine the amount of learning that has or has not taken place.

viii. The analysis of evidence of student learning in terms of variation in the critical features of a phenomenon.

The implication of this list is that the causal mechanisms in Learning Study are activated through these 8 common features, whilst the differences between enactments of Learning Study reflect differences between the contexts in which Learning Study is implemented. To date, there is no evidence of research in Learning Study to identify which of its characteristics is the most critical.

4.4. Teacher learning in Learning Study

Learning Studies are conducted with the central aim of improving student learning. Of the five Learning Studies included in the comparative survey by Cheung and

Wong (2014), three reported that the effects were statistically significant (Cheung, 2011; Marton & Pang, 2006; Pang, 2010) and two found that students in a Learning Study performed better than those students in a Lesson Study (Pang & Marton, 2003; Pang, 2010). These results are supported by Pang and Ling's (2012) study where students did better in a Learning Study lesson than in one prepared according to normal practice. Looked at as a whole, evidence suggests that Learning Study has a positive effect on student learning.

However, there is now an emerging body of evidence of the positive effects of Learning Study on teacher learning and professional development (e.g. Pang, 2006; Holmqvist, 2011; Pang & Ling, 2012). Indeed Lo et al. (2005) claim that some of the participant teachers in their 3 year Learning Study project exhibited 'remarkable professional growth' (Lo et al., 2005, p.57).

It is a fundamental assumption of PVT that learning occurs through the experience of variation in the critical features of a phenomenon. So what variation in teachers'

experience of Learning Study might help them to learn about teaching? Pang (2006) suggests the following:

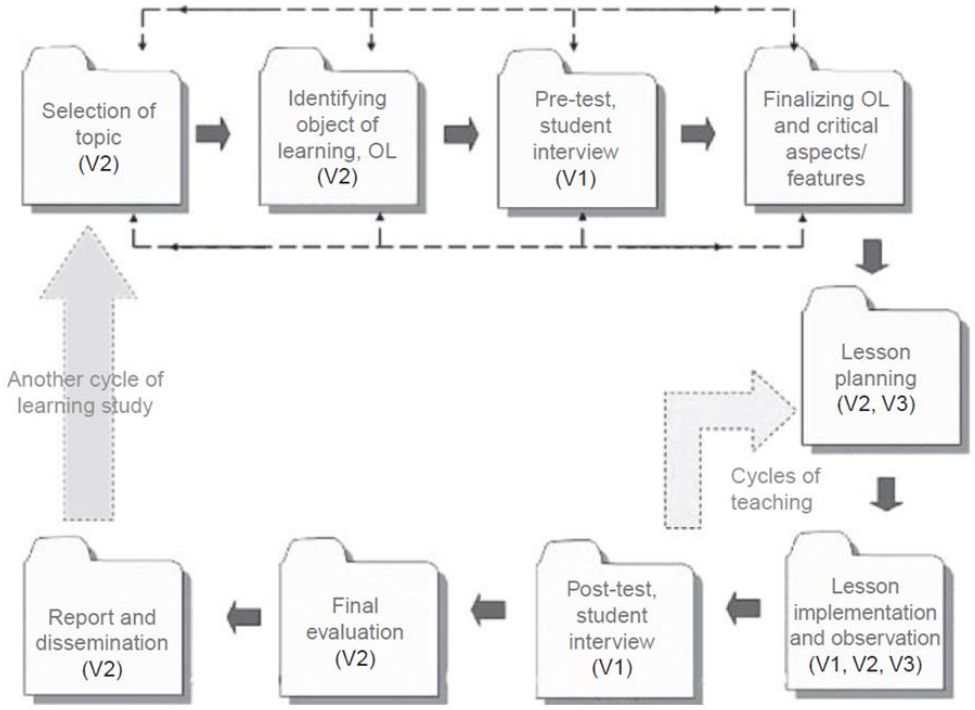
i. Variation between the intended and enacted object of learning – that is the difference between what teachers intended students to learn and what the activities that they designed actually allowed them to learn.

ii. Variation between the enacted and/or intended and lived object of learning – that is the difference between what teachers set out to do and/or what they actually do and what the students learnt.

iii. Variation between teachers' own ways of teaching and other teachers' ways of teaching – gained through mutual lesson observations.

Three related forms of variation that might be experienced by teachers were identified by Wong and Lo (2008). These are: i) variation in terms of students' understanding of what is to be taught, ii) variation in the teachers' ways of dealing with particular topics and, iii) variation as a guiding principle for pedagogical design. These are labelled V1, V2 and V3 respectively in Figure 4.2 below (Wong and Lo, 2008, p.21):

Figure 4.2 – Opportunities for variation in a Learning Study



All of the points identified above by Pang (2006) and Wong and Lo (2008) could be said to relate to the development of teachers' PCK (if PCK is defined in Shulman's terms as knowledge of 'instructional strategy' and knowledge of 'students' learning difficulties'). They might also contribute to the development of their CK. For example, through experiencing variation between different teachers' ways of seeing the object of learning.

All of the sources of variation outlined above could be present *within* the preparation and delivery of any single Learning Study lesson, or they could occur *between* Learning Study lessons (if these are taught on a number of occasions with refinements occurring at each stage). However, even in the highly unlikely event that all of the above sources of variation did not exist, there are two other ways in which teachers might experience variation. First, they can experience variation between their current and past experiences. As Marton et al. (2004) put it, 'variation that is not present in the situation can still be discerned … if variation is brought in by means of the learner's memory of previous experience' (p.21). This could help explain why learning can occur even in situations where variation does not appear to be present or is not consciously introduced by the teacher. Second, teachers can

experience variation between their current experience of Learning Study and previous Learning Studies into the same object of learning (if these exist).

Although there are many opportunities to experience variation in a Learning Study, teachers' exposure to variation is not managed in the same careful way as students' exposure to variation in a Learning Study. Students experience variation in Learning Study through a carefully phased introduction to clearly identified critical features of the intended object of learning. By contrast, for teachers in a Learning Study, whilst a researcher usually introduces Learning Study and acts as a point of reference during the process, studies do not report that researchers highlight or vary critical aspects of the phenomenon under consideration in the way that a classroom teacher would when enacting PVT. This could limit the effectiveness of Learning Study in teacher learning in two ways. First, teachers in the Learning Study group could experience 'too much' variation. This might cloud their emerging understanding of Learning Study. It might also cloud their emerging understanding of students' ways of seeing the object of learning. The existence of multiple types of variation (noted above) might serve to exacerbate this effect. Second, if researchers do introduce variation during a Learning Study (even if unconsciously) there is no guarantee that this variation will focus on the critical aspects of either Learning Study or the object

of learning. It is one of the key propositions of PVT that learning occurs through the experience of variation and that it is a teachers' role is to carefully manage that variation. It is not yet clear how this proposition applies to teacher learning in a Learning Study.

4.5. Evidence of teachers' learning in Learning Study

Research on teacher learning in Learning Study can broadly be divided into five strands related to: i) knowledge of the intended object of learning, ii) knowledge students' conceptions, iii) knowledge of PVT, iv) conceptions of teaching and learning and, v) Learning Study and BT learning.

Each of these is considered in turn in this section.

4.5.1. Knowledge of the intended object of learning

As indicated in Chapter 3, in this study, teacher's CK is defined as the awareness of the critical features of an object of learning (Marton & Pang, 2008). In one study exploring this, Holmqvist (2011) conducted three consecutive Learning Studies with the same group of teachers and measured the effects on student learning. She found

that student learning was greatest in the last Learning Study (although the differences between lessons were small). Using examples from observations of teacher preparation, she explained this in terms of teachers developing the ability to more accurately discern the critical features of an object of learning. For example, teachers abandoned their 'taken for granted' perspective on the intended object of learning adopted in the first Learning Study in favour of an approach that shows a deeper understanding of subject content. A possible weakness of this study is that variation in the object of learning across the three Learning Studies makes it difficult to compare teachers' awareness of critical features. This may have contributed towards the identification of only small gains to student learning in the later Learning Studies.

Kullberg (2011) addressed this issue by showing that critical features identified by teachers in one Learning Study can be productively used to enhance student learning in subsequent Learning Studies (by other teachers with different students). She provides evidence that if teachers are aware of more critical features, then student learning will improve. This supports the assertion that over time a 'cumulative development of insights' becomes possible (Pang & Marton, 2003, p.180). The focus of Kullberg's study was on whether teachers *could* use the knowledge outcomes of

other Learning Studies. As a result it did not seek to explain how teachers develop their understanding of critical features or how they might come to identify new critical features that might inform subsequent Learning Studies. Neither did it seek to identify the scale of changes in individual teacher understanding of critical features as a result of taking part in a Learning Study.

One common feature of the above studies, and others such as Pang and Ling (2012) and Olander and Holmqvuist-Olander (2013), is that student learning is measured in order to provide a perspective on teacher learning. Another common feature is that these studies do not apply the quasi-experimental approach to assessing the learning of either students or teachers in the manner undertaken by Pang and Marton (2003, 2005).

4.5.2. Knowledge of students' conceptions

Given the focus on student learning, it might be expected that Learning Study would increase teachers' awareness of ways in which students understand phenomena. This has been confirmed in a number of studies that have found evidence of teachers having an improved general orientation towards students' ways of looking at things.

Studies by Lo et al. (2005) and Pang and Ling (2012) give examples of teachers self-reporting of such advances. For example:

> *'Before, though I would wonder why they (students) could not understand, I would not try to follow up to find out….but now we would try to find out where students have difficulties and help them'* (Lo et al., 2005, p.58).

> *'I have taught for a number of years, and I have often thought that if I teach, students will learn. However, the test showed me that the students were not able to master what I had expected them to know'* (Pang and Ling, 2012, p.603).

Tan and Nashon (2013) applied a phenomenographic approach to establish teachers' conceptions of their own learning and reported similar findings (although they do not establish a hierarchy of conceptions against which to assess the extent of teacher learning). Other studies (e.g. Nilsson, 2014) provide specific examples of students' existing understandings in science education that were unfamiliar to teachers prior to the completion of Learning Study. Nilsson's (2014) study is important in that it provides a theoretical underpinning for the approach taken to PCK, conceptualising it in the same terms as Magnusson, Krajcik and Borko (1999). However, in general,

studies exploring the effects of Learning Study on PCK focus more on the theoretical underpinnings of PVT than on the theoretical underpinnings of PCK. This represents a missed opportunity since, as has been argued earlier, PCK (or at least significant aspects of it), can be conceptualised in terms of PVT.

4.5.3. Knowledge of variation theory

One of the aims of Learning Study is to help to develop teachers' understanding of variation theory (Pang, 2006). To date the evidence on this is mixed. Lo et al. (2005, p.62) report that 'relatively few' teachers (out of a sample of 49) recognised the benefits of identifying patterns of variation, whereas Pang and Linder (2012), based on the views of 7 teachers, present a more positive picture. One crucial factor seems to be the familiarity of teachers with the Learning Study approach. There is some evidence that the more Learning Studies that are completed, the more proficient teachers become (e.g. Pang and Ling 2012, Lo et al. 2005).

The research in this area might benefit from the application of the approach taken by Pang and Marton (2003). A study to identify conceptions of variation theory and the associated critical features would provide a basis for measuring teacher learning in relation to variation theory. It would also provide a basis for the way in which PVT

is introduced to teachers during Learning Study. As already indicated, this is an aspect of Learning Study that has not been described in great detail by researchers.

4.5.4. Teachers' conceptions of teaching and learning

One strand of research into teacher learning has set out to explore the effects of Learning Study on the quality of teachers' conceptions of teaching and learning. These studies have either focused on conceptions of teaching in general (e.g. Davies & Dunnill, 2008) or conceptions of teaching a particular subject (e.g. Pang, 2006). In Pang's (2006) study of 10 economics teachers, some evidence of improvements in the sophistication of their conceptions of teaching the subject was identified. Seven out of ten teachers exhibited either 'moderate' or 'great positive' change in their conceptions. They shifted their focus from the teacher towards the learner, from knowledge towards a way of understanding and from the school context to multiple contexts. These findings are consistent with those of Tan and Nashon (2013) who suggest that Learning Study may allow teachers to adopt a less transmission based pedagogy (Goodson, 1998).

All of these studies indicate that improvements in teachers' understanding can occur as a result of taking part in Learning Study. However, their limitation is that they do

not identify changes in teachers' understanding in relation to a particular topic in a particular subject domain.

4.5.5. BT learning in Learning Study

BT learning and Learning Study is an emerging area of research in which only a relatively small number of studies have taken place. In general however, the findings of these studies echo the findings outlined above in relation to experienced teachers, and present a positive picture of the effects of Learning Study on BTs' development.

Davies and Dunnill (2008) support Pang's (2006) findings that Learning Study increases the sophistication of teachers' conceptions of teaching and learning. Davies and Dunnill (2008) made use of Wood's (2000) description of the conceptions of teaching held by BTs, to demonstrate BTs' progress away from a transmission conception of teaching. Since all of these studies drew on the subject domain of economics/business studies, these results have a particular resonance in the context of the current study.

Van Bommel (2012) made use of the concept of Mathematical Knowledge for Teaching (MKT), as an object of learning, in order to analyse the effects of Learning Study on BTs' knowledge. MKT attempts to incorporate elements of both CK and PCK in an overarching description of BTs' knowledge. Van Bommel found evidence of positive effects on teacher trainers' teaching and BTs' learning in terms of their knowledge of five critical aspects of MKT. This was measured in terms of the connections made by BTs between critical aspects which were reported as becoming 'more relevant and more frequent' (Van Bommel, 2012, p.120). The study did not directly identify or make use of a hierarchy of conceptions in order to explore effects on BTs or their trainers. Neither did it employ a control group to act as a basis for comparison. However, the study did address a crucial limitation in the existing qualitative research in this area in providing a finer grained picture of what teachers learn in a Learning Study. Quantifying how much 'value' Learning Study adds opens the possibility to establish which teachers benefit from Learning Study and the extent to which they do so. This was identified as a priority for Learning Study research by Davies and Dunnill (2008).

Lai and Lo-Fu (2013) also made use the concept of Mathematical Knowledge for Teaching in their qualitative study of the learning journals of 32 BTs undertaking a

Learning Study. However, this study relies purely on self-reporting by BTs and does not provide any strong theoretical framework for the analysis of BTs' thinking. Although this study presents a positive picture of the benefits to BTs of Learning Study in terms of mathematical CK and PCK, the quality of these results is restricted by the way in which the data is analysed. A similar point can be made in relation to the study by Ko (2011).

By contrast, Cheng (2014) adopted a quantitative approach to analyse BT development during a Learning Study. Using a structural equation model based upon Grossman et al.'s (2009) framework of representation, decomposition and approximation of practice, the relationships between BTs' learning activities and outcomes in Learning Study were explored. Cheng's study is important because, unlike many other studies in this area, it adopts a quasi-experimental approach and draws on a large sample of BTs (n=341). Cheng (2014) provides statistical evidence that Grossman et al.'s (2009) three elements are present in Learning Study and work to mutually reinforce each other to support BTs' development. It was also found that BTs' knowledge of variation theory and its enactment was improved in Learning Study, supporting findings in relation to experienced teachers (see Section 4.5.3). A further interesting result of this study is that 'theory based tutorials' relating to

Learning Study were found to be the only predictive variable for all the learning outcomes that were measured. This suggests that this was the most important aspect of Learning Study for this group of BTs. This echoes the findings of Davies and Dunnill (2008) and others in relation to Lesson Study (e.g. Parks, 2008) that have highlighted the importance of appropriate support being provided to BTs during the Learning Study process. However, a significant limitation of Cheng's study is that it relies entirely on data from BTs' self-reporting. It cannot be said with great confidence that BTs' perceived learning outcomes necessarily represented their actual learning outcomes.

4.6. Conclusion

This chapter has explained how Learning Study grew out of Lesson Study. Lesson Study provided a model for teacher collaboration focused around the preparation and repeated testing of 'live' lessons. Learning Study added to this by drawing from Design Research a focus on more formal experimentation and on the use of theory to provide a tighter framework for interpreting student learning and evaluating it. This chapter has shown how this broad approach has been implemented in a number of different ways, but that these do cohere around a set of common principles (see Section 4.3.2).

Lesson Study is commonly accepted to place more of an emphasis on teacher learning and the professional development of teachers, in comparison to Learning Study that focuses more on student learning (Cheung & Wong, 2014). Given this focus, it is perhaps not surprising that research into the effects of Learning Study on teachers is still an emerging area of research. However, this chapter has shown how Learning Study can make teacher learning possible in a way consistent with the principles of variation theory, since it contains the mechanisms to ensure teachers are exposed to variation in a number of different ways. That Learning Study can be of benefit to teachers has been indicated in Section 4.5 where some of the conclusions of the growing body of evidence in relation to this were summarised.

This study aims to add to existing evidence about teacher learning in Learning Study in terms of teachers' understanding of the object of learning (defined as their Content Knowledge) and their understanding of students understanding of that object (defined as their Pedagogical Content Knowledge). Since the focus is an evaluation of the benefits of the Learning Study approach as a whole, the study draws heavily on the quasi-experimental approach to the evaluation of Learning Study originally undertaken by Pang and Marton (2003) and developed further in their 2005 study.

These studies placed a great emphasis on a comparison between the sophistication of students' conceptual understanding before and after a Learning Study intervention and between students who were exposed to Learning Study and students who were not. This study applies the same approach to teachers. In doing this, it aims to measure teacher learning directly, in the same terms as applied to students. This will contribute a new perspective on *what* and *how much* learning occurs for teachers in Learning Study.

5. METHOD

5.1. Introduction

The central question in this study is: what are the effects of Learning Study on BTs' CK and PCK? This is an important issue to consider when assessing the efficacy of Learning Study as an approach to teacher development in general and BT development in particular. Addressing the main research question also involves asking:

i. How can BTs' CK and PCK be described?

ii. What is the level of BTs' CK and PCK?

iii. What are the associations between BTs' CK and PCK?

In order to answer these questions, this study uses the principles underpinning Learning Study to direct the research design and the choice of research methods. This offers good theoretical consistency since the study evaluates Learning Study using an approach that is integral to Learning Study itself. It also allows the study to draw heavily upon previous key studies in the field into Learning Study and student learning (e.g. Pang & Marton, 2003, 2005). In doing this, the study aims to add to the emerging body of research into Learning Study and BTs' learning.

Since Learning Study is explicitly built on Lesson Study, the chapter begins by explaining the methodology that underpins Lesson Study – namely Action Research (AR). Learning Study claims to build on Lesson Study by combining it with another research approach known as Design Research (DR) (Pang & Marton, 2003). The nature of this combination is described in various ways – as a 'hybrid' (Cheung & Wong, 2014), as a 'reformulation' of Lesson Study 'in the spirit' of DR (Lo et al., 2005, p.192), or as an approach that is 'inspired' by idea of DR (Pang & Marton, 2003, p.178). The relationship between Learning Study and DR forms the focus of the next section of the chapter. Following from this, some criticisms of AR and DR will be discussed, along with possible ways of addressing these criticisms. This is important given that the methodology in this study will draw heavily on that in Learning Study (and by implication therefore on AR and DR).

The rest of the chapter is devoted to an outline of the method used in this study. This includes a description of how the main constructs of CK and PCK are to be measured, how the sample and intervention groups are to be organised, how the Learning Study intervention is to be structured and how the data produced is to be

analysed. Finally a brief explanation of the ethical aspects of the research is provided.

5.2. Lesson Study and Action Research

In line with other interpretivist approaches to education research, AR: i) aims to increase understanding of teaching and learning from the practitioners' perspective and, ii) is built on the assumption that knowledge about teaching and learning can be constructed in situ (Borko, Liston & Whitcomb, 2007). However, AR is distinctive in that it is carried out *by* those in a particular context and not *to* them (Cochran-Smith & Lytle, 2004). It entails examining practice from the 'inside' (largely through the eyes of the practitioners in that context) as opposed to examining it from the 'outside' (largely through the eyes of an outside party – usually a researcher). Since Lesson Study involves teachers in adopting the dual role of practitioner and researcher, it fits well with these principles. This is the reason Lesson Study is frequently described as being a form of AR (e.g. Pang & Ling, 2011; Marton & Ling, 2011; Elliott, 2012). In a Lesson Study, the site for research is a real live classroom in which teachers enact 'research lessons' with students and then gather and analyse evidence of their effectiveness (see Chapter 4).

As in other forms of AR in which practitioners document their reflections in addition to gathering evidence, teachers in a Lesson Study can make a comparison between their thoughts and intentions and an analysis of student learning in ways that are not easily accessible to researchers that are not 'living' in the context of practice (Cochran-Smith & Lytle, 2004). This can allow researchers in an AR project to combine theory generation (theory being defined as ways of predicting or explaining situations) with researcher intervention, in exciting ways (Susman, 1983; Sein, Purao, Rossi & Lindgren, 2011). AR seeks to go beyond the notion that 'theory' can inform practice, to the idea that practice can generate 'theory' which in turn can then inform practice and so on (Brydon-Miller, Greenwood & Maguire, 2003).

This approach is embodied in Lesson Study, and in AR more generally, in the adoption of a cyclical model of research (Rapaport, 1970). AR typically involves a 'self-reflective spiral of cycles of planning, acting, observing and reflecting' (Carr & Kemmis, 2003, p.162) in much the same way as Lesson Study (see Figure 4.1). The primary purpose of these cycles is to generate knowledge that helps practitioners understand and improve practice within a local context. This is motivated by an assumption that 'one size fits all' approaches to 'what works' will not be applicable in most classroom settings and that teachers must therefore develop their own

practice in context if they are to be successful. By implication, proponents of AR do not see reality (in the classroom) in terms of 'hard, tangible and relatively immutable structures' (Burrell & Morgan, 1978, p.56), but as social constructs that it is the function of AR to evaluate and change. This has led some researchers to describe the ontology of AR as being anti-realist (Iivari & Venable, 2009). Given that its focus is the refinement of lessons, change is at the heart of Lesson Study and therefore it too might be said to fit this description.

AR benefits from a highly context dependent approach in that it avoids the difficulties inherent in having to adapt knowledge generated by outside researchers to local conditions. However, although each AR project might be thought of as unique and only understandable by those that are directly involved in it, proponents of AR often argue that the outcomes of AR might also prove useful beyond local contexts (Borko et al., 2007; Jarvinen, 2007). This has led some to characterise the epistemological stance of AR as being *mainly* anti-positivist (Iivari & Venable, 2009) in that results may be in *some way* generalizable. This position is echoed in Lesson Study. Teachers work on refining their own understanding and practice in a particular school context but then share and disseminate their results with other teachers in the same school or other schools perhaps through seminars or published

materials (Yoshida, 1999). The implicit assumption is that the outcomes of Lesson Study can be of benefit to those who are not directly involved in it. The description of AR as producing 'knowledge to guide practice in modification' (Jarvinen, 2007, p.40) might be equally well applied to Lesson Study.

Advocates of AR conceive of educational action as social action. Therefore, AR seeks to understand the perspectives of all those involved in or affected by an educational action. As a result, it naturally tends to lead to the adoption of collaborative approaches to research. AR identifies the 'conditions for investigating the truth of knowledge-claims' with the 'conditions for democratic participation in critical discussion' (Carr & Kemis, 1986, p.199). It is common amongst AR researchers to emphasise the empowering effects of this participation. One strand of AR, which is sometimes referred to as 'emancipatory' AR, interprets this in political terms focusing on a broad agenda of effecting political change in order to more towards a more just, egalitarian society (e.g. Grundy, 1987). Another strand of AR interprets it in terms of the improvement of professional practice within a local context in order to achieve professional autonomy and control over one's own working life. This is sometimes referred to as 'practical' AR (Grundy, 1987). Whilst some researchers in Lesson Study seem to borrow from 'practical' AR and focus on individual

professional development (e.g. Lewis, 2009), others write about Lesson Study in more 'emancipatory' terms. Lieberman (2009) for example, points to the potential of Lesson Study to break the norms of presentism and conservatism in teaching through the creation of communities of practice.

A common feature of AR is its reliance on outside facilitators to trigger the research process. Such facilitators are necessary because the organisation of education and of schools does not naturally foster the spontaneous formation of groups of teachers working towards their own empowerment (Carr & Kemis, 1986). Facilitators might in addition, perform a wide variety of 'process consultancy' functions during the AR process including: i) helping participants articulate their own concerns, ii) planning strategic change for action, iii) monitoring the problems and the effects of change and, iv) reflecting on the value and consequences of change (Carr & Kemis, 1986). This is very similar to the role undertaken by researcher facilitators in Lesson Study. In both AR and Lesson Study, facilitators are careful not to impose their authority about what is and is not valid in relation to the content of the study. They try to ensure that that criteria are not 'imported' but emerge authentically from the self-reflection of practitioners. This places considerable demands on the skills of the facilitator in maintaining a neutral stance. As indicated in Chapter 4, it also creates

challenges for teachers in a Lesson Study in deciding on the critical features of 'good' teaching and learning.

Proponents of AR and Lesson Study suggest that the participants in the research need to be able to pick their own research methods since they have the best knowledge of the problem to be addressed. As a result, AR can make use of the full gamut of techniques. Some have suggested that this could include quantitative techniques and experimental designs (e.g. Cohen & Axelrod, 2000). Since the focus of Lesson Study is the teaching of a particular topic in a lesson, a narrower range of mainly qualitative sources of data are used that includes video of lessons, observational notes from lessons, analysis of student work and transcripts of meetings. Although Lesson Study does not explicitly preclude the use of quantitative techniques or experimental designs, advocates of Lesson Study are cautious about the implication that quantitative methods imply generalisability.

5.3. Learning Study and Design Research

5.3.1. What is Design Research?

Simon (1969) drew a distinction between natural science and artificial (or design) science. Natural sciences such as physics, biology or chemistry attempt to explain phenomena in the world. Design sciences such as architecture, computer science or medicine, attempt to discover how designed artifacts interact with their environment in order to achieve some practical objective. Their aim is to understand how these artifacts work with a view to optimising their performance.

In education, DR aims to establish what works in practice by systematically developing, reviewing and revising instructional strategies and other forms of educational intervention (Borko et al., 2007). The aim is to 'engineer' artifacts in education (such as a lesson) by putting a design into the world, testing it and ironing out the bugs (Collins, Joseph & Bielacyzyc, 2004). In doing this, DR sets out to achieve a greater understanding of the highly complex, dynamic and interrelated 'learning ecologies' (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003) that characterise real live teaching and learning situations. DR simultaneously develops theories about how such learning ecologies operate whilst proposing ways of organising them (or designs) that promote learning. The aim of DR is to enhance

both theory (the understanding of how students learn) and practice (the understanding of what actions help students learn) simultaneously (Borko et al., 2007). It has therefore been described as being both theory driven and utility orientated (Cobb et al., 2003).

DR in education focuses on a progressive refinement of instructional strategies (Collins et al., 2004) through an iterative process based upon consecutive design-analysis-redesign cycles (Shavelson, Phillips, Towne & Feuer, 2003). It draws on previous research to trigger this process of invention and revision (Cobb et al., 2003). During each cycle, evidence is systematically collected in real educational settings and the results analysed in order to establish whether the designs (and the theories that underpin them) are successful or not. New refined designs are then developed as a result. Since it traces the effects of an instructional strategy on the learning of students over time, DR is process focused.

By definition, DR is conducted in context, focusing on testing particular interventions in particular circumstances. It is normally multileveled (Cobb et al., 2003), in linking instructional strategies to the wider educational context. Given this, it is natural that it would involve teachers as well as researchers in a collaborative effort (Borko, 2007).

The researchers bring knowledge of the DR process and an understanding of previous DR to the collaboration, whilst practitioners bring local knowledge and hands on, current, teaching experience.

The success of DR depends on the skills and commitment of both teachers and researchers. In particular, a deep understanding of the educational setting within which the DR takes place is critical for the success of any research. However, other characteristics are likely to be essential. High level teaching skills will be needed to ensure that the enactment of any design is as close as possible to the way that was intended. Excellent research skills will be required in order to analyse learning ecologies and develop theory. In addition, the success of DR depends more heavily that other forms of research – such as experimentation - on the researcher's skills in working collaboratively with teachers. DR is likely to take place over extended periods of time and good relationships will need to be sustained over that time. Researchers will also need to be alive to the significance of 'subtle and often unanticipated cues' (Cobb et al., 2003, p.12) that arise during the design and review process and relate them to the overarching themes of the research.

The first stage in conducting a design experiment is to decide the theoretical intention of the study. The broad aim of DR is to relate successive patterns of student thinking to the means by which the development of those patterns is or is not supported (Cobb et al., 2003). The research team will then undertake background work by gathering data about the current educational setting. This will include knowledge of current practice and knowledge of students' capabilities. The team will also review previous research in the area. Both of these aspects will be crucial in developing and testing the design to be enacted.

Since it involves a number of cycles of development and progressive refinement, one of the distinctive characteristics of DR is that the research team will develop their understanding during the research as well as after it (Cobb et al., 2003). The team will therefore conduct both ongoing and retrospective analyses. In order to support this, they will need to keep thorough records of the design process as well as collect evidence of learning outcomes and processes (Borko et al., 2007). In practice, this usually involves collecting a wide variety of data (both qualitative and quantitative) from multiple sources. This allows evidence to be triangulated, which, given the context dependent nature of DR and the complexities of that context (and often of the design itself), can be very important in helping to validate the claims of any research.

5.3.2. The difference between DR and AR

The differences between DR and AR have been a particular focus for debate in Information Systems research. In this discipline, some researchers have emphasised the similarities between the two approaches (e.g. Loebbecke & Powell, 2009), whilst others have emphasised the differences (e.g. Iavari & Venable, 2009). Still others have focused on combining AR and DR in some way (e.g. Sein et al., 2011). At the very least, all these studies suggest that there is a significant overlap between AR and DR. Jarvinen (2007), for example, describes 7 features of AR and finds a very close analogue to each of them in DR. These are: i) an emphasis on the utility aspect of future systems, ii) the production of knowledge to guide practice in modification, iii) the combining of action taking and evaluation of actions, iv) the collaborative relationship between action researcher and client system, v) the modification of an existing system, vi) the intervention by a researcher in problem setting and, vii) the generation and modification of knowledge during the course of a project (Jarvinen, 2007). It is notable that these features provide an apt characterisation of both Lesson Study and Learning Study.

Some of the differences that have been identified between AR and DR seem to depend on the conceptions that researchers have of either AR or DR. Thus, for example, the claim by Iivari and Venable (2009) that DR may have a more critical orientation because it is more focused on constructing new ways to solve problems than AR seems to ignore the emancipatory strand of AR, where the purpose is explicitly to challenge existing power structures.

Perhaps the major basis for arguing for a difference is that DR is a research *orientation* (within which various research methods might be used – including AR) whilst AR is a research *method* (Iivari & Venable, 2009). This interpretation of DR seems to hinge on a distinction being made between the basic research undertaken when building a 'design' (during which AR might play no part) and the applied research undertaken as part of an evaluation of it (where AR might play a part). This distinction is represented in the sequence in which research is undertaken, where first an artifact or design is developed and then it is put into an organisational or operational context to test it.

This difference between AR and DR may also be seen in epistemological terms. Whilst AR can be thought of as anti-positivistic, researchers have described DR as

being either positivistic *or* anti-positivistic (Niehaves, 2007; Iivari & Venable, 2009). Niehaves (2007) points to research by Hevner, March, Park and Suddha (2004) and McKay and Marshall (2005), and finds evidence of a positivistic approach in the mathematical formalisms and experimental designs that are used and the approach taken to the relationship between research and practice. This may be particularly true of DR in such subject domains as engineering (Iivari & Venable, 2009). By contrast, other researchers have developed the notion of 'soft design science' (Baskerville, 2007) which, as it seeks to test designs in situ, seems much more akin to the anti-positivistic focus of AR. These two broad approaches will be referred to as 'hard' and 'soft' DR.

5.4. Criticisms of AR and DR

AR and DR have been subject to a range of criticisms. According to some researchers, AR lacks scientific rigour and is unable to produce valid data or allow explanations of causal connections to be safely made (Baserkville & Wood-Harper, 1996). One cause of this is the problem of ensuring that practitioners can act impartially without bias in their dual roles as researcher and practitioner (Huberman, 1996; Barab & Squire, 2004). Both AR and 'softer' versions of DR have been criticised for the difficulty in generalising results from what can be interpreted

as purely narrative descriptions of the local context that forego experimental controls (McKay & Marshall, 2001; Shavelson et al., 2003; Kelly, 2004). This problem is compounded by difficulties in drawing those generalisations from the relatively small number of subjects that are involved in many forms of DR and AR. This means that AR and DR could be criticised for lacking 'the sampling and descriptive power of a survey' (Kelly, 2004, p.120). It has also been suggested that 'soft' DR lacks an underpinning rationale that can be clearly separated from 'process descriptions' (Kelly, 2004). The thrust of this argument is that DR tends to be described in terms of its features (such as iterative, multi-levelled, collaborative etc.) rather than in terms of underlying principles or methodological concepts. The absence of a clearly articulated rationale it is claimed, means that DR might struggle to help distinguish between sound and unsound claims. To put this another way, AR and DR might be good at describing how to collect evidence but they are less good at specifying how to interpret it (Winter, 1982). This is a criticism that might also be applied to Lesson Study (and possibly AR) and echoes Pang and Marton's critique of that approach.

Given that it implicitly builds on AR and explicitly builds on DR, it is important to ask to what extent the above criticisms apply to Learning Study and if they do, how they might be addressed. One central question is whether advocates of Learning

Study claim that outcomes are generalizable. Criticising Learning Study (and by implication AR and 'soft' DR) for not producing generalizable results is inappropriate if it does not make such claims. The next section examines this issue and the way in which Learning Study incorporates aspects of AR and DR.

5.5. Applying AR and DR in Learning Study

Learning Study is said to have been 'inspired by' Lesson Study and DR (Pang & Marton, 2003). Since Lesson Study has been demonstrated to be a form of AR, Learning Study can be said to represent a way in which AR and DR can be combined. One way in which Learning Study draws on DR is in the conception of the lesson as a 'design'. Lesson Study may contain this implicit assumption but DR renders it more explicit. On this view, a lesson would be analogous to a computer programme or a manufactured product, for example. It can be seen as a self-contained entity that is amenable to rational development. This conception of a lesson is consistent with Pang and Marton's (2003) assertion that 'pedagogical rationality is a good thing' (Pang & Marton, 2003, p.180).

Pang and Marton (2003) explicitly refer to DR as being distinct from Lesson Study in two ways. First, they claim that Lesson Study cannot be thought of as systematic

research (even though the results might be documented and shared), because theory does not seem to be a 'defining feature' of the approach (Pang & Marton, 2003, p.178). They present DR as a solution to this issue because it is intended to be 'theory-based and to have its results systematically evaluated' (Pang & Marton, 2003, p.178). The theory that is commonly proposed is PVT.

Secondly, Pang and Marton (2003) place great emphasise on the benefits of the experimental methods that they see as being an integral part of DR. They say that although it is difficult to control variables in a complex system such as a classroom, 'designing experiments in education……is nevertheless worthwhile' (Pang & Marton, 2003, p.178). They go on to argue that design experiments can 'articulate the principles of organising the learning environment' and that 'although we should be cautious when making general claims based on limited observations, these generated principles can become the hypotheses and explanatory principles for research' (Pang & Marton, 2003, p.179).

Pang and Marton's (2003) emphasis on the importance of experimental design seems to reflect a positivist, 'hard' conception of DR. This manifests itself in a comparison between pre and post-tests of students in order to assess the success of a particular

lesson design. However, crucially, Pang and Marton do not propose that pure research would be conducted in isolation and then tested in practice. They do not seem to be distinguishing between a 'build' and an 'applied' research phase as suggested by some proponents of DR. Rather, the idea behind Learning Study is that the effectiveness of a lesson can be tested by the participants in the research conducting an experiment in a fairly traditional way, in context. Pang and Marton (2003) emphasise the possibilities of multiple Learning Studies in the same subject domain contributing towards the development of a 'collective consciousness' (Pang & Marton, 2003, p.180). In other words, the assumption is that the 'results' of Learning Study experiments are to some degree generalizable and are not entirely context dependent. This is a position made explicit by Kullberg (2011) who has provided evidence that critical features identified by teachers in one Learning Study can be productively used to enhance student learning in subsequent Learning Studies by other teachers with different students.

In practice, as explained in Chapter 4, two versions of Learning Study have emerged. There are those that follow Pang and Marton (2003) and involve pre and post-tests that are based upon a phenomenographic analysis of possible conceptions of a phenomenon and a categorisation of actual students' responses using those

conceptions. Following Pang and Marton (2005), such studies are characterised by the inclusion of a control group as a point of comparison. The other strand of research in Learning Study has also involved a comparison of pre and post-tests but these studies either do not make use of phenomenographic categories of description or do not involve a control group.

5.6. Challenges for Learning Study

Learning Study (in the form described by Pang and Marton, 2003) seems to aim to draw on both a positivistic interpretation of DR (indicated by a focus on experimentation) and the anti-positivism of AR (indicated in the way in which it organises research) in order to 'combine the instrumental and theory-oriented functions of research activities' (Pang & Marton, 2003, p.179). This sets up some tensions. On the one hand AR seems to offer Learning Study a solution to the difficulties in adequately explaining actions and their consequence according to the positivist criteria of a scientific explanation (Susman and Evered, 1978). On the other hand, AR and 'soft' DR, do not seem to be 'scientific' enough, and therefore an inclusion of experimental designs becomes vital.

The evaluation of lessons in Learning Studies relies on the comparison of evidence gained from pre and post-tests. In line with other experimental approaches to education research, there are a number of weaknesses with this. First, there is the possibility that students may have learned simply as a result of repeating pre and post-tests. This is a particular risk if identical tests are used in pre and post-tests (as they frequently are in Learning Study). Alternatively, any apparent improvement in student learning observed after a Learning Study lesson might be as a result of students responding positively to the 'energising' effects of being the subjects of research. Students might also be responding to the impact of such effects on their teachers. This is likely to be a particular problem for Learning Study given the sense of ownership and the considerable investment of time and energy that teachers must make in the design and enactment of Learning Study lessons.

However, even if differences between pre and post-test results were assumed to be the result of Learning Study, it can be difficult to identify exactly which aspects of the Learning Study lesson were critical. This is because of the degree of complexity present in any classroom situation. This is particularly true, if as complexity theory (e.g. Cohen & Axelrod, 2000) suggests: i) very small changes in classrooms can often

produce significant and unpredictable outcomes and, ii) similar classroom conditions can produce highly dissimilar outcomes.

These difficulties are likely to be more significant for Learning Studies that do not make use of a control group as a point of comparison. In these studies it is more difficult to attribute any learning that may have taken place to the Learning Study intervention. The best that be concluded is that a particular group of students exposed to a Learning Study lesson have or have not made progress in terms of their conceptual understanding. It cannot be said with any certainty whether or not those students would or would not have made similar progress given another approach to teaching.

However, there are challenges for Learning Studies that have made use of control groups. This is because they are usually designed as quasi-experiments, rather than as Randomised Controlled Trials (RCTs). The argument for randomisation is that although individual participants in research might all be said to be different, those differences can be ironed out at a group level if participants are randomly assigned to experimental or control groups. In other words, if the differences can be spread equally across both groups, a more meaningful comparison between them is then

possible. This is seen by some as an 'elegant' solution to a key difficulty in ensuring valid conclusions about interventions can be drawn amongst diverse populations (Torgeson & Torgeson, 2001). Some researchers have noted a significant absence of what they describe as well controlled trials in Learning Study, and have called for more to be done (Cheung & Wong, 2014).

One critical requirement of RCTs however is a large enough sample size to ensure statistical power. This can be tricky in Learning Study because the natural focus is a single phenomenon taught across a small number of lessons where there are generally only a relatively small number of students involved.

One way to address the difficulty in Learning Study is adopt an approach similar to the Cochrane Collaboration in evidence based medicine. This involves the aggregation of small scale RCTs through a meta-analysis, resulting in a combined body of evidence. This bears some relationship to the model proposed by Pang and Marton (2003) concerning the development of a 'collective consciousness' (Pang & Marton, 2003, p.180). Some advocates of RCTs argue that the approach is particularly appropriate for education research as there is a considerable amount of data already in existence (Torgeson & Torgeson, 2001). Unfortunately, this is not the

case in relation to Learning Study, since: i) data on student conceptions is not routinely collected, ii) the number of studies of any particular phenomenon is currently limited (particularly as a result of the resource demand of Lesson/Learning Study and, iii) gaining access to the data that does exist may be problematic.

Another possible difficulty with scaling Learning Study or aggregating different Learning Studies is variation in the enactment of Learning Study. In their description of Learning Study, Pang and Marton (2003) allow teachers to implement lessons according to their own style and with any modifications they deem necessary. Whilst important in ensuring ownership of the Learning Study process and allowing teachers to adapt their teaching to local conditions, this raises an important question about how different Learning Studies can contribute to the accumulation of a single body of knowledge in relation to a particular phenomenon.

The 'closeness' of the different iterations of a lesson is something that might be particularly hard to achieve *between* different Learning Study cycles taking place in different contexts with different people. For example, how can Learning Studies be compared if one has delimited the phenomenon underpinning a study in a different way to another, or if one Learning Study is 'good' quality (perhaps because the

teachers involved possess a good understanding of PVT) whilst another is 'bad' (because they possess a poor understanding of PVT)? The 'closeness' of iterations *within* a single Learning Study cycle is not guaranteed either. Ceteris paribus, the more times a lesson can be tested in action, the more successfully it can be refined and the more it can be thoroughly understood. However, given the complexity involved in the design and teaching of lessons, it could be the case that the greater the number of iterations, the more opportunity there could be for significant variation to emerge. Whether successive iterations would turn out to be 'convergent' or 'divergent' might depend on a number of factors, including the way in which teachers CK and PCK develop, group dynamics and the skills of the researchers involved.

If the issues of uniformity can be addressed, a question arises as to the basis for the organisation of the control group. A small number of studies have compared Lesson Study and Learning Study (e.g. Pang & Marton, 2003) in order to explore the benefits of PVT. However, there have only been a very few studies (e.g. Pang and Ling, 2012) that have been conducted comparing Learning Study with more routine methods of teaching. This is important in order to establish the benefits of Learning Study in the

context of other approaches to teaching (and teacher development) beyond Lesson Study.

A further question concerns the way in which data about student learning in Learning Study has been presented in previous studies. One common pattern is to set out the percentage of students falling within each level of conception (e.g. Pang & Marton, 2003) or producing a particular type of answer (e.g. Andrew, 2012). Any increase in the percentage of students showing more sophisticated conceptions or correct answers is interpreted as indicating the benefits of the Learning Study intervention. In presenting data at a group rather than at an individual student level, these studies give the impression that all students' understanding moved in the same direction. It is possible that this might not have been the case. Presenting data at the individual student level would add to understanding about the nature of changes in conceptions, as well as giving some idea about the reliability of the tools used to measure those conceptions.

It is a fundamental assumption of Learning Study that teachers must be able to alternate between working as researchers and/or theorists and working as practitioners (or at the very least be aware of when they are acting as one or the

other). The priority given to PVT in Learning Study is likely to help with this since it offers not only a theoretical framework for the analysis of teaching and learning that is already at a distance from practice, but it also offers a research methodology in which teachers must be involved. One implication of this however, is that the better teachers' knowledge of PVT and its application, the better the resultant Learning Study lesson will be.

Teachers new to Learning Study are usually introduced to PVT by researchers. As teachers build their understanding of PVT, researchers can provide further clarification of the theory, should it be needed. Previous reports of Learning Study do not provide significant detail about what the way in which PVT is presented to teachers or the way in which such guidance is offered. It is perhaps ironic that an approach so carefully focused on a forensic analysis of student learning should neglect to specify the ways in which teachers might learn about PVT.

Those Learning Studies that do not make use of PVT in the pre and post-testing process seem to be missing a golden opportunity. PVT simultaneously offers a way of defining student learning, a methodology for gathering appropriate evidence in relation to it and a way of measuring it. This is not simply a matter of ensuring

greater theoretical consistency across Learning Study (although it is that), it is a matter of utility too. For a start, using PVT removes the need to justify or validate an alternative testing regime. More importantly however, in identifying variation in students' conceptions through phenomenographic research it is likely to be easier to more accurately identify the critical features associated with those differences. Since Learning Studies make use of variation in critical features to promote learning, an opportunity to arrive more easily at these should both speed up the process and result in better quality Learning Study lessons.

Finally, Pang and Marton's (2003) characterisation of Lesson Study, and by implication AR, as being necessarily light on theory would be challenged by many proponents of AR. There may be better and worse examples of AR (and indeed of Lesson Study) but McKay and Marshall (2001) contend that AR without theory is not research. One key issue is what stage theory comes in to the AR research process. Some argue that in areas that have not been previously well researched, too early a move to established theory the AR process may limit possibility (Heller, 1993). Most AR researchers, however, support the view that reference to theory at some stage is vital in delineating the scope of data collection and analysis and ensuring that the

research is relevant to the wider community beyond a particular client's interests (Davison, Martinsons & Kock, 2004).

5.7. Addressing challenges in Learning Study

This section explores how the challenges identified in the previous section can be addressed through: i) the adoption of an epistemological stance that draws together the objective and the subjective, ii) the systematic nature of the iterative cycles involved in Learning Study and, iii) the design of the current study.

5.7.1. The epistemological stance of Learning Study

Although a positivist approach is appealing because of its promise of offering value free, 'scientific' conclusions, closer examination reveals that the claims for objective knowledge production may not be secure (Susman & Evered, 1978). In addition there may be significant practical difficulties in accurately capturing the context dependence and incredible complexity inherent in educational settings (Berliner, 2002). These difficulties could help provide an explanation as to why education research has not successfully delivered practical solutions to problems in education in the way in which it might be expected (Carr & Kemmis, 2002). One possible

reaction to this line of thought is that educational research is a relatively immature field and that it has yet to develop methods that are effective at identifying patterns in the enormous complexity present in any given educational setting. However, it could also be due to the inappropriateness of the positivist model of science for many aspects of educational research.

As has been shown, approaches such as AR are constituted on a different basis to a traditional experimentation model of research. Whereas 'conventional researchers might focus on objectivity, distance and controls, action researchers focus on relevance, social change and validity tested in action by the most at risk stakeholders' (Brydon-Miller et al., 2009, p.17). This last point is crucial. It is possible that AR and DR might produce results that are more valid than those coming from more traditional scientific approaches because of the way in which they combine expert research knowledge and local knowledge whilst ensuring that the interpretation of results and the design of actions involves those in the best position to understand them (Anderson & Shattuck, 2012). If this is true then the question of the epistemological basis of alternatives such as AR arises.

Carr and Kemmis (2002) provide a powerful solution in their formulation of teaching as praxis. They suggest that researchers adopt a dialectical view of rationality that stands astride the objective and the subjective and alternate between the two. This would be distinct from positivists (who would tend to focus on the objective) and interpretivists (who would tend to focus on the subjective). The suggestion is that researchers would thus avoid the determinism and physicalism of the former and the relativism and rationalist theory of action of the latter in recognising the importance of both (Carr & Kemmis, 2002).

Conceptualising research in these broad terms offers a good way of linking retrospective understanding of an educational situation with prospective action in comparison to other approaches. For instance, a positivist would rely heavily on prediction based on controlled experiments undertaken in the past in order to guide future action. This runs the risk of not accounting for local conditions. By contrast, an interpretivist relies on practical judgements based on practitioner observations of previous situations. This runs the risk of placing too much emphasis on the role of practitioners' ideas in guiding actions. A dialectical view of education research on the other hand involves looking forward and looking backward during a carefully

designed programme of self-reflective spirals, the purpose of which is not simply to understand an existing situation but rather to improve it (Carr & Kemmis, 2002).

There is a strong parallel between this perspective and the 'knowledge of practice' conception of teacher learning developed by Cochran-Smith and Lytle (2004). Knowledge of practice involves practitioners using both the knowledge that they develop in practice and the knowledge they draw from others. In this way knowledge *of* practice is a combination of knowledge *in* practice and knowledge *for* practice. As such, it breaks down the dualist stance that distinguishes between knowledge that is formal and knowledge that is practical. Cochran-Smith and Lytle's (2004) idea of 'inquiry as stance' is intended to capture the sense that teacher learning is mainly about forming, reviewing and then re-forming frameworks for understanding practice. Such frameworks might be referred to as 'theory'. Therefore, developing knowledge of practice does not involve either 'putting theory into practice' or realising that a 'theory' is simply not practical in a given context, it is about both. Unfortunately without a clear definition of what 'theory' is it extremely difficult to apply a 'knowledge in practice' perspective. The strength of Learning Study is that it can offer a theory on which to base an understanding of knowledge in practice.

Both sets of ideas outlined above are consistent with the approach taken in Learning Study. To an extent their dualism also mirrors the relational stance adopted by PVT in its attempt to be both scientifically rigorous and authentic (see Chapter 2).

5.7.2. The iterative research cycles in Learning Study

Some researchers have argued that in DR, 'successive iterations …. play a role similar to that of systematic variation in experiment' (Cobb et al., 2003, p.9). Successive iterations of the design would allow the understanding of the mechanism by which the design works to be advanced (Shavelson et al., 2003). In other words, an iterative research approach can be seen as a compressed version of the cycles in more traditional research, where findings of one study are scrutinised and form the basis for further studies and so on. This argument has also been used in relation to Lesson Study (Dudley, 2013), Learning Study (Pang & Ling, 2012) and AR (Cochran-Smith & Donnell, 2006). It places emphasis on the gradual accumulation of evidence over the long time ahead of the requirement for large scale studies (such as RCTs) in the short term.

This argument rests crucially on there being a good degree of similarity between different iterations of the lesson in order to avoid the 'fatal mutations' identified by Brown (1992). According to Pang and Marton (2003), this problem is addressed in Learning Study by the introduction of PVT. Their point is that PVT can have a standardising effect on Learning Studies through its consistent focus on identifying (through established phenomenographic research techniques) and systematically varying (through the application of variation theory) critical features of a phenomenon. Of course, there may still be differences in the interpretation and enactment of PVT (see Section 4.3.2 for examples), but applying the theory significantly increases the chances of coherence and consistency being achieved. This is particularly true in comparison to Lesson Study, where a similar difficulty has been identified by some researchers. Lewis et al. (2009) for example, simultaneously point to the need for more 'reliable, predictive measures' (Lewis et al., 2009, p.300) of the effects of Lesson Study, whilst recognising the difficulty in doing this if teachers are left to decide just what it is that should be tested (as is the case in Lesson Study).

The argument that a greater number of research cycles is beneficial rests on the assumption that the greater number of iterations of a Lesson Study lesson, the more 'results' will converge on an stable body of knowledge in relation to the teaching of a

phenomenon. This assumption however, is consistent with the empirical evidence from a very large number of studies that have applied phenomenographic methodology and have found that repeated analysis of evidence results in the emergence of a stable set of categories of description.

5.7.3. Other methodological issues

Section 5.6 identified three important gaps in previous research into Learning Study. In summary, these are: i) a comparison of Learning Study with more conventional methods of teaching, ii) the presentation of data at the individual rather than the group level and, iii) the explicit application of PVT in the introduction of PVT to teachers in a Learning Study. This study will address these issues in its design and implementation.

5.8. The design of the current study

In the sections above it has been demonstrated how Learning Study attempts to combine the methodological principles of AR, DR and PVT. AR and 'soft' DR offer models of research that link naturally with the day to day practice of teachers and seem more connected to the messy reality of teaching. However they suffer from

difficulties in terms of the status of the knowledge that they produce, mainly because it is hard to tease out the difference between the observers and the observed. In attempting to capture the local and the complex micro-level workings of an educational situation, they seem to trade off validity and generalisability. This is in contrast with more positivistic modes of research (such as 'hard' DR). These are appealing because of their promise of value free, 'scientific' conclusions (even if, as has been briefly shown, these promises may not be secure). They may also be more suited than practitioner based research to capturing the global. However in doing this they put themselves at a distance from practice and the ability to tackle the local head on. Such approaches therefore subsequently suffer from the problem of adequately translating broad theory into particular practice.

Learning Study represents an attempt to bring together the authentic, participatory and practice based nature of AR (and 'soft' DR) with the more formalised, experiment based methodology of 'hard' DR. This task mirrors the non-dualistic ontological stance of PVT explored in Chapter 2. PVT, as a framework in which to conduct both the 'soft' and 'hard' elements of Learning Study, can act as the bridge between the two elements. This is because PVT simultaneously embodies a method of researching and measuring the effects of teaching and learning interventions and a

method for instructional design. As noted, this brings challenges in terms of trying to establish the status and therefore the function of the evidence that is generated.

One way forward is to ensure that any claims resulting from Learning Study research are expressed tentatively in the full light of the assumptions that are being made. As Pang and Marton (2003) note, the outcomes of any Learning Study will be crucially dependent on the particular object of learning that is being studied, the particular context in which it is being studies and the way in which PVT is being operationalised. As a result, Pang and Marton (2003) argue that it is not possible to claim that Learning Study is always 'better' than Lesson Study but rather that in a particular case it might seem to be. On this view, any individual study can be seen as a contribution to a growing body of evidence, rather than as a study offering any kind of definitive proof. This is consistent with the adoption of an orientation to teaching and learning that transcends both the objective and the subjective and attempts to combine the two (see Section 5.7.1). The aim of the current study is to adopt a similar stance in the evaluation of the contribution that Learning Study might make to BTs' knowledge development, and offer its conclusions in a similar way.

Since the key focus of the current study is an examination of the effects of Learning Study on BTs' knowledge, its primary objective is similar to other studies that have set out to evaluate the benefits of Learning Study *in general* rather than those that have focused more on the refinement of teaching a particular topic. As such the study will draw heavily on the method used in the original presentation of Learning Study (Pang & Marton, 2003, 2005) and will be based around a quasi-experimental design. This will involve pre and post-testing that is based upon qualitatively different conceptions as a measurement of impact.

The main differences between this study and the original version of Learning Study in Pang and Marton (2003) are:

i. The target was BTs aged between 21 and 45, rather than school students. The reason for focusing on BTs, as outlined in Chapters 1 and 3, is because of the importance of the link between the level of BTs' knowledge and the quality of teaching. It is particularly crucial to identify effective strategies for the development of such knowledge within the context of the relatively short and intense nature of most teacher training in England (approximately 9 months). A further reason for focusing on BTs rather than experienced teachers relates to

the logistics of the research. There are very few occasions in England where relatively large numbers of teachers of the same subject domain come together to work on planning and teaching lessons. Groups of BTs based in universities provide such an opportunity, allowing a single researcher to undertake a project of this kind. Finally, although the focus on BTs in this research is novel in the context of Learning Study, there have been many phenomenographic studies that have involved adults (rather than students) as subjects. Therefore, there is considerable precedent for gathering evidence related to BTs' conceptions in the same way as students' conceptions.

ii. The adoption of conventional practice as the point of comparison for the control group rather than any particular intervention. This is in line with the research conducted by Pang and Ling (2012), however it differs in that they compared 'research' groups whereas this study compared Learning Study 'research' groups with BTs working in a routine way.

iii. The focus on BTs' conceptions of students' conceptions of a phenomenon, in order to gain an understanding of BTs' PCK. This is

an approach that is new to this research and therefore involved the development of a new form of evidence gathering.

iv. Explicit account being taken of the internal and the external horizon in the design of pre and post written tests and interviews.

v. The use of statistical tools for the analysis of BTs' conceptions that have not previously been used (i.e. Kendall's Tau-b and the Wilcoxon signed-rank test).

vi. A statistical comparison between BTs' conceptions of one phenomenon (CK) and their conceptions of another (PCK).

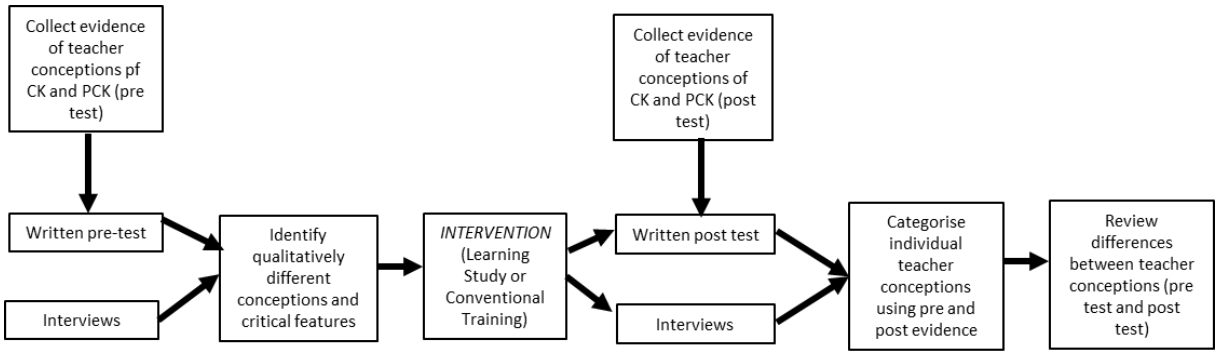
vii. Presentation of results of conceptions at the individual rather than the group level.

viii. Introduction of participants to Learning Study/PVT in a way that takes explicit account of PVT.

To ensure that this study can represent a contribution to the body of evidence in relation to Learning Study, the interventions were constituted according to the key features of Learning Study that were identified in Chapter 4. In addition, the parameters of the study fell well within the range of differences noted between Learning Studies in Section 4.3.2.

In summary, the design of the current study broadly followed the typical Learning Study sequence set out in Section 4.3.1. This consisted firstly of gathering evidence of BTs' conceptions of a topic in their subject area in a pre-test. These conceptions were taken as measures of BTs' CK and PCK. This was analogous to the way in which evidence of student conceptions of a phenomenon is gathered in a typical Learning Study. Next there was an intervention phase (to replace the time that would be spent in Learning Study planning and teaching a lesson). In line with Pang and Marton (2003, 2005), this was established as a quasi-experiment where there was a comparison group running alongside a Learning Study group. Finally a post-test was conducted to assess BTs' conceptions of the phenomenon, allowing a comparison to be made between pre and post-test results. Results of pre and post-tests were converted into numerical data to allow part of the comparative analysis to be statistical. Figure 5.1 provides an outline of the research process undertaken.

Figure 5.1 – The research process in the current study



5.9. Implementing the current study

This section explains the way in which the study design was implemented. It begins by describing the phenomenon to be studied and how BTs' conceptions were captured and measured. It then outlines whose conceptions were going to be captured and how the intervention and comparison groups were to be organised. Following from this, the Learning Study intervention is described, along with an explanation of how evidence of BTs' conceptions was gathered. Finally the way in which the results were analysed is explained, before the section concludes with some ethical considerations.

5.9.1. The phenomenon to be studied

As outlined in Chapter 3, this study used BTs' conceptions of the phenomenon of price to measure their CK and PCK. It is conventional practice in Learning Studies for the teachers involved to select the object of learning. They draw on their teaching experience to decide on something that they consider to be particularly difficult to teach or something that is a current priority. In this study, because the focus was BTs, they did not have this experience. Therefore, in line with Ko (2011), the topic of price was allocated to BTs. This may have reduced their sense of ownership of the process, meaning that any development of BTs' knowledge identified as a result of the Learning Study intervention, might be less than the full possible benefits.

5.9.2. Methods for measuring CK and PCK

In this study, BTs' CK was be taken to be synonymous with the sophistication of their understanding of a phenomenon. BTs' PCK was taken to be measured (at least to a significant degree) by the sophistication of their understanding of student understanding. The success of this research therefore hinged on an accurate identification of BTs' conceptions.

As indicated above in Chapter 4, in typical Learning Studies (and in phenomenographic research in general), evidence of students conceptions is usually gathered through a combination of written testing and semi-structured phenomenographic interviews. In their two earlier studies Pang and Marton (2003, 2005), were very much in line with traditional phenomenographic research in focusing on interviews as the primary research tool. Interviews were presenting as 'facilitating' the analysis of any written test data. However in later descriptions of Learning Studies (Marton & Pang, 2008; Marton, 2014), evidence appears to be drawn solely from written pre-tests. This shift of emphasis may be in response to: i) the considerable practical difficulties in managing and analysing the large amounts of data resulting from phenomenographic interviews in comparison to written responses and, ii) the challenge in ensuring that school teachers have the necessary skills to conduct the analysis of interview transcripts effectively.

In this study, evidence was drawn from both written tests and interviews. This is because they have the potential to work in a complementary way. Interviews can provide an in depth picture of a small number of individuals' understandings, whilst written tests can provide a snapshot of a broader range of understandings. As a result, there was more chance of gaining access to the greatest range of variation in

BTs' responses. This approach also offered the potential for triangulating between an individuals' responses in the written task and their responses in the interview in order to check the reliability of both.

5.9.2.1. Written pre and post-tests

Evidence of BTs' CK and PCK was gathered through two written tasks. To ensure uniformity in an important aspect of the context, the product was the same in both questions. Coffee was chosen as a product with which BTs would be familiar and because it is a product that can be set in either a wider market context (in relation to the global market for coffee beans) or in an individual business context (in relation to price of a cup in a school canteen). This allowed pre and post-tests to be designed that could highlight differences between these two contexts in order to encourage BTs to reveal the full range of their understanding. Task A set out to measure BTs' CK by asking them to explain a change in the price of coffee in a given scenario. This was either in relation to the global market (Appendix 10.1) or in relation to an individual business (Appendix 10.2). Task B set out to measure BTs' PCK by asking them to suggest qualitatively different ways in which students might think about a change in the price of coffee. This was also either in relation to the global market (Appendix 10.3) or in relation to the school canteen business (Appendix 10.4).

A pilot study involving 59 BTs from 3 universities in England was undertaken in June and July of 2011 to test early drafts of both of the written tests. Task A was very similar to the problem given to students in a previous study (Marton & Pang, 2008). As then, this task proved successful in generating a range of varied responses. It revealed BTs' conceptions through their responses to a general price problem that could have been tackled by almost any individual, regardless of age.

By contrast, Task B did require revision. Initially, BTs were asked directly to describe qualitatively different students' conceptions. This approach proved to be very challenging for BTs. An analysis of evidence from the pilot study revealed that there was much less coherence in BTs' responses than expected. This was perhaps because the task required them to express their understanding of students' thinking in a way in which they were not familiar. Assessment in school economics and business in England is largely based upon a Bloomian 'levels of response' framework and so BTs' experiences in school, both as students and as new teachers, are unlikely to have exposed them to thinking in terms of levels of conceptual understanding. As a result, alongside a number of minor changes to sharpen the rubric, it was decided to provide a short briefing on phenomenography at the start of each set of written tests.

In addition, Task B was modified by asking BTs to comment on the reasons why they had placed their suggestions about student thinking in the order that they had. It was intended that this rationale would facilitate an analysis of the BT's proposed set of conceptions in the same way that interviews were said to facilitate the analysis of written data in other studies (Pang & Marton, 2005).

One significant additional modification was undertaken following the pilot study. Having previously been asked to consider student thinking on price from one standpoint, BTs were asked to consider students' conceptions from two different standpoints (that of a 14 year old student and a 21 year old student). Since contrast more readily highlights differences, this change was intended to prompt BTs to express the fullest range of thinking possible. The age of 14 was chosen because all BTs had experience of teaching 14 year olds and so were familiar to at least some degree with their understandings. The age of 21 was chosen because 21 year olds are individuals who will be at a completely different life stage. Since all BTs were older than 21, they had direct personal experience of both ages on which to draw.

As a result of these changes, the final version of Task B asked BTs to: i) suggest the qualitatively different ways in which 14 year-old and 21 year-old students might

explain a price change, ii) rank these possible ways of understanding the problem from the least sophisticated to the most sophisticated and, iii) write a commentary explaining why they ranked the conceptions in the way they had (see Appendix 10.3 and Appendix 10.4).

In addition, the PCK questionnaire asked BTs for information about whether they had taught the topic of price before. This was done in order to check the number of BTs who had had to engage with the topic during their training. BTs were also asked for the name of their first degree and the classification that they had been awarded. This information was gathered in order to examine the relationship between degree classification and levels of CK and PCK.

5.9.2.2. Interviews

The reliability of the written evidence of BTs' CK and PCK was checked by interviewing a sample of BTs. Interviews were semi-structured and contained a small number of standard questions with additional unstructured follow up questions. Following Åkerlind (2005b), two types of standard questions were asked: open and situated. The purpose of the open questions was to try to establish what the phenomenon of price meant to the BT and allow them to focus on the aspects

most significant to them. This included such questions as 'please can you talk through your answer to the question of how the price of coffee was arrived at?' and 'can you tell me about students thinking about how price is set?' The situated questions asked BTs to provide concrete examples to illustrate their thinking. Examples of unstructured questions used to probe the concrete examples given by BTs were 'could you tell me a bit more about this phrase you used?' and 'could you explain why you saw this type of reasoning by a 14 year-old student as being more complex than that type of reasoning?'.

In order to build the skills of the interviewer and test the questions, 6 interviews were undertaken as part of the pilot study in 2011. Recordings of these interviews were reviewed against two criteria: i) the extent to which the interviewer introduced any new aspects that the interviewee had not referred to and, ii) whether the interviewer's focus was characterised by a continual searching for meanings. As a result of this review, two major revisions to the interviewer's approach were made in order to reduce any impact the interviewer may have had. These were : i) ensuring that more regular requests for concrete examples were made and, ii) making greater use of more open ended questions in order to counter the interviewers tendency to 'teach' through the use of leading questions.

All final interviews were recorded and transcripts produced. These formed part of the evidence base for this study.

5.9.3. The organisation of intervention and control groups

5.9.3.1. The initial sample

BTs from eight English universities were chosen to take part in the study. A key aim was to ensure that there was a good degree of uniformity across the sample. As a result, all the BTs in the sample were enrolled on the same type of training - Post Graduate Certificate of Education (PGCE) programmes in business and economics. PGCE programmes must all comply with the requirements that are laid down by the UK Government's Department for Education. They are full-time courses lasting around 9 months with BTs being required to spend a minimum of 120 days in schools teaching and 60 days of study in university.

To further ensure a level of uniformity, the universities were chosen because at the time of the study, each had been awarded the same 'outstanding' quality rating by England's independent schools inspectorate (the Office for Standards in Education: Ofsted). Ofsted undertake a rigorous inspection process that involves assessing the

quality of training against a national set of standards. It includes a review of recruitment procedures, observations of BTs' teaching and discussions with school based mentors and BTs. Ofsted inspection results are a widely recognised measure of quality in England. As a result, no other data in relation to course structure or content was gathered.

The sample of 8 universities was drawn from 3 Russell Group universities and 5 non-Russell Group universities in order to include a range of different types of institution. In addition, the universities were chosen to balance what it was practicable for a single researcher to achieve (given the relatively wide geographical spread of universities in England) with the aim of gaining the largest sample size possible (given that individual universities had different sized cohorts of BTs). In the end, the total sample comprised a large proportion (49%) of BTs who were trained in England in 2011/12 to teach business and economics in secondary schools.

5.9.3.2. Intervention and control groups

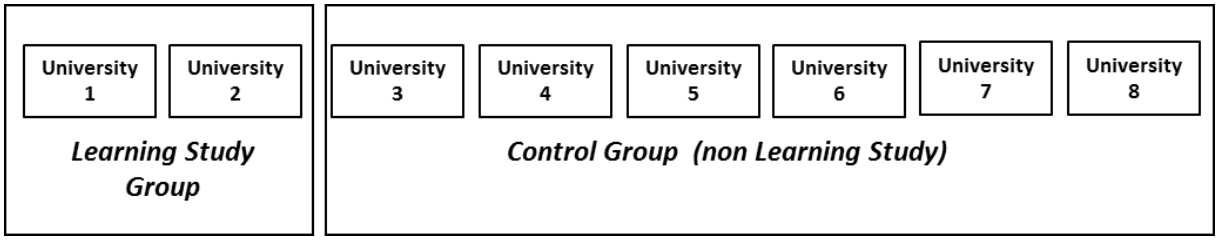
Learning Study was included in the training programme at two universities – University 1 and University 2 (n=18). Given that pre and post-testing in all eight universities needed to be completed at approximately the same time twice during the

year, and given the resource constraints on this study, it was not possible to extend the sample beyond two universities. The two universities were chosen because of their geographical proximity to the main researcher and because they had the flexibility and willingness to build the Learning Study intervention into their training.

BTs enrolled at six other universities comprised a control group (n= 65) who completed both pre and post-tests. Additionally CK and PCK data were gathered from BTs (spread across all universities) who were only present for either the pre-test (n=27) or the post-test (n=3). Absences from the post-test were mainly as a result of BTs withdrawing from training. Absences from the pre-test were due to illness.

An overview of the scope of the study is presented below in Figure 5.2:

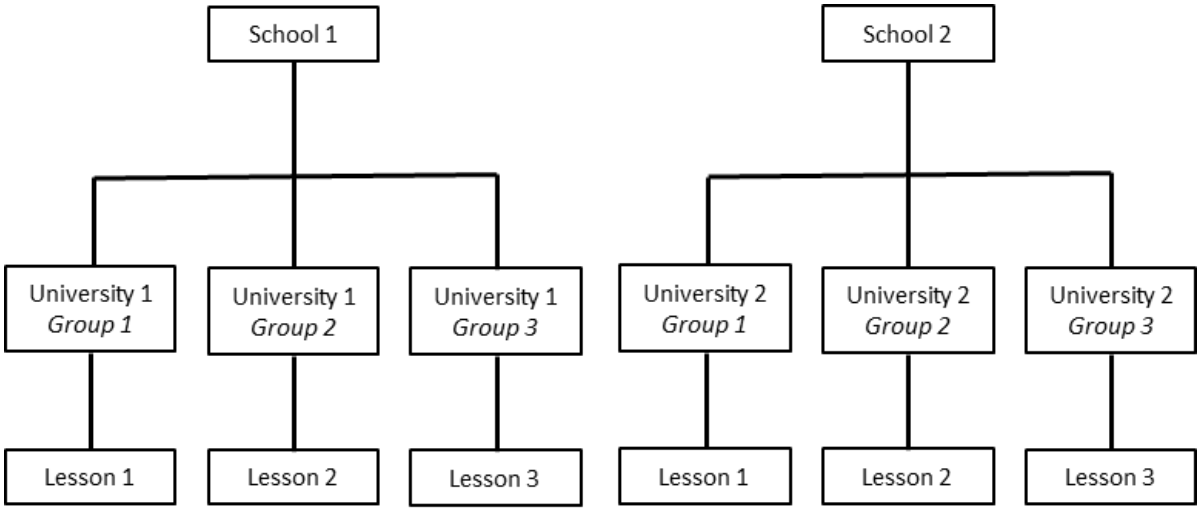
Figure 5.2 – Summary of scope of the study



All the BTs from the Learning Study group in Universities 1 and 2, were randomly divided into 6 groups of 3 and each group was asked to undertake a Learning Study on price. This took place about a quarter of the way through their 9 month training programmes. Lessons were to be presented to 6 groups of school students in two secondary schools. University 1 Learning Study groups would teach lessons in School 1 and University 2 Learning Study groups would teach lessons in School 2. All the lessons to be taught involved 14-19 year olds studying economics and/or business studies. Schools were chosen because of their strong links with each of the universities involved. None of the school students (or BTs) had previously taken part in lessons based on PVT.

Each of the 3 groups from University 1 taught a different Learning Study lesson (lasting between 50 and 60 minutes) to different classes of students in School 1 and then in the following week, each group from University 2 taught a different Learning Study lesson to different classes of students in School 2. This is illustrated in Figure 5.3 below:

Figure 5.3 – Structure of the Learning Study intervention



5.9.4. The Learning Study intervention

The format of the Learning Studies in this research drew heavily on those set out by Pang and Marton (2003, 2005). These are outlined in Section 4.3.1. In summary, BTs were provided with an introduction to PVT, they then analysed evidence of student pre-conceptions, planned a lesson around these using PVT, taught the lesson, analysed evidence of student post-conceptions in order to review and revise the lesson and, finally, re-taught the lesson.

However, the fact that this study was focused on BTs did influence the design of the Learning Studies completed. This was largely an issue of time constraints imposed by the relatively short training BTs receive in England (typically only 36 weeks - with

120 days in school). As a result, a number of steps were taken to streamline the Learning Study process:

i. BTs were provided with the initial object of learning (the phenomenon of price). As outlined in Section 2.4, this topic was chosen because of its centrality in the teaching of economics and business studies, the significant amount of previous research on price on which to draw and the fact that it is generally considered to be a difficult concept to teach.

ii. BTs were provided with written evidence of student pre-conceptions that had been gathered by a researcher. This meant that BTs missed out on any beneficial effects on their CK and PCK of working with others to design appropriate problems to test students' pre-conceptions.

iii. Evidence of student conceptions (both pre and post-lesson) were gathered using the same price problems that had been completed by the BTs themselves as part of this study (about 50% of students completed the business context problem and 50% the market context problem). The aim of this was to speed up BTs' analysis of student conceptions, since they were already familiar with the price problems.

iv. To ensure that BTs were exposed to as wide a variety of conceptions as possible, they were given access to 118 student written responses drawn from students in the schools in which they would be presenting the Learning Study lessons. To keep the task of data analysis manageable, BTs were not given access to the transcripts of interviews with students.

v. In line with Pang and Marton (2003), only one cycle of Learning Study was undertaken during this study. BTs were encouraged to re-teach the revised lesson, but no record was kept as to whether they did so and no further measure of their CK or PCK was taken. Given that BTs are likely to improve in their understanding of Learning Study by undertaking repeated cycles, this means that any effects on CK and PCK found in this study are likely to understate the full effects of Learning Study.

At the start of this research it was necessary to introduce Learning Study to BTs in the two universities. This was conducted by the same researcher, as far as was possible, in the same way. In planning this introduction it was striking how little detail previous studies provided on how this is done. Two quotations might give some flavour of this:

i. *'In this group (the Learning Study group) the researcher introduced variation theory as a tool for developing a lesson plan to the two teachers involved'* (Pang & Marton, 2005, p.166).

ii. *'In the first learning study cycle, the teachers only got a brief introduction on the variation theory together with some articles to read …… the researcher played an important role to introduce the concepts of the variation theory during the meetings'* (Holmqvist, 2011, p.4).

One obvious way to approach an introduction would be through the application of PVT. To this end, this study drew heavily on a small scale, exploratory study conducted by Davis and Durden in 2008 (see Appendix 10.5) that identified BTs' conceptions of Learning Study and associated critical features. The two 2 hour formal briefing sessions on PVT/Learning Study that were presented to BTs in this study attempted to explicitly vary these critical features in the activities that were involved. Unfortunately, evidence of the effectiveness of these sessions through pre

and post-testing was not formally undertaken. Given the time hungry nature of Learning Study however, developing more expeditious and effective ways of introducing it is an important priority.

Following the introductory sessions, BTs were given 3 half days (about 15 hours in total) over 2 weeks to analyse evidence of student conceptions and prepare the lessons. Although the pre-tests had been focused around a price problem related to coffee, BTs were given the choice to set their lessons in the context of whatever product they wished. In order to ensure that BTs produced the best quality lessons possible, they were supported during all of this time by an experienced business studies/economics teacher and a researcher (who was also an experienced teacher). Both the researcher and the teacher were extremely careful not to 'tell' the BTs what to do, even if only implicitly. They only intervened by asking BTs questions or reflecting their questions back to them. The exception was if a question was related to PVT. In this case clarification and explanation was given. The BTs completed substantial additional preparation outside of the formal sessions.

Lessons were presented to students in school within a week of the final Learning Study preparation sessions, with the aim of keeping matters as fresh as possible in

the BTs' minds. Each group of BTs was present in each lesson along with a researcher and the regular class teacher. Apart from setting up the lesson, neither the researcher nor the teacher took any part. BTs were encouraged to gather evidence of student learning during each lesson. They did this mainly through observation and the collection of written work or evidence from other classroom activities.

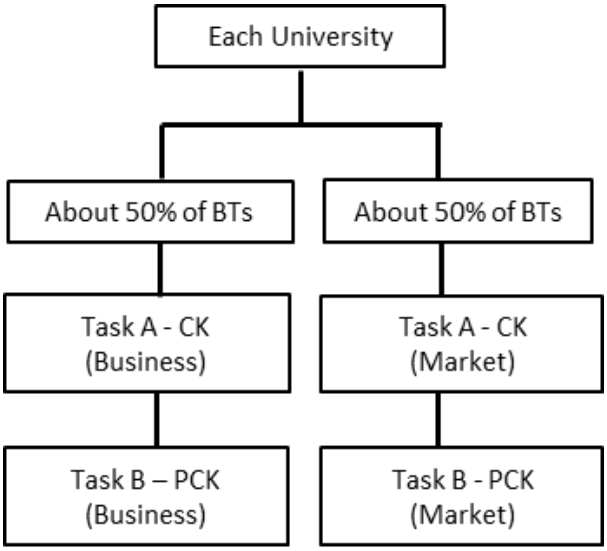
The day after each of the Learning Study lessons, a researcher returned to the schools to conduct post-tests with all of the students. The price problem set in the post-tests was the same as had been set in the pre-test. This is in line with previous research (e.g. Pang & Marton, 2003, 2005) but clearly runs the risk of students improving their responses through practice rather than as a result of Learning Study. In some previous studies (e.g. Marton & Pang, 2008) the question format remains the same but the product in the post-test is changed. In retrospect this could have been a desirable course of action. However the effect in the current study was likely to have been mitigated to some extent by the length of time between the pre and post-testing (14 weeks). In addition, the open ended nature of the task would probably reduce the potential for students simply remembering previous responses.

A few days after the post-test, a researcher worked with the BTs over half a day (about 5 hours) to review the evidence from the test and the evidence that they had collected themselves. BTs were asked to focus on how they could improve the lesson in the future and they redrafted lesson plans and redesigned teaching resources. They were then strongly encouraged to re-teach the revised lesson during the remainder of their training and subsequently in their first jobs. There was a very good probability that this would be the case given the centrality of the topic of price to economics and business studies.

5.9.5. Collecting evidence of CK and PCK

Evidence of BTs' CK and PCK was gathered from both the control and Learning Study groups through a written pre-test conducted 4 weeks from the beginning of their training and a written post-test conducted 4 weeks from the end. Each test took around 45 minutes to complete. In each of the 8 universities, the BTs were randomly divided into two groups of approximately equal size. One group was given the single business context version of Tasks A and B and one group was given the international market version. This is illustrated in Figure 5.4:

Figure 5.4 – How evidence of CK and PCK was collected



The time between pre and post-tests could make it difficult to identify whether any improvements in CK or PCK were due to Learning Study or were due to other factors. However, since all the universities involved in the study had been given the same outstanding quality rating by the school's inspectorate, it might reasonably be expected that all might develop BTs' CK and PCK to a reasonably similar degree. In addition, all 8 universities involved were able to confirm that they did not run specific training on the topic of price. This is not surprising given the short amount of time BTs spend in university (usually only about 60 days) and that the emphasis is more often on general pedagogical issues rather than on the pedagogy in relation to particular topics. Both of these factors made it more likely that any effects noted

were the result of the Learning Study intervention. Indeed the length of time between pre and post-tests might have had additional benefits since: i) it allowed this study to demonstrate that changes in CK and PCK from Learning Study could be long lasting (given that the Learning Study intervention occurred 9 weeks into the training) and, ii) it encompassed a good proportion of the total training period, allowing for the maximum possible effect of any generic training on PCK and CK to be revealed.

Evidence of BTs' CK and PCK was also gathered through interviews that were conducted after each written pre-test and after each written post-test. One randomly chosen BT from each university was interviewed, meaning that 16 interviews in total were undertaken. This meant that a slightly larger percentage of subjects were interviewed in this study (9.1%) compared to previous studies into the effects of Learning Study on students (Pang & Marton, 2003 – 3.2%; Pang & Marton, 2005 – 5.9%). Wherever possible, the same BTs that were interviewed in the first round were re-interviewed in the second. Each interview lasted between 25 and 45 minutes and was roughly divided in half, the first part focusing on CK and the second focusing on PCK. To ensure that issues were fresh in the mind of each interviewee,

interviews took place immediately following the written tests. The text of the BTs' written responses to the problems was used as a prompt during the interviews.

5.9.6. The analysis of data

5.9.6.1. The final sample

In the first round of the study, written evidence from 116 BTs was gathered. There were 25 BTs potentially involved in Learning Study with 91 in the control group. Of the 25 in the Learning Study group, 2 BTs were interviewed. Six BTs were interviewed in the control group. At the end of the study, evidence from the Learning Study group was restricted to 18 BTs. This was because 4 BTs had left training and 3 BTs were absent. For the control group, the sample was reduced to 65 BTs. Here, 18 BTs had left training, with 8 being absent. Eight BTs were again interviewed, but because of absences and withdrawals from training it was only possible to conduct interviews with the same BT in pre and post-test phases in 5 cases.

5.9.6.2. Developing descriptions of conceptions

At the start of the analysis, 50 of the BTs' written responses were randomly chosen and set aside order in order to test the validity of the final categories at the end.

Twenty five were chosen from the pre-test (with 12 being from Task A and 13 from Task B) and 25 from the post-test (with 13 being from Task A and 12 from Task B). Then all evidence (both interview transcripts and written responses) was repeatedly read over four weeks, with a high degree of openness being maintained as to possible differences between BT's conceptions.

Following this, draft categories were drawn up that set out to describe the qualitative differences between BTs' CK and their PCK. Next followed a process of repeatedly reviewing these descriptions in the light of the evidence. This involved the grouping and re-grouping of perceived similarities and differences between conceptions. For some of the time this involved working with the entire BT response, whilst at other times it meant focusing on extracts from those responses. At times these groupings would occur before the actual description of a category was finalised and at times they would be grouped afterwards to validate tentative draft descriptions (Åkerlind, 2005a). Throughout the analysis, researchers were consistently mindful of the need to recognise the difference between the words that the BTs used and the underlying meaning (Bowden & Walsh, 2000). For example, if a BT used the phrase 'supply and demand' it was important to try to distinguish between those that understood this as

an interaction between market forces and those that simply reproduced it as a textbook phrase that referred to two discrete factors – 'supply' and 'demand'.

Drafting was done away from written evidence in order to preserve as much objective distance from the written evidence as possible (Prosser, 2000). Analysis was completed over eight months to help in ensuring that evidence was looked at 'from different perspectives at different times' (Åkerlind, 2005a, p.328). This is likely to encourage the 'free imaginative variation' that was emphasised by Sandberg (1997).

To aid this process, after the initial phases of the analysis, an additional experienced researcher was involved in drafting and reviewing categories (Bowden & Walsh, 2000). About half of the time this involved both researchers working together in drafting and reviewing, and half of the time it involved them independently reviewing each other's work.

Pertinent quotations that illustrated meanings contained within a particular BT response were used to lend clarity to the analysis by making the data more manageable to deal with. However, in order to maintain a sense of the importance of

context, at no point did quotations became the sole focus. Frequently during the analysis researchers referred back to the complete text in order to confirm that it accurately captured the meaning when seen in the context of the whole response. This was particularly important in the PCK tasks where clarification could often be found by analysing the conceptions suggested by BTs in the light of the rationale that they provided.

In sharpening up draft categories, three sets of quotations proved of considerable value: i) those on the 'borderline' which did not immediately appear to fall into one category or another, ii) those that seemed to indicate either extremely straightforward or extremely complex conceptions and, iii) those that did not seem to fit into any categories at all. These three types of responses were frequently used as a focus for discussions between researchers.

The fundamental assumption in phenomenography is that there are not only a set of meanings of a phenomenon but that there is often a structural, inclusive relationship between (at least some of the) meanings. In order that the researchers maintained a high a degree of awareness of possible meanings in the data, the early stages of this analysis were more focused on meaning than on the structural relationship between

the categories (Ashworth & Lucas, 2000). As the drafting process progressed, both structure and meaning were simultaneously considered. Researchers were also aware of the possibility of including data that did not obviously fit with the emerging categories as either sub-categories of the main categories, or non-critical variation in ways of understanding or as part of a branching, non-linear set of categories (Åkerlind, 2005a). This awareness was used to help ensure that potential meanings in the data were not overlooked.

Whilst it is difficult to be precise about where one iterative research cycle begins and another ends, there were well over 10 of these cycles during this study. At least three cycles were completed by a single researcher, with an additional researcher being involved thereafter. There were a greater number of revisions in relation to PCK than CK possibly because this represented a new area of research. Eventually however the scale of the revisions and redrafting reduced and the set of categories became relatively stable.

Throughout this study, dialogic reliability (Kvale, 1996) was achieved in the way in which the two researchers involved finally reached agreement after extended discussions around their individual interpretations and re-interpretations of the

evidence. Coder reliability (Kvale, 1996) was addressed in the analysis of the 50 written responses that had been set aside at the start of the research. A high degree of inter -judge reliability was achieved, with the second researcher placing 88% of these written responses for both CK and PCK in the same category as the first researcher and the remaining 12% no more than one category different (as measured by the ranking of conceptions that was developed).

5.9.6.3. Categorising BTs' responses

Having developed a hierarchy of conceptions, researchers then ranked each conception for both CK and PCK. They then returned to the data to categorise each of the BTs' responses in both the pre-tests and the post-tests. Following Marton and Pang (2005), each BT response was categorised on the basis of the most sophisticated conception shown in it. This seemed to be a reasonable procedure, particularly when the structural relationship between conceptions is linear (with each less sophisticated conception being nested inside a more sophisticated conception). If a BT expresses a more sophisticated conception it seems likely that they would be aware of a less sophisticated conception (even if they do not refer directly to it).

5.9.6.4. Statistical analysis

After being categorised, relationships between the rankings given to each BTs' CK and PCK were examined: i) to determine the extent to which Learning Study had a significant effect on CK and PCK (measured using the Wilcoxon signed-rank test) and, ii) to look at the extent to which CK and PCK were associated with each other (measured using the Kendall's Tau-b).

The Wilcoxon signed-rank test is the non-parametric analogue to the paired samples t-test. It gives a measure of the statistical significance of an outcome being the result of a particular intervention and allows for a calculation of the effect size of that intervention. The Wilcoxon signed-rank test does this by testing for a median difference of zero when used with related groups of data. It does not assume normality in the data and is appropriate when sample size is relatively small as here (for the Learning Study group n=18). The effect size was calculated using the formula: $r=Z\sqrt{n}$ (Rosenthal, 1994). The interpretation of effect size in the study followed Cohen's (1988) guidelines that a 'large' effect is ≥0.5, a 'medium' effect is ≥0.3 and a 'small' effect is ≥0.1.

The Wilcoxon signed-rank test makes three assumptions: i) that dependent variables (that is BTs' conceptions of CK and PCK) are ordinal, ii) that the independent variable (that is individual BTs) is made up of related groups and, iii) that the differences between the related groups are distributed symmetrically (this means that there are approximately the same number of values above as there are below the median). This study appeared to meet the first two of these conditions. First, it focused on qualitative differences between conceptions that do not necessarily have the properties of an equal-interval scale. Therefore it is appropriate to treat different conceptions as being ordinal in nature. Second, given that the study involved a comparison between an individual BT's conceptions revealed in the pre-tests and that BT's conceptions as revealed in the post-tests, the independent variable is made up of related groups. The third assumption of a symmetrical distribution of differences between related groups was tested through construction of box-plots of the differences between pre and post levels of CK and PCK.

Kendall's Tau is a non-parametric measure of correlation between two ranked variables. Unlike Spearman's rank order correlation, it represents a comparison between the probability that rankings are in the same order and the probability that the rankings are not in the same order. In other words, it assesses the probability of

the difference of concordant and discordant rankings. Kendall's Tau has the benefits of being intuitively more accessible that Spearman's rho, being relatively insensitive to extreme differences in ranking and producing p values that are more accurate than Spearman's rho with smaller sample sizes. Also, Kendall's Tau can be adjusted to account for data where there are a considerable number of ties (Kendall's Tau-b).

5.10. Ethical considerations

This study follows the guidelines of the British Education Educational Research Association (2011). Informed, written consent was obtained from BTs, the Head Teachers in the two schools involved in the Learning Studies, the parents/guardians of all school students and the two school teachers who set up the lessons. All were fully briefed on the purpose and methods involved and were free to withdraw at any stage. One BT and 3 school students did infact choose not to take part in the study.

The study was organised to minimise the impact on all of the participants. The data collection exercises did not significantly increase the workload of BTs since they were relatively short. The Learning Studies were fully integrated into the training programmes at the two universities that took part. In terms of the school students, as far as possible, the Learning Study lessons were presented to students who had not

encountered the topic of price before. For the very small number that had, the opportunity cost of covering it again was likely to be relatively low given its centrality in the curriculum. In four out of the six Learning Study lessons, students would have been taught by a BT anyway, so there were no additional implications for their progress as a result of taking part in this study.

The study set out to preserve the anonymity of all those involved. To aid matching of BTs' responses in pre and post-tests they were asked to initial each response at the start of the test. However, immediately after each test, the researcher coded and photocopied responses without identifying initials. Originals were then securely shredded.

Since evidence gathered from the Learning Study lessons is not presented here, it is not possible for either BTs or school students to identify themselves from this. The only detailed, direct evidence reported from individuals is extracts from interview transcripts or quotations from written responses. To minimise the risk of BTs identifying themselves, all written and verbal evidence was anonymised and in general, only relatively short extracts are presented. No specific universities were named at any point in the study nor was it highlighted whether a particular extract

or quotation was or was not drawn from a BT that was part of the Learning Study or control group.

All original written work on paper was securely stored such that only the prime researcher had access to it. All written answers were also scanned by the main researcher and stored electronically. These files were password protected with passwords only being available to the two researchers involved. Any printed copies of BT responses or extracts from them that were used during the analysis were securely kept by each researcher and then destroyed at the end of the research. Recordings of interviews were stored electronically and were password protected as were interview transcripts. Any paper copies of transcripts were securely stored.

6. RESULTS

6.1. Introduction

This study examines effects of Learning Study on CK and PCK (in comparison to a control group of BTs) and the relationships between CK and PCK. Accurately describing BTs' CK and PCK in terms of the sophistication of their conceptual understanding is crucial to this process (as it is to the process of Learning Study itself). Therefore the first stage in presenting results is to set out the hierarchy of BTs' conceptions related to their CK and PCK. In each case, conceptions are illustrated through quotations from BTs that are drawn from both written responses and interview transcripts. Following on from this, there are sections outlining the way in which individual BT responses were classified and how the conceptions that were developed were ranked. Both of these steps are important in being able to conduct the subsequent statistical analysis. This analysis is presented in terms of: i) the *differences* between the CK and PCK of the Learning Study Group (LSG) of BTs and the control group and, ii) the *associations* between all BTs' CK and PCK at both pre and post-test phases. Also included is an exploration of the relationship between BTs' degree classifications and their CK. The chapter concludes with a summary of the main findings.

6.2. BTs' conceptions of price (CK)

As outlined in Chapter 5, evidence of BTs' conceptions of price was drawn from a written task (see Appendices 10.1 and 10.2) and interviews with a sample of BTs. In the written task, BTs were asked to respond to a price problem concerning the price of coffee (either in terms of a cup of coffee in a school canteen or in terms of coffee beans on the world market). Interviews explored BTs' understanding of the written task. This section offers quotations from BTs to illustrate the different conceptions that were identified. Those quotations drawn from responses to price in the context of a cup of coffee in a school canteen are labelled Q1. Those quotations from responses related to the world price of coffee are labelled Q2. Each quotation is also labelled according to the conception that it illustrates (A1, B1 etc.).

Each conception of price was analysed in terms of the 'internal horizon' and the 'external horizon' (see Section 2.3.5 for an explanation of these two ideas). Results are presented in Table 6.0. Variation in conceptions within the internal horizon ignores the context within which the phenomenon of price was set. Variation in conceptions within the external horizon captures different ways of understanding the context in which prices are set. Different conceptions within the internal horizon are

arranged in order of increasing sophistication from Columns A – D. Differences in conceptions within the external horizon are arranged in order of increasing sophistication from Rows 1 - 3. Each conception is labelled according to its components.

Table 6.0 – BTs' conceptions of price (CK)

				Internal horizon			
				Increasing sophistication →			
				A	B	C	D
				Either supply or demand factors	Supply *and* demand factors listed	Interaction *between* supply and demand	Interaction between supply and demand a*ffected by competition, power and equity*
External horizon	Increasing sophistication ↓	1	Pricing decision made by firms or individuals	A1	B1	C1	D1
		2	Price determined *within* a market context	A2	B2	C2	D2
		3	Price determined in context of multiple markets	A3	B3	C3	D3

6.2.1. Structural relationships – BTs' CK

6.2.1.1. The internal horizon

Turning first to the internal horizon, the structural relationships between the columns in Table 6.0 can be summarised as follows. Column A refers to conceptions that include *either* demand or supply, Column B refers to conceptions that include both supply *and* demand, Column C refers to conceptions concerned with the relationship (or interaction) *between* supply and demand, whilst Column D expresses a conception of price where supply and demand are *affected by* the factors of competition, power or equity.

6.2.1.2. The external horizon

In this study a categorical distinction was found between BTs whose conceptions focused on pricing decisions by individuals or firms (Row 1 in Table 6.0) and those focusing on the outcomes of market behaviour (Rows 2 and 3 in Table 6.0). This is the difference between BTs who see the pricing decision as being largely a matter of individual choice, in comparison to those who see the price as being 'received' by individuals from the interaction of the forces of supply and demand.

In Table 6.0, Row 1 sets price directly in the context of individual experience (either business or individual). Rows 2 and 3 set price in the context of more abstract processes that are remote from individual experience. So, for example, a conception typical of Row 1 would refer to an individual farmer of coffee beans setting the price of beans according to costs. A conception typical of Row 2 would refer to the price of coffee being a result of negotiation and bargaining between buyers and sellers. This difference echoes the distinction between uni-structural and relational representations of knowledge in the SOLO taxonomy (Biggs, 1996) that was referred to in Section 2.4.

In Table 6.0, Rows 2 and 3 are distinguished from each other by the number of markets to which they refer. Row 2 defines price in terms of the outcomes of a single market, whereas Row 3 defines it in terms of an outcome of interactions between markets. So, for example, a conception typical of Row 3 would be that the price of coffee is partly determined by impacts that the supply and demand for instant coffee might have on the supply and demand for coffee beans. The difference between Row 2 and Row 3 might also be seen as a shift from the uni-structural to the relational in the SOLO taxonomy, only now highlighting the number of markets involved.

6.2.1.3. Evidence of BTs' CK

Quotations 1 - 4 below highlight differences within the perspective of price setting by an individual or individual business (Row 1 in Table 6.0). Quotation 1 refers to a cost-plus model of pricing where farmers work out their costs and then add a margin to determine the price of coffee beans. Since it does not consider customers' demand for coffee, this perspective refers to supply only and therefore falls within Conception A1. Quotation 2 also refers to supply (in terms of the 'cost of production'), however this time also considers customers' demand (in highlighting 'market research'). Quotation 2 does not explicitly consider the relationship between demand and supply. They are presented as two discrete factors that affect the businesses decision about what price to charge. Therefore this quotation is taken to be illustrative of Conception B1. Quotation 3 also refers to both demand and supply. Demand is indicated at the start of the quotation through reference to a 'questionnaire' to be given to customers. Supply is indicated indirectly if it is assumed that lowering the 'quality of coffee' is synonymous with lowering the cost of coffee in order to ensure that profit is made. However it is also referred to explicitly in terms of 'breakeven'. Breakeven is that level of sales where the amount of money coming in from customers is equal to the costs of the business. The implication in Quotation 3 is that the business must consider the relationship

between supply and demand in terms of whether or not it will break even. This quotation is therefore taken to be indicative of Column C1 in Table 6.0. Finally, Quotation 4 also expresses an interaction between customers and the business in that the business must match 'service and quality' (supply) to customer 'expectations' (demand). This interaction is influenced by the power that the business derives from being the sole (monopoly) supplier of coffee within a school, in balance with the need to still consider customer needs. However, it is still very clear that the final decision in relation to price rests with the business itself. Quotation 4 is therefore indicative of Column D in Table 6.0 (Conception D1).

Quotation 1 (Q2) – Conception A1

Producers of the product would know how much it takes to make coffee beans ie how much labour and capital employed is used to harvest the bean. They would be able to find out how much it costs to harvest a field full of coffee beans, then break the cost into kilos, they would then find how much it costs per kilo, taking into account fixed and variable costs (total costs). The farmers would then want to decide which price they feel that they could sell per kilo. They may have a mark-up price of 200 to 300 per cent.

Quotation 2 (Q1) – Conception B1

Before setting the price of a cup of coffee I would look at the previous owner's sales; I would look and see on average how many cups of coffee he would sell on a weekly basis, and then work out would I want to sell more or the same as the previous owner....Secondly I would look at the cost of production, how much it would cost me to buy in the coffee.....I would carry out some market research, ask the consumers why they buy the coffee, what do they think of the coffee...

Quotation 3 (Q1) – Conception C1

It would be interesting to find out from the school how many coffee drinkers previously purchased from the school canteen through questionnaires. This would give an overview of whether the number of customers would rise, if the price was lowered, and therefore raise sales/profits without lowering the quality of the coffee….I would review the amount of money needed through purchases in the canteen to break even.

Quotation 4 (Q1) – Conception D1

A consideration must be made with regards to the customer, but as it is a monopoly I can set the price as I want providing the service and quality matches expectations – expectations being the key word. What do customers of a school canteen expect?

Below are quotations that exemplify conceptions of price setting in markets (that is in terms of Rows 2 and 3 in Table 6.0). Quotation 5 imagines a change in demand that would occur with constant consumer preference (through an increase in population). This is in contrast to Quotation 2 above, where a change in demand is viewed in terms of changes in consumer preference. In addition, whilst Quotation 2 considers the cost of production for an individual company, Quotation 5 considers technical progress affecting all producers (through the reference to the 'mechanisation of the supply chain'). In both of these ways, Quotation 5 is illustrative of a broader market perspective and thus relates to Row 2 of Table 6.0 (Conception B2).

Quotations 3 and 6 are responses to Q1 which posed an 'individual business' problem, yet Quotation 6 explicitly refers to interaction between supply and demand in stating 'if costs *in general* have gone up it would be realistic to marginally increase the price of all products where the products are not price sensitive'. This is a more

complex form of understanding than simply stating that price would be affected either by costs or by demand. In contrast to Quotation 3 which just focuses on the school perspective, Quotation 6 also explicitly considers the behaviour of other businesses in the 'general market' (such as Costa), although it is notable that only one type of market is considered (the coffee shop market). There is no mention of the market for coffee beans, for example. Therefore, this quotation is taken to represent Conception C2 in Table 6.0. Finally, Quotation 7 also refers to the interaction between supply and demand, explicitly referring to 'market forces'. However, this BT also acknowledges the constraints on that interaction represented first, by differences in market power (in the reference to 'purchasing power') and, second, by considerations of equity (through Fairtrade). Quotation 7 is therefore illustrative of Conception D2 in Table 6.0.

Quotation 5 (Q2) – Conception B2

Some of the factors which will influence price will be from the demand or supply side. On the demand side, factors such as population growth in countries where coffee is popular will affect the price. If the demand is increasing it stands to reason that the price will go up, based on basic supply and demand principles. On the supply side,

mechanisation of the supply chain could reduce average unit costs so that price will decrease.

Quotation 6 (Q1) - Conception C2

The price would be dependent upon a number of factors, the cost of materials, the demand, the coffee, the location of other coffee shops and the financial state of the canteen i.e. if costs in general have gone up it would be realistic to marginally increase the price of all products where the products are not price sensitive. People purchasing (coffee) are most likely to buy the product even if price was increased to say 70p. Also in the general market, setting a price of say 95p would still be considerably cheaper than purchasing the coffee from others such as Costa.

Quotation 7 (Q2) – Conception D2

The price of any product is affected primarily by market forces – the supply and demand for that product. In theory equilibrium price is where supply equals demand……..There is a large inequality in the wealth of the nations supplying coffee and the countries demanding the most coffee. The companies in developed countries can apply a great deal of purchasing power and put down the price farmers get for their coffee. There are also political factors at play though and differences in consumer

choice…… it is possible that the coffee price would have been even lower without the Fairtrade movement. Fairtrade doesn't look at the price customers are willing to pay but the price that gives a reasonable standard of living for farmers. This is outside the traditional economics of supply and demand.

There was a category of response that did not explicitly refer to *both* supply and demand factors, and yet seemed to reflect a market context. There were relatively few of these and they were captured by the descriptions of Conception A2 (and A3) in Table 6.0. One group of these responses (usually to Q1) related to the price charged by the competition and the location of competition as being factors affecting the pricing decision. Quotation 8 below is typical of this type of response. Although competition is an issue affecting customers (and is therefore related to demand) this quotation does have a strong sense of price as being the outcome of broader interaction between businesses as well. The answer even hints at the possibility of working with competition in order fix price through collusion.

In another type of response (most usually to Q2), BTs made explicit reference to the idea of markets without specifically referring to both supply and demand in their explanations. Quotation 9 is typical. This BT uses the term 'market' in conjunction

with a double use of the phrase 'throughout the world', the term 'demand' twice (which is of associated with more market based perspectives) and the term 'economic'. These are not suggestive of a conception of price as being determined by individuals or businesses and were interpreted as relating to a market perspective.

Quotation 8 (Q1) – Conception A2

To begin with I would do some market research. Here I could determine how much money consumers are willing to pay at my location……secondly I would consider the price of my competitors. There is little point in me charging 75p if there is a coffee shop next door charging 50p. On the other hand, if they are charging a lot more it may make sense to rise my price or even to collude.

Quotation 9 (Q2) – Conception A2

Factors that influence the price of coffee sold throughout the world would be: economic influences such as demand throughout the world. Demand being high would allow world markets to increase their price. The opposite would happen if demand fell - this would influence countries to sell at a lower price.

A few BTs placed price setting in the context of interaction between markets (Row 3 in Table 6.0). The BT reported in Quotation 10 uses the concept of opportunity cost to express the way in which supply to a particular market may change according to opportunities for using resources in other markets. However, this BT only refers to the supply side, so although this is a sophisticated answer in terms of context, it is less sophisticated in terms of interaction between supply and demand. This example indicates that, whilst from a subject knowledge point of view, it is reasonable to see the two dimensions of context and supply and demand as mutually supportive, they can be seen as distinct dimensions of conceptions of price.

> *Quotation 10 (Q2) – Conception A3*
>
> *$6 will be the price that the producers can produce the coffee for and still make enough profit to merit producing it over other crops. If they were to sell for just $5 it may well be a large opportunity cost to continue to grow coffee over other goods with a better mark up. $7 is likely to be an unacceptable.*

Quotation 11 below is taken to be illustrative of Conception D3. This quotation states that the coffee 'has gone through many channels' (markets) before it reaches the consumer. These channels are expressed in terms of a chain of production from

the producer (the farmer), to the wholesaler and finally through to the consumer (in a retail coffee shop). That this chain is seen in terms of markets is demonstrated in the distinction that is drawn between a 'wholesale' market (lines 3/4) and a 'retail' market (indicated by the use of terms 'consumers' – line 5 - and 'market' – line 6). This quotation therefore fits closely with Row 3 in Table 6.0. In addition, the quotation implies that these different markets have different structures where firms have different levels of market power (Column D, Table 6.0). For example, it is stated that wholesalers 'control the market' and can 'take advantage of farmers'. In other words, wholesalers have market power. In addition, in the retail market for coffee the quotation refers to the fact that consumers 'shop around'. This suggests that this is a market in which consumers have market power. This impression is reinforced by the use of the phrase in the final line, that 'this (the retail market) is not a monopoly market'. The exact nature of the relationship between markets is not specified in this quotation, but this BT sees price as being the outcome of the interaction between them (Row 3, Table 6.0). Whilst many BTs in this study referred to the 'mark-up' that sellers would aim for, Quotation 11 describes the ways in which market power might affect this mark-up. This is a type of reasoning that requires an understanding of the interaction between buyers and sellers and therefore of supply and demand.

Quotation 11 (Q2) – Conception D3

Before coffee reaches the consumer, it has gone through many channels; farmer right through to wholesaler and retail shops. The reason why the price is $6, is that wholesalers/manufacturers can take advantage of farmers because they are vulnerable ..... wholesalers control the market. Another aspect of this is the supply and demand of the market, and the fact that consumers can shop around for the cheapest price of a cup of coffee. This is not a monopoly market.

6.3. BTs' conceptions of student conceptions of price (PCK)

Evidence of BTs' conceptions of the differences between students' conceptions of price was gathered in two written exercises (see Appendices 10.3 and 10.4) and interviews with a sample of BTs. In written tasks, BTs were asked to provide: i) a possible hierarchy of student conceptions and, ii) a rationale for that hierarchy. Interviews were based on these tasks.

As for CK, BTs' conceptions were found to range along both internal and external horizons (see Table 6.1 below). The organisation of Table 6.1 is broadly similar to Table 6.0 above, with the exception that only 3 components to the internal horizon were identified (rather than 4).

Table 6.1 – BTs' conceptions of students' conceptions (PCK)

				Internal horizon		
				Increasing sophistication →		
				A	B	C
				No explicit basis for qualitative differences	Multiple factors account for qualitative differences	Structure accounts for qualitative differences (where more complex integrates less complex)
External horizon	Increasing sophistication ↓	1	Maintains one context (*either* everyday consumer experience, a business context or a market context)	A1	B1	C1
		2	Shift from everyday consumer experience to a business context	A2	B2	C2
		3	Shift from everyday consumer experience or business context to a market context	A3	B3	C3

6.3.1. Structural relationships - BTs' PCK

6.3.1.1. The internal horizon

On the internal horizon, BTs' conceptions varied according to the degree of structure they contained. At the lowest level (Column A), BTs typically presented a series of conceptions each based on isolated factors that could affect the price of coffee. There was little explicit structure to the ordering of these factors or any clear rationale for the qualitative differences between them. By contrast, other BTs presented an increase in the sophistication of students' conceptions of price in terms of an increasing number of factors (Column B). Responses of this type frequently put 'supply and demand' or 'costs and revenues' at a higher level than either 'supply', 'demand', 'costs' or 'revenues'. Finally, some BTs offered a nested set of conceptions, where the less complex was more or less explicitly integrated into the more complex (Column C). These hierarchies were often similar to those proposed by Pang and Marton (2005, 2008) and that put forward in this study. In terms of the SOLO taxonomy, given the absence of clear structure, Column A might be classified as pre-structural, whilst Column B and C might be interpreted as being multi-structural and relational respectively.

6.3.1.2. The external horizon

On the external horizon, the lowest conception (Row 1) was expressed by BTs who set differences in students' understanding of price in a single context. This context was either everyday consumer experience of price, a business perspective on price or a market perspective on price. This was distinct from BTs who focused on shifts between those contexts (as in Rows 2 and 3). A response typical of Row 2 would highlight students' everyday experience of the price of coffee at the lowest level (perhaps as a result of a visit to a coffee shop), then move to 'costs and revenue' at higher levels (typical of a business perspective). By contrast, a response typical of Row 3 would involve a move from everyday consumer experience or a business perspective to a market perspective. This might be presented in terms of a shift from a consideration of 'costs and revenue' or other internal factors, to a consideration of 'demand and supply'. Since the type of conception represented by Row 1 was a logical pre-cursor to those in Rows 2 and 3, it was interpreted as being a less sophisticated form of understanding.

The distinction between the rows in Table 6.1 echoes the distinction observed in the rows in Table 6.0. In Table 6.0, price as a result of individual business decisions was presented as being a less sophisticated conception than price as a result of market

outcomes. This is because a market perspective is more remote from direct experience and thus more abstract than an individual business perspective. Thus in Table 6.1, a shift in students' conceptions from those focused on individual experience to those focused on a business context was interpreted as being at a lower level than a shift from a business context to a market context.

6.3.1.3. Evidence of BTs' PCK

The quotations below illustrate the differences between the conceptions identified in Table 6.1. The parts of quotations that refer to the thinking of 14 year olds and that of 21 year olds are drawn from BTs' written comments, whilst the parts that refer to the rationale are drawn either from interview transcripts or from written comments. Hierarchies are presented in full whilst rationales are edited to highlight the key aspects.

Quotations 12 - 15 are all interpreted as relating to a single context (Row 1 in Table 6.1). In Quotation 12 there is a strong sense of the importance of everyday experience. This is emphasised when the BT states '14 year olds have been given a lunch budget for the day and will look at how much they can receive for that amount'. However it is difficult to discern a clear rationale for the order of the

suggested conceptions. For example, the notion of 'disposable income' seems to be emphasised for both the 14 year old (in Conception 1) and the 21 year old (in Conception 3) along with the notion of the price of substitutes (see Conception 2 for both 14 and 21 year olds). However it is not clear why for the 14 year old disposable income is placed above the price of substitutes and yet for the 21 year old it is placed below it. This sort of inconsistency is typical of BTs' responses that fell into Column A.

Quotation 12 (Q2) – Conception A1

Ways of student thinking - 14 year olds (in order of decreasing sophistication):

1. *Amount of money left over after lunch was paid for*
2. *Same price as another drink, but providing different options*
3. *Other products in canteen maybe cheaper way of getting more for your money*

Ways of student thinking – 21 year olds:

1. *Value for money*
2. *Costs against other products*
3. *Disposable income*

Rationale:

14 year olds may have been given a lunch budget for the day and will look at how much they can receive for that amount, providing that the student can get enough food then strategic pricing may place the 75p drink in that category. With the 21 year olds other aspects of budgeting may be taken into account, such as travel, car, the need for saving etc.

Another example of Conception A1 is given in Quotation 13 below. This BT emphasises the importance of experience in the rationale but this seems to bear little relation to the suggested sets of conceptions for the 21 year olds. Experience is given as a rationale for profit as a way in which 14 year old students might think about price. However, it is not clear why 'promotion', 'place' or 'some ethics' are below 'profit' or indeed why these are arranged in the order that they are. The ordering of conceptions for the 21 year old is also unexplained.

Quotation 13 (Q1) – Conception A1

Ways of student thinking - 14 year olds (in order of decreasing sophistication):

1. *Profit*
2. *Promotion i.e. competition*
3. *Place*

4. Some ethics

Ways of student thinking – 21 year olds:

1. Philosophically i.e. look into it more deeply

2. Economically i.e. demand, supply, recession

3. Socially i.e. the people in the developed countries, ethics of business

Rationale:

A lot of what young people see today in the media goes back to money……so profit would be a main agenda for a company…..looking at the outside world and the effect of economic conditions I feel would be more relevant to 21 year olds. The reason for this is that many will be in the working world themselves…..and they will have more life experience and so more in depth discussions can occur…

Quotations 14 and 15 below are illustrative of Conception B1. Both refer to multiple factors combining to determine price. In Quotation 14, lower level conceptions of price are not imagined as including a consideration of costs, whereas high level conceptions are based on costs and an understanding of the impact on profit of the canteen's status as the single seller of coffee. In Quotation 15, the conceptions for 14 year olds include both demand (Conceptions 1 and 2) and supply (Conceptions 3 and 4). These are combined in the conceptions for 21 year olds, where supply *and*

demand is presented as the highest conception. In this case the rationale provided by the BT supports this, with supply and demand being presented as a complex, 'in depth' idea.

Quotation 14 (Q2) – Conception B1

Extract from suggested rationale:

Some students will assume that the school canteen is just there to make money and will ignore the costs behind production. Some students will be sceptical and assume that the canteen will take advantage of their position as the sole trader for coffee. Some students will combine this and reason that the price is based on the canteens position and profit making.

Quotation 15 (Q1) – Conception B1

Ways of student thinking - 14 year olds (in order of decreasing sophistication):

1. *What consumers are willing to pay*
2. *Competition*
3. *Transportation*
4. *Price of materials*

Ways of student thinking – 21 year olds:

1. *Supply and demand*
2. *Competition*
3. *The skill of the workers*

Rationale:

I feel that 14 year olds would not have much understanding or would not have been introduced to supply and demand context at that age. They would think of more basic factors rather than in depth. However, for a 21 year old who may have been to university (they) would understand demand and supply a bit better.

In this study, there were no BTs who were judged to have exhibited Conception C1 in Table 6.1 and therefore it is not possible to provide an illustration of this. Although the existence of Conception C1 can be logically inferred from the organisation of components of both the internal and external horizons, it cannot be confirmed. The scarcity of the more sophisticated conceptions of price suggests that this could be a result of the sample size in this study.

Quotations 16 - 19 illustrate Row 2 of Table 6.1. Quotation 16 suggests a shift in context from a 'focus on themselves' (everyday experience) to digging 'deeper into aspects of business' (business context). In this case it is not just a matter of increasing

experience in order to develop a more sophisticated understanding (as in Quotation 12), it is about analysing the 'business impact' of pricing decisions. In Quotation 17, the BT's rationale refers to a shift from experience to 'not taking the price at face value'. That this shift represents a business perspective is supported by the difference between the suggested conceptions for the 14 year old (based largely on direct experience) and the suggested conceptions for the 21 year old (based largely on business concepts). This conception is classified as Conception A2 in Table 6.1 because it is not easy to discern an explicit basis of the differences between conceptions.

Quotation 16 (Q2) – Conception A2

Rationale:

14 year olds tend to focus on themselves and therefore any answer that is not directly related to themselves is seen as quite sophisticated. At 21 students are more about how the world works. They begin to analyse the business impact of such decisions and they dig deeper into the different aspects of business. What are the internal and external factors involved in producing coffee for the school canteen?

Quotation 17 (Q2) – Conception A2

Ways of student thinking - 14 year olds (in order of decreasing sophistication):

1. *Most students would price according to the price in their own school canteen*
2. *Some students would price lower as they have no like of coffee*
3. *Some students would price lower as they believe students can't afford 75p*
4. *Some students may price higher as they are not thinking of consequences to students or demand*
5. *Some students would keep price the same as they believe it would require less thought as the previous owner had it at 75p*

Ways of student thinking – 21 year olds:

1. *Set price according to demand figures*
2. *Conduct market research*
3. *Set price according to the average price of coffee purchased by the student*

Rationale:

The answers to question 1 have been placed as they have because I believe that 14 year old students would price according to their own experience, setting and surroundings. Whereas, 21 year old students have more life experience and assuming more academic knowledge. Therefore, research to them would be crucial as oppose(d) to taking a price at face value.

Quotation 18 below refers to a change from one to many factors (Column B in Table 6.1). This is implied by the inclusion of the notion of 'profit/breakeven' as representing a more sophisticated conception. 'Breakeven' combines the ideas of sales, costs and profit, as this BT points out. Quotation 18 also includes a shift from a personal experience, where price is related to 14 year olds perceptions of the relative price of a cup of coffee, to a business context, where 21 year olds 'think more about business terms'. However no explicit structure to student conceptions is offered. A similar pattern is evident in Quotation 19. Again the rationale refers to 'break-even points' as the 'most advanced' idea (although this is not directly reflected in the suggested conceptions). That this BT states that 21 year olds will come into contact with more businesses and have a better idea of basic concepts suggests a move from an individual perspective on price to a business perspective.

Quotation 18 (Q1) – Conception B2

Rationale:

A group of 14 year olds may think that a cup of coffee is expensive for example, they may not have enough money to buy a cup of coffee……..this does not require 14 year olds to think too much, it is an observation on pricing. 21 year olds will think

more about business terms for example, sales, costs and profit……I feel that profit/breakeven is most important as pupils start thinking why sell cups of coffee.

Quotation 19 (Q2) – Conception B2

Ways of student thinking - 14 year olds (in order of decreasing sophistication):

1. *The school sells at the price it can make most profit*
2. *They may think the school has based its prices on outside coffee makers*
3. *Students at this age may think the school sells it at the price they buy it for*
4. *They may not be particularly bothered as coffee does not interest them*

Ways of student thinking – 21 year olds:

1. *They may think the school has set a target for how much they should make from coffee sales*
2. *They may think the school has thought about its prices in relation to its other products*
3. *They will think the school wants to make profit and have a better understanding of the cost*

Rationale:

In regards to 14 year olds, most do not know much about business concepts……in regards to 21 year olds my answers are based on the view that as they will come into

contact with more businesses, they may have a better idea of basic concepts……at the most advanced, students may have a grasp of break-even points and a business trying to cover its costs first to be successful.

There was only one BT who exhibited Conception C2. This BT presented a set of conceptions that were quite tightly nested within each other (particularly in relation to the 21 year olds). However, these were only set in a market context. The use of the terms 'buyers' and 'sellers' and 'producers' and 'consumers' is strongly indicative of this. The BT explains the difference between conceptions in terms of 'awareness of the coffee market' or of some conceptions being 'more basic' than others. However, it is not possible from the data provided to be sure what these phrases mean. It is not clear whether this BT does not have a rationale for differences or that it has not been revealed in this evidence. As a result, Quotation 20 was classified as Conception C2.

Quotation 20 (Q1) – Conception C2

Ways of student thinking - 14 year olds (in order of decreasing sophistication):

1. *Compromise between producer and consumer*
2. *Power of buyers over sellers*
3. *Amount of coffee drunk in the world*

4. *Price charged by producers*

Ways of student thinking – 21 year olds:

1. *Compromise between producers and consumers, taking into account external factors*
2. *Power of buyers as they don't want to pay too much*
3. *Incentive by producers to encourage buyers to buy their product.*

Rationale:

For 21 year olds there is more awareness of the coffee market and difficulties in trade between developed and developing parts of the world. This is taken into account at all 3 levels. 2 and 3 are fairly similar but look at the issue from different perspectives. 14 year olds have less awareness of the coffee market with this only being apparent at the top of the pyramid. The lower levels are much more basic than lower levels for the 21 year olds.

The final set of quotations (21 - 24) refer to Row 3 in Table 6.1. Quotation 21 is one of a very small number of examples of Conception A3 where there is a move from a business context to a market context for price. This is seen in the difference between the conceptions for a 14 year old, which are mainly business oriented (particularly Conceptions 3 and 4), and those of the 21 year old, which are market oriented

(referring to general features of markets – such as scarcity and market power). The rationale – whilst in note form – also provides some support for this in focusing on costs and production techniques (business oriented ideas) as being 'easy to imagine' with subsidies and regulation (more market oriented ideas) being more complex because they are not 'so direct'. There is no corresponding rationale for qualitative differences between conceptions in Quotation 21, however. For example, there is no sense given as to why 'profit of coffee companies' should be a less complex idea than 'transport and farmers costs'. In fact, it might be expected that the reverse is true. Quotation 22 also contains no clear reasons for the qualitative differences between particular conceptions and yet does present a shift in context, this time from everyday consumer experience to a market context. The market context is most strongly indicated by the phrase 'macro relationship' and in the idea of connecting 'two themes together' (where those themes might be assumed to be the personal and the market).

Quotation 21 (Q1) – Conception A3

Ways of student thinking – 14 year olds (in order of decreasing sophistication):

1. *Transport and farmers costs*
2. *Weather and product techniques*

3. *Profit of coffee companies*

4. *How it is marketed, TV adverts, radio*

Ways of student thinking – 21 year olds:

1. *Trade agreements, tariffs, subsidies*

2. *Demand for product*

3. *Scarcity of product*

4. *Existence of powerful multi-national companies*

Rationale:

Transport and farmers costs are easy to imagine awareness of coffee beans grown abroad – transport costs. Idea that production technique affect the amount of production. 21 year olds very aware of multi-national companies and understand they 'rip off' farmers. Hardest concept is how UK subsidies and regulations may affect farmers in the tropics because they are not direct.

Quotation 22 (Q1) – Conception A3

Ways of student thinking – 14 year olds (in order of decreasing sophistication):

1. *Supply – general category if you produce something and make it scarce it can affect the price*

2. *Competitors – competitive rivalry in supermarkets could change the price of coffee*

3. *Weather – if there was a drought crops could be destroyed and coffee prices affected*

Ways of student thinking – 21 year olds:

1. *Substitutes – if goods become less expensive people may switch to another commodity*
2. *Advertising – a strong media tool that can be persuasive and affect the price of coffee*
3. *Exchange rate – the exchange rate can affect the price of imports*

Rationale:

Younger students will be able to say my 3 answers about the price of coffee as my categories are something they are familiar with on a day to day basis…….(21 year olds) will be able to make the connection to a more 'macro' relationship i.e. exchange rates. They will also understand that shopping around for the best good will also affect the price. They will probably do this on a day to day basis and therefore will connect the two themes together and make the link.

In comparison to Quotations 21 and 22 above, Quotation 23 offers a combination of factors as representing higher levels of sophistication. It does this in its reference to 'supply and demand' for 21 year olds and 'price elasticity' for 14 year olds (price elasticity represents a combination of a change in price in relation to a change in

demand). The rationale implies that lower level conceptions are based on students' experience (at Starbucks) and that high level conceptions 'relate back to theory'. Given the use of the terms 'subsidy', 'price elasticity' and 'supply and demand' this 'theory' is interpreted as being illustrative of a market perspective. Quotation 24 follows a similar pattern. The move from an everyday consumer experience to a market context is signalled by this BT's reference to 14 year olds viewing price 'personally or on a small scale' and 21 year olds being in a position to 'apply grander economic theories'. This may be supported to some extent by the hierarchy that is proposed for 14 year olds, where Conceptions 3 and 4 are more business related and Conceptions 2 and 1 are more market related.

Quotation 23 (Q2) – Conception B3

Ways of student thinking - 14 year olds (in order of decreasing sophistication):

1. *Price elasticity*
2. *Subsidies*
3. *Costs*
4. *Market research*
5. *Competitors prices*

Ways of student thinking – 21 year olds:

1. *Supply and demand*
2. *Price elasticity (higher level)*
3. *Subsidies*

Rationale:

I feel that students would come up with answers that are more practical to them at the beginning. From their experience as consumers you should be able to relate it back to theory…….a student is quite likely to notice that a Starbucks coffee is far more than 75p. From here it will probably be easy to move them on to different costings and subsidies.

Quotation 24 (Q1) – Conception B3

Ways of student thinking – 14 year olds (in order of decreasing sophistication):

1. *Price elasticity of demand*
2. *Supply and demand*
3. *Pricing Strategies*
4. *What they pay for coffee*

Ways of student thinking – 21 year olds:

1. *Competitive advantage*
2. *Market demands*

3. *Purchasing power*

Rationale:

I feel 14 year olds will view the task personally or on a small scale. Unable to see the global and political issues that will have an impact. They will think of it as a simple pricing strategy as any normal shop would sell coffee for. Older students should be able to apply grander economic theories to the question. Older students will be able to see it less personally and better analyse issues that may come into play.

The final two quotations illustrate the highest conception (C3 in Table 6.1). In Quotation 25 there is a fairly clear set of propositions that are nested within each other, moving from 'what they know' through demand and supply factors to an 'interaction to give equilibrium price'. A shift from an individual/business perspective (highlighted in the phrase 'experience from supermarkets') to a market context (highlighted in the idea of an *interaction* between supply and demand) also appears to be present. In Quotation 26 there is a move from students' direct experience of business (represented as something that they would 'talk more easily about') to a market perspective where demand and supply is highlighted. Conceptions 3, 4 and 5 identified by the BT for 14 year olds seem nested together in the sense that costs precede a calculation of profits which (if a cost plus model is

assumed) could be said to lead to market price. Then moving to a market perspective in Conceptions 1 and 2, 'supply' is followed by 'demand' and then 'supply and demand' (Conception 3 for the 21 year old). Finally Conceptions 2 and 1 for the 21 year old could both be seen as macro-economic factors bearing on the operation of supply and demand (although it is not clear why they are in the order that they are).

Quotation 25 (Q1) – Conception C3

Rationale:

The most basic answer will assume suppliers set the price and people buy the product (ignoring demand), more complete answers will factor in demand, how supply and demand interact to give equilibrium price and the factors that affect the quantity supplied/demanded. The students will base their preconceptions on what they know about price (experience from supermarkets)…they might understand demand and supply etc. but only as a limited concept.

Quotation 26 (Q1) – Conception C3

Ways of student thinking – 14 year olds (in order of decreasing sophistication):

1. *Demand for coffee up or down*

2. *Supply of coffee up or down*

3. *Market price*

4. *Profit margins*

5. *Production costs*

Ways of student thinking – 21 year olds:

1. *Inflation*

2. *State of economy*

3. *Supply and demand*

Rationale:

I feel the younger students would talk more easily about profit margins and costs than talking about supply and demand and how it affects pricing. The much older students would talk and include aspects of inflation, the state of the economy alongside supply and demand when explaining factors affecting the price of coffee. This would be because at 21 you would have a better understanding and knowledge to analyse the external factors affecting price rather than just talking about profit and other internal factors such as production costs.

6.4. Issues in the analysis of evidence of CK and PCK

6.4.1. Classifying BTs' conceptions

In developing the classification of CK and PCK presented in Tables 6.0 and 6.1, a number of issues arose in relation to the interpretation of data. BTs were given two opportunities to demonstrate an explicit basis for their understanding of qualitative differences. First, in the hierarchy of conceptions that they proposed and second, in the rationale (provided either in the written responses, or for a smaller number, in interviews). Where the BT's rationale tied up well with the suggested conceptions this presented few difficulties. However where the link was less clear, researchers referred to both the rationale and the suggested conceptions in making a judgement about the highest conception that was being expressed.

Basing these judgements solely on the relatively short written answers provided by some BTs and the relatively few words describing each conception that were given by other BTs, opens up the risk of not capturing fully any underpinning rationale. However, evidence from the interviews that were undertaken suggests that this problem was not particularly significant. Of the 16 interviews that were conducted, only 2 revealed conceptions higher than that displayed in the written test (and in these cases the interview conception was only one 'step' higher).

Another challenge in the interpretation of evidence from BTs was in relation to Column B of Table 6.0. There was a possibility that BTs who referred to 'demand and supply' for example, were presenting this as a single idea rather than as a combination of ideas. In other words, these BTs were just using a phrase that they associated with the idea of price but to which they did not necessarily attach its full meaning. In order to counter this, BTs' conceptions were only classified in Column B if there were other aspects of 'demand and supply' presented in their other suggested conceptions. This principle was applied to all instances where factors related to demand and supply were combined.

6.4.2. Ranking BTs' conceptions

In order to make use of the conceptions laid out in the previous section to analyse BTs' CK and PCK, it was necessary to rank these conceptions. As noted above (Section 2.4) previous studies into price (e.g. Pang & Marton, 2005; Marton & Pang, 2008) have varied in their rankings of the same conception. There was a shift from treating supply and demand as being qualitatively different (in 2005) to treating them as qualitatively the same (in 2008). It was argued in Section 2.4 that the 2005 study may have bought in teachers' first-hand experience of students' difficulties to

decide on the relative importance of supply and demand. By contrast, the 2008 study treated supply and demand as if they were just 'factors' to be considered (an approach akin to that suggested by the SOLO taxonomy).

The difficulty with the first approach (if this was the reason) is that it was not made explicit. The difficulty with the second approach is that it assumes that the factors of demand and supply are qualitatively the same without presenting evidence that this is the case. Therefore the general question arises as to how conceptions should be ranked. This question gains an added significance and complexity when conceptions are discovered to be arranged along two dimensions in a grid, as in this study. Although phenomenography does not exclude the possibility of non-linear hierarchies of conceptions, guidance on how to decide on relative rankings in these circumstances is limited to the search for differences in 'complexity' (Pang & Marton, 2005).

In order to address this question, it was helpful to consider whether there were any a priori reasons for viewing particular conceptions in Tables 6.0 and 6.1 as being more complex than others. In terms of CK, it might be expected that moving from Column A to Column B would be relatively easily addressed by BTs (particularly given that

BTs have studied the subject at degree level). This is because it only involves a move from considering supply or demand to considering supply and demand. The step to Columns C and D might be expected to be more challenging given that they both relate to interactions between supply and demand. It might also be thought that a movement from Column A to Column B would be more difficult than a shift from Row 1 to Rows 2 and 3. This is because the step from Row 1 to Row 2 requires a move from an individual perspective to a market perspective, whereas the step from Row 2 and Row 3 is a step *within* a market perspective. In this sense a move from Row 2 to Row 3 would be of the same order of difficulty as a move from Column C to Column D.

Turning next to PCK, it might be expected that a move from Column A to Column B might be relatively straightforward, with a more significant step to Column C. Given the requirement to suggest conceptions that pass through a number of contexts (Row 3, Table 6.1) and that have a strong internal structure (Column C, Table 6.1), it would be expected that many BTs would find this very challenging indeed.

To test these a priori suppositions the pattern of BT responses was analysed in the light of the empirical evidence. The results of this analysis can be seen below in Section 6.5.1.3.

6.5. The effects of teacher training on BTs' CK and PCK

In this section, the effects of teacher training on BTs' CK and PCK are presented. This begins with a description of some general findings in relation to the nature of the sample and the rankings that were assigned to BTs' conceptions, the distribution of BTs' conceptions and the relationship between CK, PCK and BTs' prior knowledge (as measured by the classification of their first degree). Next follows an analysis of comparative changes in CK and PCK for the Learning Study Group (LSG) and the control group. These are organised first into descriptive statistics and second into the results of the Wilcoxon signed-rank test analysis. Following this section, the associations that were found between CK and PCK are presented.

6.5.1. Describing BTs' CK and PCK

6.5.1.1. The sample of BTs

The following data is drawn from 116 BTs who responded to the pre-test. Of these, 114 completed the CK pre-test and 111 the PCK pre-test. This meant that there was a data set of 111 BTs' CK and PCK. The post-test involved 84 responses in relation to CK and 85 for PCK. This resulted in a set of 83 paired answers across both CK and PCK, with 4 data collection points for each of the 83 BTs.

In the group of matched pairs, 18 BTs were involved in the LSG and 65 in the control group. In the pre-test, in the control group, 8% of BTs reported having previously taught a lesson price, whereas in the post-test the figure was 90%. For the LSG these figures were 6% in the pre-test and 100% in the post-test. No university involved in the study reported having conducted any subject specific sessions related to the teaching of price during training.

Of the 83 paired answers in the study, 48% of BTs completed a price problem set in a market context (see Appendices 10.1 and 10.3) and 52% of BTs completed a price problem set in a business context (see Appendices 10.2 and 10.4). Of those completing the market context problem, 15% displayed a business conception in the

pre-test and 10% in the post-test. Of those completing the business context question, the figures were 7% and 5% respectively. These figures are potentially significant because they suggest that the context within which the question is set is not always mirrored in the conceptions that BTs reveal.

6.5.1.2. The distribution of BTs' conceptions

The percentage of BTs demonstrating each CK and PCK conception is set out in Table 6.2. This shows that for CK, there are three broad groups of BTs: i) those that exhibited the most common conception (Conception B1) with 32% of BTs in the pre-test and 39% in the post-test, ii) those that exhibited a 'middle' group of conceptions (consisting of Conceptions A1, B2, C2 and D2) that were all within a fairly narrow range of 12 – 16% in both pre and post-tests and, iii) those that exhibited the other conceptions where the percentage of BTs ranged between 0 - 4%. BTs' conceptions appeared clustered towards the lower end, with 47% showing either Conceptions A1 or B1 in the pre-test, and 53% in the post-test.

For PCK, there was also a single conception that was predominant in both pre and post-tests (Conception B1). In addition, there were a number of conceptions that were shown by less than 7% of BTs. These were Conceptions A3, C1, C2, C3 and the

post-test result for Conception A2. Other conceptions ranged between 9 - 23% of BTs. As for CK, the conceptions again seemed to be concentrated at the lower end, with 52% in the pre-test showing Conceptions A1 or B1 and 57% in the post-test. There seemed to be less consistency between pre and post-test percentages for PCK than CK (for example, there were relatively larger percentage falls in Conception A1 for PCK and relatively larger rises for Conception B1).

Table 6.2 – Percentage of BTs with different conceptions in pre and post-tests

Conception	Percentage of BTs			
	CK Pre-test (n=114)	**CK Post-test (n=84)**	**PCK Pre-test (n=111)**	**PCK Post-test (n=85)**
A1	15	14	23	16
B1	32	39	29	41
C1	4	4	0	0
D1	3	1		
A2	3	1	12	6
B2	16	12	13	18
C2	15	12	0	4
D2	13	12		
A3	0	0	3	1
B3	1	0	13	9
C3	0	1	6	5
D3	1	4		

6.5.1.3. Ranking BTs' conceptions

In order to proceed with the statistical analysis, it was necessary to develop a method of ranking the conceptions that had been established in Table 6.0 and Table 6.1. Section 6.4.2 above set out the a priori case for the way in which conceptions might be ranked. In this section, these proposed rankings are tested in the light of the empirical evidence of the distribution of BTs' conceptions.

This was done by analysing the number of BTs exhibiting each conception. Thus a BT who was classified as Conception A1 would by definition have addressed Conception A1. A BT with Conception C1 would have addressed Conception B1 and Conception A1, whilst a BT with Conception B2 would have covered A1, A2 and B1 in addition. The percentages of BTs responding in this way in pre and post-tests and overall are given in Table 6.3 below (for CK pre-test n=114/post-test n=84, for PCK pre-test n=111/ post-test n=85). Since there were no BTs that fell outside of the categorisation developed, the values for Conception A1 for both CK and PCK are 100%.

Table 6.3 – Percentage of conceptions exhibited by BTs

	Conceptions											
	CK (pre-test n=114, post-test n=84)											
	A1	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	**D1**	**D2**	**D3**
% in pre-test	100	46	3	82	43	2	34	27	1	17	14	1
% in post-test	100	41	5	86	41	6	33	28	5	16	15	4
% overall	100	44	4	84	43	4	34	28	3	17	15	2
	PCK (pre-test n=111, post-test n=85)											
	A1	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**			
% in pre-test	100	47	23	65	34	19	6	6	6			
% in post-test	100	42	15	77	35	15	9	7	5			
% overall	100	45	20	70	35	18	7	6	5			

Looking at both CK and PCK, the data largely supports the a priori reasoning given in Section 6.4.2. Turning initially to BTs' overall CK, Conceptions A1 and B1 are easily the most straightforward (with 100% and 84% of BTs respectively). Conceptions A2 and B2 are at about the same percentage (on 44% and 43% respectively). This suggests that the difference in difficulty between Row 1 and Row 2 (for Conceptions A1 and A2) is greater than that between Column A and Column B (for Conceptions A1 and B1). Conception C1 looks to be more difficult (with 34% of BTs) followed by Conception C2 (with 28%). Row 3 proved very challenging for BTs, with only 4% of BTs demonstrating Conceptions A3 and B3 and 3% and 2% demonstrating Conceptions C3 and D2 respectively. This is consistent with the idea that Row 3 conceptions were all of approximately equal difficulty.

An analysis of the PCK data reveals a similar pattern. Here, there is also a pronounced difference between responses in Row 1 for Conceptions A1 and B1, and Responses in Rows 2 and 3. As for CK, Conceptions A3 and B3 are at approximately the same level (with 20% and 18% respectively), whilst Column C proved challenging for BTs, with a low number of responses here. In contrast to the CK percentages, there is an apparent difference between Conceptions A2 and B2 (45% as against 35%) and therefore these were interpreted as being at different levels of difficulty.

As a result of this investigation, the following rankings were developed where 1 is the least sophisticated and 8 the most sophisticated (see Table 6.4). These rankings are dependent upon this being a representative sample of BTs and on judgements made in relation to the significance of differences between percentages. The proposed rankings however are lent support from the good level of consistency that exists between the percentages in the pre-test and those in the post-test (for both CK and PCK).

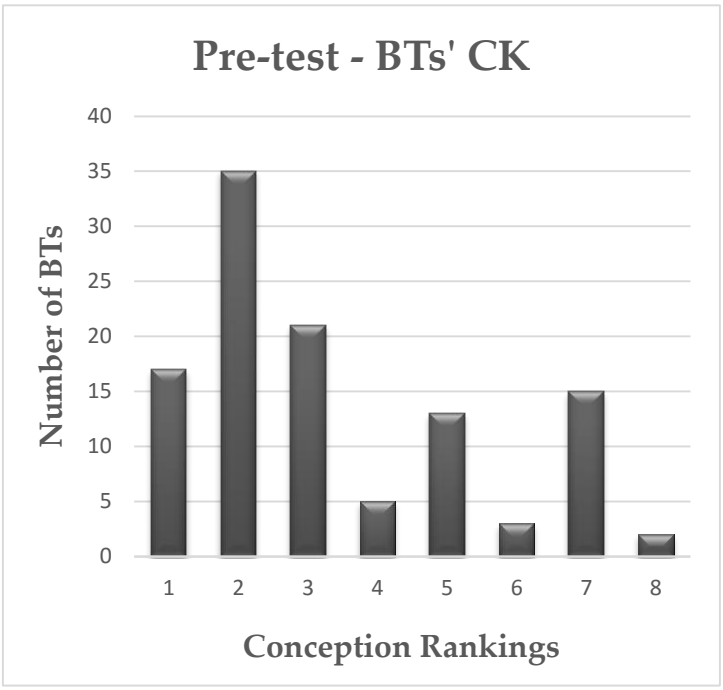
Table 6.4 – Ranking of BTs' conceptions

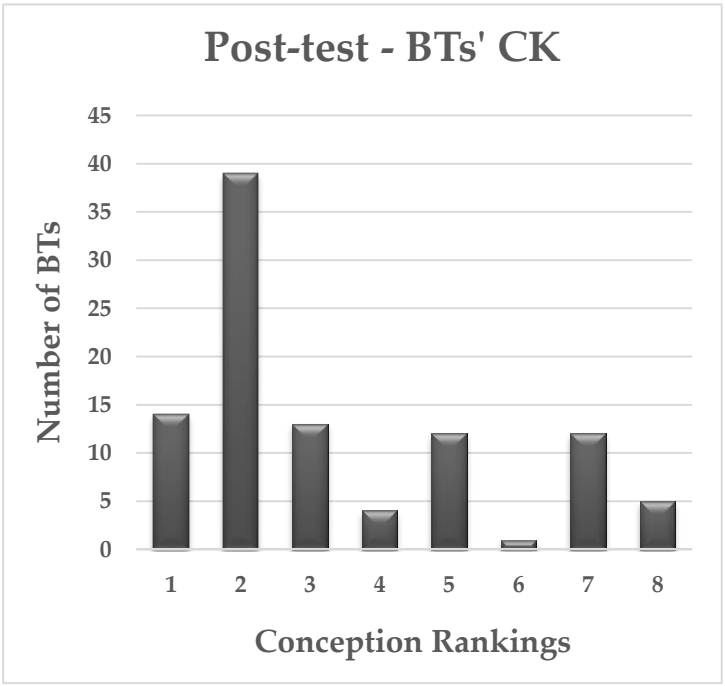
CK – Conceptions	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	**D1**	**D2**	**D3**
Ranking	1	3	8	2	3	8	4	5	8	6	7	8
PCK - Conceptions	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**			
Ranking	1	3	5	2	4	5	6	6	6			

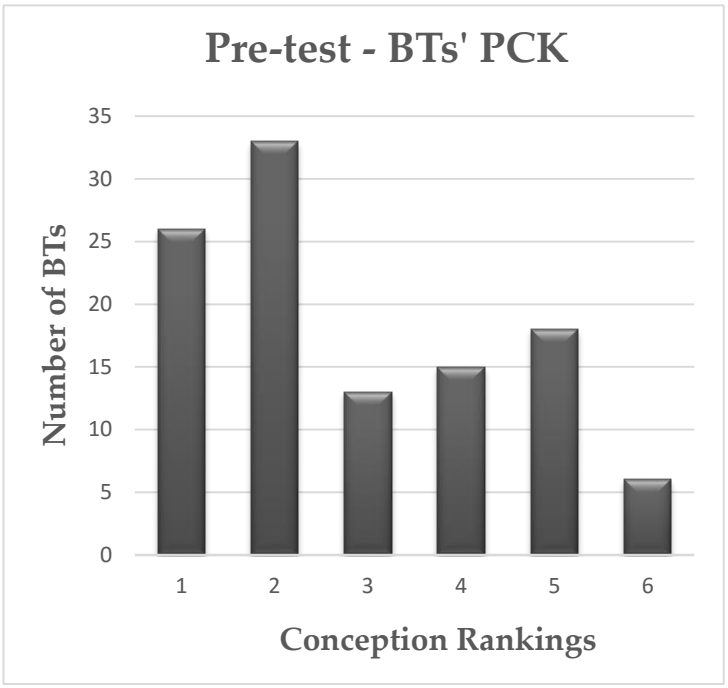
6.5.1.4. The distribution of BTs' ranked conceptions

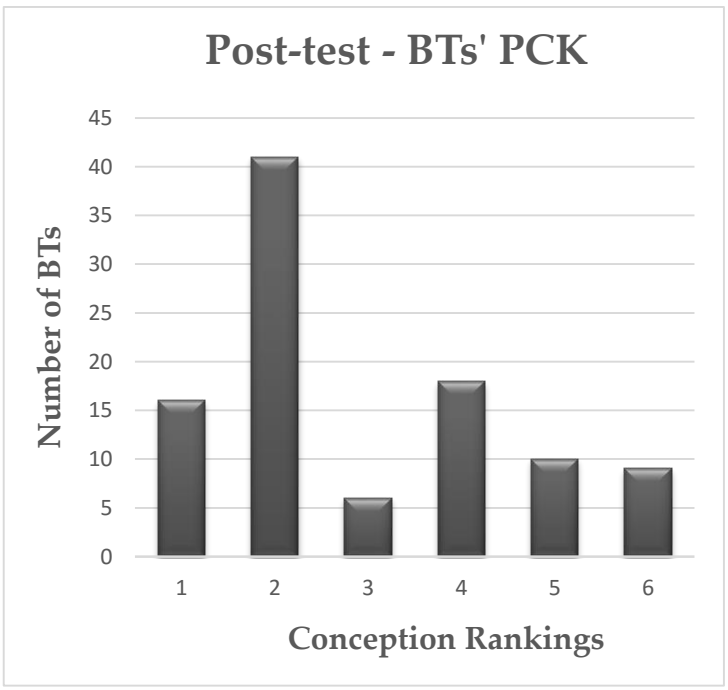
The pre and post-test frequencies of BTs' conceptions of CK and PCK are represented in the histograms in Figure 6.1. Here the number of BTs' is plotted against the ranking of their revealed conceptions.

Figure 6.1 – Histograms to show the distribution of BTs' CK and PCK






Pre-test - BTs' PCK
Number of BTs
35
30
25
20
15
10
5
0
1
2
3
4
5
6
Conception Rankings


Post-test - BTs' PCK
Number of BTs
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
Conception Rankings

A visual analysis of the histograms suggested that in all four cases the data was not normally distributed, being skewed to the right. This was confirmed through a calculation of skewness which returned a positive value (see Table 6.5) and Kolmogorov-Smirnov and Shapiro-Wilk tests that returned a significance of $p<0.001$ (see Table 6.6). In addition, applying a rule of thumb test by dividing the values for skewness and kurtosis by their standard error did not give figures within the range of +/- 1.96 (see Table 6.5).

Table 6.5 – Skewness and kurtosis for CK and PCK

		All BTs (pre-test n=111/post-test n=83)	
		CK	**PCK**
Skewness	**Pre-test**	0.77	0.47
	Standard error	0.27	0.23
	Post-test	0.91	0.65
	Standard error	0.26	0.26
Kurtosis	**Pre-test**	-0.68	-1.07
	Standard error	0.46	0.46
	Post-test	-0.52	-0.74
	Standard error	0.52	0.52

Table 6.6 - Kolmogorov-Smirnov and Shapiro-Wilk tests of CK and PCK

	Kolmogorov-Smirnov test			Shapiro-Wilk test		
	Statistic	**Df**	**Sig**	**Statistic**	**Df**	**Sig**
CK Pre-test	0.23	111	0.00	0.86	111	0.00
PCK Pre-test	0.24	111	0.00	0.86	111	0.00
CK Post-test	0.27	83	0.00	0.83	83	0.00
PCK Post-test	0.30	83	0.00	0.80	83	0.00

6.5.1.5. BTs' CK and degree classifications

BTs' first degree results were ranked according to whether they achieved a first class honours, an upper second class honours or a lower second class honours. Of the 107 BTs for whom there is data in the pre-test, 13% attained a first class degree, 47% attained an upper second and 40% a lower second. Of the 105 BTs who gave data, 19% had first degrees that contained economics within the title and 81% were business related.

The correlation between BTs' first degree classification and their levels of CK and PCK was analysed using Kendall's Tau b. The results below (Table 6.7) are based on 107 BTs in the pre-test comparison and 80 in the post-test.

Table 6.7 – Correlation between BTs' first degree classifications and CK/PCK

	CK Pre-test	PCK Pre-test	CK Post-test	PCK Post-test
Kendall's Tau b	-0.40	0.07	0.66	-0.18
***p* value**	0.63	0.50	0.44	0.85

These results do not indicate any correlations that are statistically significant. This was confirmed through the application of a Kruskal-Wallis test which also returned no correlations of any statistical significance.

6.5.2. Comparing BTs' pre and post-test CK and PCK

6.5.2.1. BTs' average conceptions of CK and PCK

Data related to BTs' median, mean and mode rankings of CK and PCK in pre and post-tests are laid out in Table 6.8.

Table 6.8 – Median, mean and mode BT rankings for CK and PCK

		Control group (n=65)		Learning Study Group (LSG) (n=18)	
		CK	**PCK**	**CK**	**PCK**
Median ranked conception	**Pre**	3.00	2.00	2.00	2.00
	Post	2.00	2.00	3.50	3.50
Mean ranked conception	**Pre**	3.29	2.89	3.44	2.55
	Post	3.16	2.60	3.94	3.61
Mode ranked conception	**Pre**	2.00	2.00	1.00	2.00
	Post	2.00	2.00	2.00	2.00

Looking first at the median ranked conceptions, the evidence indicates that for the control group, the rank for CK fell (from 3.00 to 2.00) and remained the same for PCK (at 2.00). By contrast, in the LSG, the median value rose by the same amount for both CK and PCK (1.50). The data in relation to the mean broadly echoes these findings. For both CK and PCK in the control group, the mean fell by a small amount (by 0.13 and 0.29), whilst for the LSG it rose. In the case of PCK for the LSG, this rise appears to be particularly substantial (an increase of 1.06). The mode ranked conception was 2.00 for all pre and post-tests, apart from the pre-test for the LSG, where the figure was 1.00.

6.5.2.2. BTs' overall performance in pre and post-tests

In Table 6.9, a breakdown of BT performance in pre and post-tests is given. This shows the percentage of BTs whose rankings in post-tests either increased, decreased or stayed the same in relation to the pre-test results.

Table 6.9 – BTs' relative performance in CK and PCK in pre and post-tests

		Control group (n=65)		Learning Study Group (LSG) (n=18)	
		CK	**PCK**	**CK**	**PCK**
Pre vs post-test rankings (% of BTs)	**Post > Pre**	21	32	44	56
	Post = Pre	48	28	44	39
	Post < Pre	31	40	12	5

This data indicates that 21% of the control group showed a higher level of conception in the post-test in relation to CK, with 32% showing a higher level of PCK. By contrast, 44% of the LSG displayed an increase in the sophistication of the conception of their CK, with a 56% increase in terms of PCK. A much higher percentage of the control group than the LSG demonstrated a lower level of conception in the post-test than in the pre-test. Compared to 12% (for CK) and 5% (for PCK) in the LSG, 31% and 40% of the control group fell in terms of the conception shown.

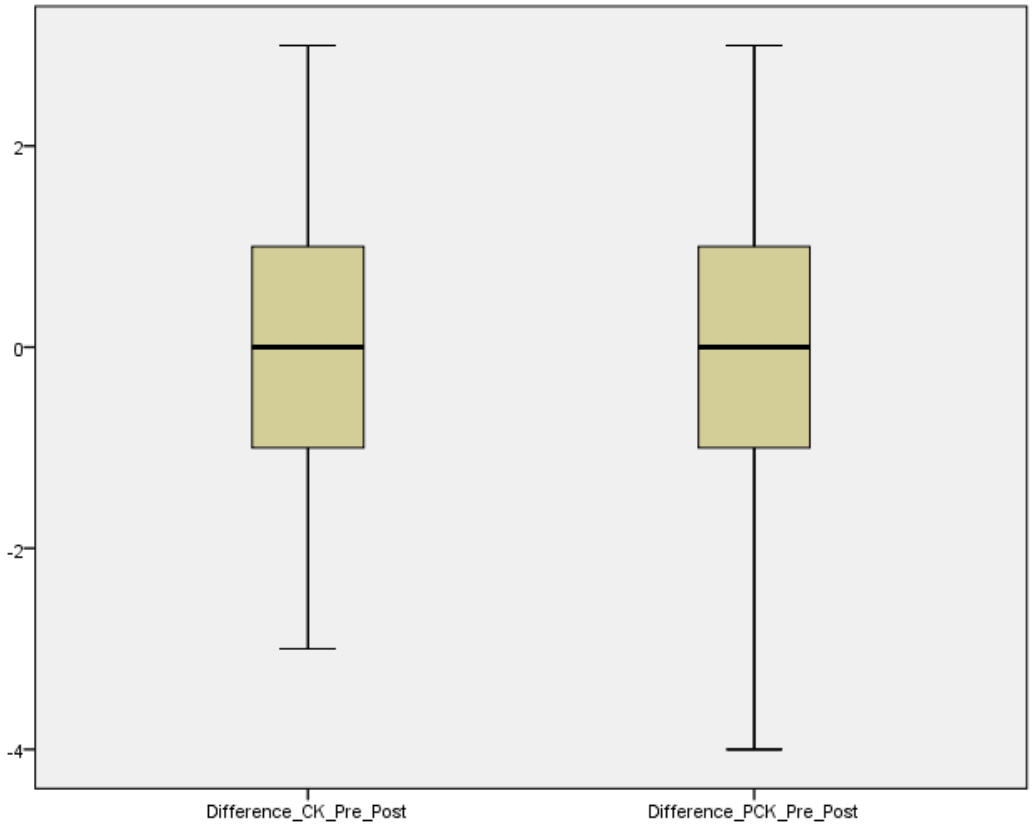
For the control group, of those BTs that exhibited a fall in ranking, the average fall was 1.59 for CK and 2.07 for PCK, with 46% of BTs showing a fall of only 1 ranking for CK and 41% for PCK. In the LSG, of those BTs that exhibited a fall in ranking, 2 BTs fell by 1 rank in their CK whilst 1 fell by 1 rank in terms of PCK. In both the control group and LSG, nearly half of BTs showed no changes in their CK (48% for

the control group and 44% for the LSG), whilst 28% and 39% of BTs showed no change in their PCK.

6.5.2.3. Significance of comparisons of pre and post-test CK and PCK

Given that the data related to CK and PCK was not normally distributed, the statistical significance in the differences between the pre and post-test was analysed using the Wilcoxon signed-rank test. As set out in Section 5.9.6.4, this tests requires three assumptions. This study meets the first two of these assumptions because the dependent variables (CK and PCK) are measured at the ordinal level and because the independent variable consists of two categorical matched pairs (83 in total). This means measuring the same BT twice against the same dependent variables. The third assumption is that the distribution of differences between the two related groups should be symmetrical (Sprent, 1998). This was checked by constructing a box plot of the distribution which showed that for both CK and PCK the distribution was symmetrical. There were no outliers identified in this analysis (Figure 6.2).

Figure 6.2 – Distribution of differences between pre and post-test CK and PCK



The results of the Wilcoxon signed-rank test are shown in Table 6.10 along with the associated *p* values and effect sizes.

Table 6.10 – Wilcoxon signed-rank test for the control group and the LSG

	Control group (n=65)		**Learning Study Group (LSG) (n=18)**	
	CK	**PCK**	**CK**	**PCK**
Z score	0.73	1.15	1.20	2.71
***p* value**	0.47	0.25	0.05	0.01
Effect size (r)			0.33	0.45

For control group BTs, this test did not highlight a statistically significant effect for either PCK or CK. In both cases, p was greater than 0.05. However, for BTs undertaking Learning Study at the level $p = 0.05$, there is sufficient evidence to conclude that the Learning Study intervention had a beneficial effect on CK and PCK. Calculation of the effect size indicated that this was a medium/large effect (Cohen, 1988) for both CK and PCK with the effect on PCK being larger than on CK (CK = 0.33 and PCK = 0.45).

6.5.3. The associations between BTs' CK and PCK

In order to examine the association between BTs' CK and PCK, Kendall's Tau b was calculated using the ranking data. The high proportion of ties in BT rankings made this a particularly appropriate test to use. A scatterplot was drawn to assess whether a monotonic relationship existed between CK and PCK. Plots of both pre and post-tests data were inconclusive in this regard. Given the existence of good a priori arguments for a positive correlation between CK and PCK (and therefore a monotonic relationship) and other evidence to support this correlation (e.g. Kraus et al., 2008), it was decided to proceed with Kendall's Tau b. This was undertaken for all BTs completing both pre-tests (n=111) and post-tests (n=83). Results can be seen in Table 6.11.

Table 6.11 – Correlation between BTs' pre and post-test CK and PCK

	Correlation between CK and PCK pre-test (n=111)	Correlation between CK and PCK post-test (n=83)
Kendall's Tau b	0.22	0.22
***p* value**	0.00	0.01

These results indicate that there is a weak but statistically significant positive correlation between CK and PCK. The correlation between CK and PCK was identical in the post-test to that in the pre-test.

6.6. Summary of results

This chapter has consisted of two main sections. The first section presented the results of a phenomenographic analysis of interview and written response data to establish the scale by which BTs' CK and PCK could be measured. The second section presented a statistical analysis of the same data in terms of that scale. The purpose was: i) to explore the differences between CK and PCK in pre and post-test for the different groups of BTs and, ii) to examine the associations between CK and PCK.

The key findings in the first section can be summarised as follows:

i. BTs' conceptions of price (their CK) and their conceptions of students' conceptions of price (their PCK) can be described in terms of a combination of strands from both the external and the internal horizon that can be represented as a grid.

ii. The context within which problems are set has a powerful effect on conceptions that are revealed, but it does not 'control' them completely.

iii. For the external horizon in conceptions of CK, there are categorical differences between a market based conception and a non-market based conception of price and a conception based in multiple markets.

iv. For the internal horizon in conceptions of CK, there is a categorical difference between 'listing' factors related to supply and demand and demonstrating an appreciation of their interactions. There is also a difference between a BT that appreciates an interaction between supply and demand and one that appreciates the factors that might affect that interaction.

v. For the external horizon in conceptions of PCK, increasing sophistication is interpreted as a move from seeing students'

conceptions of price in terms of a single context to seeing it in terms of a shift between contexts. In line with the findings for CK, a non-market (i.e. business) context is interpreted as being of a lower degree of sophistication than a market context.

vi. The internal horizon in conceptions of PCK echoed the differences in CK. There was a difference between BTs who displayed an explicit basis for understanding differences between students' ways of thinking about price, those that could propose some factors and those that could organise those factors into some basic structure where the more complex integrated the less complex.

The key findings in the second section can be summarised as follows:

i. A large percentage of BTs demonstrated the lowest ranked conceptions of both CK and PCK (Conceptions A1 and B1) in both pre and post-test. Relatively few BTs exhibited the higher level conceptions. Again this was true in pre and post-tests.

ii. There is no statistically significant correlation between either CK or PCK and BTs' prior attainment as measured by their degree classifications.

iii. Data for CK and PCK was not normally distributed and was skewed to the right.

iv. As a result of the Learning Study intervention, the median ranked conception rose by a large amount (1.50 rankings) for both CK and PCK whilst, for the control group, it fell for CK and remained the same for PCK.

v. The mean rankings fell for the control group for both CK and PCK but rose for the LSG (in the case of PCK by 1.06 rankings).

vi. The results of the Wilcoxon signed-rank test suggested that there was a statistically significant, medium/large effect of Learning Study on CK and PCK. There was no statistically significant effect on BTs' knowledge in the control group.

vii. There was a weak, but statistically significant correlation between CK and PCK. This was identical in pre and post-test comparisons of CK and PCK.

7. DISCUSSION

7.1. Introduction

The primary purpose of this study was to assess the impact of Learning Study on BTs' CK and PCK making use of the framework and tools provided by PVT. This involved firstly, categorising the qualitative differences in BTs' CK and PCK and secondly, measuring and analysing individual BTs' CK and PCK. The first two sections in this chapter discuss the significance of the categorisation of BTs' conceptions of CK and PCK (as laid out in Table 6.0 and Table 6.1) and examines the proposed classifications in terms of the previous research into CK and PCK. Next follows a section explaining the proposed classification of conceptions in more detail, focusing on the structure of BTs' conceptions. The final section of this chapter addresses the results of applying the classification to the measurement of BTs' CK and PCK. It considers the contribution of this study in terms of: i) BTs' levels of CK and PCK, ii) changes in BTs' CK and PCK in the Learning Study and control groups and, iii) associations between CK and PCK.

7.2. Contribution to non-PVT research into CK/PCK

The notions of CK and PCK that were originally presented by Shulman (1986a) have been widely acknowledged to be difficult to define, locate and capture (e.g. Loughran et al., 2003; Park & Oliver, 2008). One indication of this difficulty is the wide range of approaches that have been adopted to describe CK, PCK and their relationships. These include interpreting CK and PCK: i) as situated and cognitive (Depaepe et al., 2013), ii) as 'transformative' and 'integrated' (Gess-Newsome, 1999) and, iii) as being divided into models based on Shulman's approach, models based on research evidence that includes CK within PCK and models of PCK drawing on theoretical perspectives (Kind, 2009). This study uses the theory and practice of PVT to present an alternative, more integrated conceptualisation of CK and PCK that is based in PVT.

The evidence presented in this study is significant because CK and PCK are both defined in the *same* theoretical terms. This is in stark contrast to previous research. For example, important quantitative studies comparing teachers' CK and PCK (e.g. Krauss et al., 2008; Baumert et al., 2010) have carefully developed distinct test items to measure CK and PCK that are based on clearly stated conceptualisations of CK and PCK, but that are not explicitly theoretically linked. One interesting qualitative

approach to PCK, developed by Loughran et al. (2003), does draw aspects of CK and PCK together in 'Content Representations' and 'Pedagogical and Professional Experience Repertoires'. However, this approach is more concerned with developing a rubric that structures and captures teachers' thinking, rather than providing an account of the theoretical underpinnings of CK and PCK in the way that PVT can.

The classification of BTs' conceptions of a phenomenon (as a representation of their CK) and BTs' conceptions of students' conceptions of a phenomenon (as a representation of their PCK) are, therefore, substantive parts of this study's claim to add to knowledge. This classification (see Table 6.0 and Table 6.1) provides one way of addressing the issues of definition and measurement that have been seen to limit the potential of CK/PCK research to contribute to improving BTs' teaching (Abell, 2008; Kind, 2009).

This is particularly true in relation to PCK. The results in this study (see Table 6.1) contribute directly to knowledge about an aspect of PCK, namely BT's knowledge of students' learning difficulties (Shulman 1986a) that has been the object of much previous research. The importance of the idea is emphasised in the way that the

overwhelming majority of studies focusing on PCK adopt Shulman's definition of PCK in at least part of their conceptualisation (Depaepe et al., 2013). This is perhaps because it is difficult to conceive how BTs could be successful without such knowledge, something that has been confirmed in a number of empirical studies (e.g. Griffin et al., 2009, Baumert et al., 2010).

Defining CK and PCK in terms of PVT has a number of important advantages. This approach can avoid the tendency of some situated visions of knowledge to become complex and unwieldy as a result of attempting to encompass too large a number of factors (Depaepe et al., 2013). Such visions are likely to be of little practical help to BTs, particularly in the early stages of their training when it is hard to identify and focus on the critical aspects in teaching. Indeed it is conceivable that complex conceptualisations of BTs' knowledge could actually get in the way of BTs making progress, as they focus on the non-critical issue of trying to make sense of a theory of knowledge rather than the critical issue of applying theory to their understanding.

Defining CK and PCK in terms of qualitatively different conceptions means that each form of knowledge can be rendered explicit in a relatively straightforward way. Making the tacit explicit is likely to have significant benefits for BT's because it

provides a concrete basis from which to make comparisons (Loughran et al., 2003; Davis, 2004) and therefore highlight variation. These benefits are likely to take the following forms: i) BTs have the opportunity to develop a coherent way of thinking about CK and PCK – in terms of qualitatively different conceptions arranged along both internal and external horizons, ii) teacher trainers and BTs can develop a shared understanding and therefore a shared language about CK and PCK – for example, they might refer to the descriptions of conceptions in their planning or evaluations of lessons and, iii) BTs (and teacher trainers) can express both the learning of school students and the learning of BTs in the same terms – for example, by drawing on the previous PVT research into school students conceptions of price (e.g. Pang & Marton, 2003).

7.3. Contribution to PVT research into CK/PCK

The results of this study contribute directly to the findings of the emerging body of PVT research into CK and PCK and to previous evaluations of Learning Study. This contribution occurs as a result of the rigorous application of the principles of PVT to the measurement of teachers' (in this case BTs') knowledge. This builds on the results of other PVT studies that have *either* identified teachers' CK (e.g. Sperandeo-

Mineo et al., 2006) *or* have identified aspects of teachers' PCK (e.g. Kellner et al., 2011) by simultaneously identifying (and then comparing) both CK and PCK.

This study also extends the scope of PVT research into CK and PCK in two ways. Firstly, the focus of previous PVT studies in economics and business studies has been *students'* conceptions of price (or their CK in the terms of this study). This study adds to this by focusing on BTs – a group whose conceptions of price have yet to be explored. Secondly, the small number of PVT studies that have examined teachers' understanding of students' conceptions (or their PCK in the terms of this study) have not focused on the phenomenon of price. This research therefore adds to previous research by examining a new topic in a different subject domain.

In proposing a framework of BTs' conceptions of *student* conceptions of price (Table 6.1), this study adds to the findings of other PVT studies (e.g. Attorps, 2003; Sperandeo-Mineo, 2006; Nilsson, 2014) that have emphasised the importance of taking a topic specific approach to the development of CK and PCK. This study also builds on the work by Kellner et al. (2011) in which a phenomenographic approach was taken to researching BTs' conceptions of student difficulties. Kellner et al. (2011) placed emphasis on the importance of establishing BTs' understandings of students'

understandings, rather than focusing on students' understandings alone. The current study shares the same impetus, but adds to it by providing a more fine-grained, qualitatively distinct outline of BTs' conceptions in relation to a single phenomenon in a subject domain.

There have been other more generic PVT studies that have focused on BTs' conceptions of student learning in a particular subject domain (e.g. Paakari et al., 2011; Kellner et al., 2011) or approached it less directly through an analysis of wider measures of BT knowledge (e.g. van Bommel, 2012). These studies may be useful to BTs and their trainers in that their results can have a bearing on any specific topic that is being taught. However, they have the disadvantage that they require BTs to bridge a broader gulf than would be the case if more topic specific conceptions were identified, as they are in this study.

The results of this study are consistent with the results of previous evaluations of Learning Study that have identified benefits to teacher learning (e.g. Pang, 2006; Davies & Dunnill, 2008; Ko, 2011; Lai & Lo-Fu, 2013). However these studies have only been undertaken with relatively small sample sizes, something that is also true of other PVT studies that have examined CK or PCK. For example, in Nilsson's

(2014) study, n=3, for Paakari et al. (2011), n=20 and for Kellner et al. (2011), n=32. Van Bommel (2012) undertook a larger scale study, but even this only involved 53 BTs.

In the context of these sample sizes, the initial sample of 116 BTs in this study and the subsequent analysis of data in relation to 83 matched pairs of BTs makes it more likely that the study has identified a full range of BTs' conceptions. Moreover, the study included just over one third of all BTs training in economics and business studies in England during the year of the study. This sample size increases the confidence that the associations and effects observed are representative of the whole population of BTs training in economics and business studies in England. There has been one large scale quantitative study of the effects of Learning Study on BTs (Cheng, 2014), although this study did not make use of qualitatively different conceptions as a framework for the analysis of evidence and was limited by its reliance on teachers self-reporting their levels of knowledge.

Finally, this study breaks some new ground in PVT research in the way in which it compares the sophistication of conceptions of one phenomenon (CK) with the sophistication of conceptions of another (PCK). This is in contrast to previous studies

(e.g. Pang & Marton, 2003, 2005) that have compared the sophistication of conceptions for the same phenomena over time (in pre and post-tests). The approach in this study could help educators understand more about the way in which different objects of learning relate to each other. So, for example, if high level conceptions of topic X are found to be generally associated with high level conceptions of topic Y, this might influence the way in which the learning of these two topics is organised. Topic X might be given a higher priority, or more time, given that it can perhaps act as a gateway to an understanding of topic Y.

7.4. The structure of BTs' conceptions of price

As indicated in Section 2.3.4., PVT distinguishes between the internal and the external horizons in the analysis of conceptions (Marton & Booth, 1997). The external environment has been treated in a number of ways in the previous PVT research into price. Some important studies have seemed to focus only on the internal horizon (e.g. Pang & Marton, 2003; Marton & Pang, 2008) both in the study design and in the resulting descriptions of conceptions. In another study by Marton and Pong (2005) more prominence was given to the context but this was accounted for only in terms of the type of product. This might be considered to be surprising given that in most studies of students' conceptions, the quality of product is regarded as being a feature

of the most limited conception of price (e.g. Dahlgren & Marton, 1978; Pang & Marton, 2008). One possible interpretation of all of these PVT studies is that they are based on an assumption that the internal horizon is structured in terms of qualitatively different conceptions, but the external horizon is not (or if it is, that it is possible to account for this in the variation between the descriptions of the internal horizon).

By contrast, this study has found two things: i) that conceptions of price have two aspects – one from the internal horizon and one from the external horizon and, ii) that the external horizon is structured in terms of qualitatively different ways of understanding (following the structure of the internal horizon). The second of these findings supports the work of Davies (2011b) who presented the contextual frame for the phenomenon of price in terms of different degrees of sophistication (ranging from a 'business' perspective to a 'market' perspective).

This study systematically varied the context through the use of different price problems set in either a market or a business context. The purpose of this was to provide BTs with the opportunity to express conceptions related to a particular context. Some BTs in this study displayed conceptions that were not 'controlled' by

the context. Thus, for example, 15% of BTs given a pre-test price problem set in a market context exhibited a business based conception in terms of CK (n=83). This provides good evidence of the powerful effect that the context of the question has on the revealed conception. In addition, it provides evidence of both the separateness of the phenomenon of price and its connectedness to the context. The results of this study may therefore strengthen the theoretical account of the relationship between the internal and external horizon by offering a way of expressing conceptions in terms of a grid that explicitly links the external and internal horizons. This approach is highly consistent with the relational stance of PVT (Marton & Booth, 1997).

A lower percentage of BTs responded to the business based price problem with a market based conception of price compared to the percentage of BTs who responded to a market based problem with a business conception of price (see Section 6.5.1.2). This provides supporting evidence for the notion that market based conceptions are more complex than business based conceptions.

This study did not examine any links between the critical aspects along the internal and external horizons. However, given that both refer to the same phenomenon, it is highly likely that there is some kind of relationship between the two. It is therefore possible that some students exposed to variation in critical features along the internal

horizon (as would commonly be the case in lessons on price designed around the results of previous PVT research) may not be able to progress at all, or as quickly, to higher conceptions if they are not simultaneously exposed to variation in critical features along the external horizon. The layout of Table 6.0 as a grid does not, at first glance, preclude an increase in the sophistication of conceptions along any particular row but it could be that there are relationships between the internal and external horizons that are yet to be discovered and that are not easily represented on a two dimensional grid. This raises two other questions in relation to: i) the 'correct' sequencing of variation in a grid of conceptions (as laid in Table 6.0) and, ii) the implication of the ranking exercise undertaken in Section 6.5.1.3 that the 'jumps' between conceptions along either the internal or external horizons might not be even. The questions are firstly, should the critical features along the external horizon be varied before, after or alternately with those on the internal horizon and, secondly, what does the uneven nature of the 'steps' between conceptions mean for the way in which critical features should be varied. These are questions that the current study did not address directly.

This study identified new conceptions related to the internal horizon that could further contribute to an improvement in the teaching of price. The new conceptions

(Columns C and D and Row 3 in Table 6.0) represent an extension and refinement of previous findings (e.g. Pang & Marton, 2005). Column D and Row 3 are significant because they extend the degree of sophistication that had previously been observed in conceptions of price. Column D might be said to broaden understanding and Row 3 might be said to deepen it. This is helpful in challenging BTs (and perhaps more able school students) who have already displayed the lower levels. Column C also represents a refinement of the existing research into conceptions of price. It can be helpful to BTs and teacher trainers in highlighting a common weakness in BTs' understanding price (and that of their students).

7.5. BTs' conceptions of price (CK)

7.5.1. The internal horizon

BT's conceptions of the internal horizon (set out in Columns A – D in Table 6.0) are similar in many respects to descriptions of conceptions developed by Pang and Marton (2005). The similarities and differences to Table 6.0 are set out below in brackets:

i. Price change as a fundamental characteristic of a product - varying only as a consequence of its intrinsic value (Not present in Table 6.0).

ii. Price change as a function of demand - that is consumers' purchasing power and willingness to pay (Column A, Table 6.0).

iii. Price change as function of supply - that is producers' willingness to provide products at a particular price (Column A, Table 6.0).

iv. Price change as a function of changes in both supply and demand - as a result of the interaction between supply and demand (Column C, Table 6.0).

v. Price change as a function of changes in both supply and demand - taking into account the relative magnitudes of the changes (an aspect of Column D in Table 6.0).

Pang and Marton's distinction between 'price as a function of demand only' and 'price as a function of supply only' (Conceptions 2 and 3 above) was also identified in the current study (Column A). However a challenge arose in deciding what the structural relationships between these two conceptions should be. Pang and Marton have treated supply and demand differently over time. In the 2005 study (Pang & Marton, 2005), they placed supply above demand on the basis of 'increasing complexity' (p.173) but in 2008 (Marton & Pang) they placed them at the same level. Although it was not specified what was meant by complexity in the 2005 study, one

possible reason for placing supply above demand is that 'demand' is closer to students' experience as consumers than 'supply' (which is a matter for more 'distant' businesses) and therefore easier to grasp. One reason for placing them at the same level is that both are 'uni-structural' (Biggs & Collis, 1982) in nature, being only concerned with a single factor. This presents a difficulty for subsequent researchers as both the 2005 and 2008 versions could be valid.

In this study, it was decided to follow the 2008 version and place supply and demand at the same degree of complexity. There are two reasons for this. First, it ensures a greater degree of theoretical consistency. This is because, if the suggested reason for the 2005 approach holds, then the rationale for putting Conceptions 2 and 3 at different levels (a rationale based on student experience) appears to be different to that of placing Conception 4 (supply and demand) above both (a rationale based on the structure of the concept). A greater degree of theoretical consistency could be ensured by moving from a uni-structural conception to a multi-structural conception – as was the case in the 2008 study. Second, there is some evidence from the current study to suggest that BTs in this sample found the ideas of supply and demand fairly similar in their level of difficulty. Of the 16 BTs who expressed conceptions that only referred to either supply or demand (in the CK pre-test), 56% of them referred to

demand and 44% to supply. This does at least suggest that the combined view of supply and demand is correct (although a larger sample would have been helpful in increasing the robustness of this conclusion)

In the use of the word 'interaction', Column C in Table 6.0 appears to be the direct equivalent of Category 4 in Pang and Marton's (2005) analysis. However, in the current study a categorical difference was found between BTs who simply referred to supply and demand (Column B) and those who referred to the *interaction* between them (Column C). This difference was highlighted by those BTs who recognised that both supply and demand played a role in the determination of price but did not display a sense of how each might affect the other in that determination. In terms of the Pang and Marton (2005) categorisation, this amounts to the introduction of an intermediate category between Conceptions 3 and 4. In terms of the SOLO taxonomy it amounts to a distinction between the multi-structural (Column B) and relational (Column C).

Conception 5 above focused on the relative magnitudes of changes in supply or demand. This is similar to Column D in Table 6.0 in describing the nature of the interaction between supply and demand. However it is different to that in the 2005

study, where relative changes were presented in terms of 'shifts' in demand and supply. Shifts occur where conditions change such that the quantity demanded or supplied at each price increases by the *same* amount. Shifts do not account for the effects of variations in the elasticity of demand or supply that mean that given changes in price can cause *different* changes in the quantity supplied or demanded. The evidence from BTs in this study highlighted conceptions of the interaction between supply and demand that encompassed both shifts in supply and demand and the notion of elasticity. These were principally seen in terms of: i) market power, ii) competition and, iii) equity issues. So, for example, in a situation in which a firm has market power the same price increase might result in a smaller fall in demand than that faced by a firm with less market power. In another example, a consumer concerned with equity might respond to a price change in 'Fairtrade' products in a different (less responsive) way to a price change in other products. These examples might be seen as an advanced aspect of the 'relational' in the SOLO taxonomy. They do not appear to fall into the 'extended abstract' category since they do not necessarily refer to a general way of thinking about price.

Finally none of the BTs in the study expressed a conception of price as a fundamental characteristic of a product. This may be a consequence of BTs engaging with the

topic at a higher level, given that they were all honours graduates in Business or economics with 'good' degrees (that is none possessed a third class honours degree).

7.5.2. The external horizon

The external horizon in terms of conceptions of price was found to consist of a number of different levels of sophistication. These confirmed the findings of Davies (2011b) of a categorical difference between a conception of price set in the context of a single business or individual and a conception of price set in the context of a market (Rows 1 and 2 in Table 6.0). An additional category (Row 3) was found that related to a conception of price set in the context of multiple markets. This category fits logically into the framework proposed by Davies (2011b).

The difference between Rows 1 and 2 could highlight the difference between an 'economics' perspective and a 'business studies' perspective. Row 1, because of its focus on business decisions might reflect the latter, and Row 2, with its focus on markets, might reflect the former. In the English education system, business studies and economics are predominantly seen as two different subject domains (even though are considerable overlaps in terms of subject content). This distinction is observed in both universities and schools. One example is the coexistence of A

Level courses (qualifications aimed primarily at 16-19 year olds) in business studies and economics. Indeed, the UK government recently reinforced this distinction by withdrawing validation for the small number of A Level courses that combine business and economics (Ofqual, 2013).

The framework of conceptions developed in this study suggests that BTs with a business studies background might only have been exposed to Row 1 and therefore only have acquired that level of conception themselves. Through its effects on PCK, this might in turn restrict the conceptual depth that their students can achieve in their CK. There is some evidence for this in this study. The average CK rankings in the pre-test (n=105) were 3.70 for BTs with economics in the title of their first degree (n=20) and 3.30 for BTs without economics in the title (n=85). This was supported in the post-test where the average CK was 3.60 for economics BTs (n=16) and 3.30 for those without economics (n=83). This finding is of potential significance, since despite the apparent separation of economics and business studies as subject domains, 'price' is nearly always an aspect of both qualifications in England.

7.6. BTs' conceptions of students' conceptions (PCK)

7.6.1. The internal horizon

The critical features found along the PCK internal horizon distinguish between a BT who explains differences in how students understand price in terms of multiple factors (Column B) and a BT who explains these differences in terms of more and less complex ways of understanding price that integrate (Column C). In short, the BT who displays conceptions in Column C is able to predict the qualitatively different ways in which students see price on the internal horizon. These BTs are relatively rare, although this study demonstrated that they constituted 6% of BTs in the pre-test (n=111) and 9% in the post-test (n=85). The source of BTs' knowledge of students' conceptions is likely to be their own experience of learning or their experience of others' learning, but it is not clear which. However, there is the possibility that these BTs might be able to undertake a successful Learning Study *without* having undertaken the phenomenographic pre-testing process (assuming that their predictions are accurate). Alternatively, they might be able to undertake such research at a reduced scale. This is an important possibility because of the resource hungry nature of Learning Study (Holmqvuist, 2011).

The three columns of the internal horizon for PCK are: i) Column A – No explicit basis for qualitative differences, ii) Column B – Multiple factors account for qualitative differences and iii) Column C – Structure accounts for qualitative differences. The columns correspond closely to the pre-structural, multi-structural and relational dimensions of the SOLO taxonomy and provide supporting evidence for this approach to the structure of knowledge. One interesting feature is that the Columns in Table 6.1, are much less domain or topic specific than the other horizons identified either in relation to the external horizon (for PCK and CK) or the internal horizon (for CK). That is, they do not explicitly relate to the phenomenon of price.

7.6.2. The external horizon

The critical aspects arranged along the external horizon were found to encompass individual business and market contexts. In this way they acted to confirm those found along the external horizon for CK and in other research (Davis, 2011a, 2011b). However, these contexts were arranged differently because the focus was BTs' PCK. One important categorical distinction was between BTs who maintained a single context throughout their response and those that exhibited a shift between two different contexts. This distinction might be said to be indicative of a BT who understands how to enact a more transformational view of learning along the

external horizon and one that does not. This chimes with previous PVT studies that have identified that a transformational view of learning represents a more sophisticated conception of learning (e.g. Paakari et al., 2011; Durden and Davies – Appendix 10.5). However this study adds to these findings because it makes the difference between a business and a market context explicit. This could provide a BT who might *intend* to adopt a transformational approach but lacks the awareness of the difference with the opportunity to *enact* it effectively. This lack of awareness could be related to low levels of CK since Table 6.0 also indicates that a knowledge of market contexts is a crucial element of higher level conceptions of price.

7.7. The level of BTs' CK and PCK

The evidence from this study is that pre-test levels of BTs' conceptual thinking about CK and PCK are generally weak (see Section 6.5.1.4). This confirms the findings of previous research that has demonstrated gaps in pre-service teachers PCK and by extension, CK (e.g. Davis, 2009; Nilssen, 2010). It is also in line with the wider evidence pointing to the gap between teachers' procedural and their conceptual understanding. For example, Mewborn (2001) provides a good summary of key examples of these gaps from mathematics education.

Low levels of PCK might be expected, given that these BTs by definition have had little experience of teaching and that they were tested early on in their training. However the results for CK are striking, particularly given that BTs are required to have good first degrees in business or economics in order to meet the government specified entry requirements for teacher training in England (all BTs in this study had at least a second class honours degree with 60% holding upper second class or first class degrees).

It was not possible to find a statistically significant correlation between BTs' degree classifications and their CK or PCK in this study (see Table 6.7). This finding seems to contradict those studies that have found that teachers' educational level is positively correlated to their PCK (Krauss et al., 2008) or that teachers' educational level has a greater impact on CK than on PCK (Baumert et al., 2010). Even though, in England, the degree system only provides very broad classifications of degree achievement, it is still surprising that no correlation with either CK or PCK could be identified. This is important because, although low levels of CK have been shown to have smaller effects on teaching quality than PCK, they do seem to impact significantly on teachers' ability to develop high levels of PCK (Baumert et al., 2010). Low levels of conceptual CK therefore could help explain the results of those studies

in England and elsewhere (e.g. Slater et al., 2012) that have not been able to find any link between teacher quality and degree classification.

The lack of correlation between CK and degree classification is also consistent with the evidence from studies that have found a difference between the CK required in a school context and that required in a university context (Kind & Taber, 2005; Deng, 2007). However, the price problems set to BTs in this study were not couched in terms relevant only to a school context, they were general price problems (see Appendices 9.1 and 9.2). This means that BTs' apparently low levels of CK might be less about whether they have 'school' or 'university' forms of knowledge and more about their inability to use their 'university' knowledge in different contexts. From the evidence in this study, BTs' ability to apply knowledge in this way does not seem to be related to their levels of PCK.

7.8. Changes in BTs' CK and PCK

There is the possibility that BTs' weak pre-course CK could be improved through the training they receive. However, for the control group, there was no statistically significant improvement in CK when measured using the Wilcoxon signed-rank test. Infact only 22% of BTs demonstrated any improvement in CK, with 48% displaying

the same quality of conception pre and post training. Given that 90% of BTs reported in the post-test that they had taught the topic of price, it appears that the experience of having to teach about price did not necessarily result in an improvement in BTs' CK.

Perhaps the absence of statistically significant gains in CK in the control group might be explained by a greater emphasis being placed on PCK development during training rather than on CK development. Two reasons for this could be: i) the time constraints imposed by the relatively short nature of postgraduate teacher training in England (about 9 months) and, ii) the widespread assumption that BTs do not require CK development because they begin training with a 'good' degree. If teacher training in England does largely focus on what is perceived to be generic PCK development (and the evidence from this study is that this was the case in relation the topic of price), then the findings in this study suggests that it is not very effective at raising their PCK (or CK) in particular topics. The control group did not experience a statistically significant increase in PCK as a result of their training. This is consistent with the proposition that CK is a necessary but not a sufficient condition for the development of PCK (Sperando-Mineo et al., 2006; Krauss et al., 2008; Baumert et al., 2010). PCK training may be being restricted by BTs' relatively weak

CK (assuming that the intended and enacted objects of learning in teacher training align and that the training has the potential to be effective). It would seem that PCK training alone cannot be relied upon to have any strong 'spill-over' effects into BTs' CK on particular topics. This is indirect evidence of the separateness of CK and PCK that has been identified by other studies (e.g. Kraus et al., 2008; Baumert et al., 2010).

The results of this study do show a medium/large, statistically significant effect of Learning Study on the CK and PCK of the Learning Study group in comparison to the control group. These results confirm the findings of a number of studies that have pointed to the potential of Learning Study for developing teacher's CK and PCK. For example, Holmqvuist (2011) found that following Learning Study, teachers were more able to identify the 'critical features of the object of learning' (p.509) and that they moved from 'a more general level to a detailed level' (p.509) in their approach to teaching the phenomenon. Both of these can be seen to be aspects of the CK improvement noted in this study. In another example, Nilsson (2014) demonstrates how participation in a Learning Study developed PCK as three science teachers were more able to identify what made it easy or difficult for students to learn about a topic through their analysis of pre and post-test responses. The evidence from this study in relation to PCK provides support for this finding. Van

Bommel (2012) identified critical features of Mathematical Knowledge for Teaching which, when highlighted through Learning Study, were found to have beneficial effects on both teacher trainers teaching and BTs' knowledge. Since Mathematical Knowledge for Teaching might be described as a hybrid of CK and PCK, Van Bommel's findings echo those in the current study.

The results of the Learning Study group also support the findings of other studies that have pointed out the benefits of Learning Study to teachers' conceptions of teaching and learning without directly referring to CK or PCK. Tan and Nashon (2013), for example, found evidence of teachers developing 'a greater clarity about what they wanted students to learn' (p.867) and of having their 'prior assumptions about science pedagogy' challenged (p.868). These findings could be attributed to improvements in CK and PCK, of the kind noted in this study.

One of the findings of this study is that Learning Study was shown to have more of an effect on PCK than CK (for CK, r=0.33 and for PCK, r=0.45 - see Table 6.10). This might be a result of the emphasis that Learning Study places on making differences in students' understanding an explicit element in the planning, delivery and review of lessons (Pang & Ling, 2012). This provides teachers with the opportunity to

experience (and therefore learn from) variation between their pre-understandings and: i) the evidence from students gathered before the lesson, ii) the understandings of other BTs in the Learning Study group, iii) the evidence of student learning gathered during the lesson and reviewed after it and, (iv) the experience of teaching or observing the teaching of a lesson. In discerning, through experience, what is important in the teaching of a lesson and what is not important, teachers may be able to use these markers to navigate their way through the complex relationships that characterise PCK (and CK) and build their understanding of these (Nilsson, 2014). The results of this study can contribute towards the identification of these features.

A number of previous studies (e.g. Pang, 2006; Tan & Nashon, 2013), have shown that Learning Study has the potential to encourage teachers to move away from a transmission based pedagogy (Goodson, 1998). This study demonstrates that BTs were more aware of qualitatively different levels of student thinking as a result of taking part in a Learning Study. This awareness is likely to be an important feature of an approach to teaching that is less transmission based because it is oriented towards a conception of students' knowledge that focuses on conceptual change. Therefore the results of this study are consistent with previous findings in this area.

It is notable in this study that for some BTs in both the Learning Study group and the control group, CK and PCK did not improve between pre and post-tests. For example, 48% of BTs in the control group and 44% of BTs in the Learning Study group showed no difference in their conceptions of CK. This is perhaps an indicator of the intractability of BTs' conceptions and an idea of the scale of the challenge faced by teacher trainers. It is also notable that for some BTs, their levels of CK and PCK actually fell between the pre and post-tests. In the control group 31% of BTs scored less in the post-test than the pre-test for CK and 40% for PCK. These percentages were lower for the Learning Study group, at 12% and 5% respectively. Previous quasi-experimental studies into student learning in Learning Study (e.g. Pang & Marton, 2003, 2005) have not reported conceptions at either the student or the teacher level. Therefore it is difficult to know whether this pattern of results has been observed in previous studies or not. If it has been observed in previous studies, then these do not provide an indication as to how the results in this study might be interpreted.

One possible explanation for the volatility in BTs' levels of CK and PCK is provided by PVT itself. BTs often experience a considerable degree of turmoil during the planning of lessons in particular and in their teacher training in general. In PVT

terms they may not be able to discern critical features accurately against what appears to be an ever changing background. In other words, BTs may be faced with 'too much' variation that 'clouds' their thinking. Consequently some may not develop their conceptual understanding. If this is the case, then one implication is that teacher training should concentrate on more carefully managing variation in BTs' experience of teaching in the way that occurs in Learning Study. That the percentages of the Learning Study group who displayed lower conceptions in the post-test were lower than those in the control group provides at least some supporting evidence for this interpretation of the evidence (although the sample size was relatively small).

7.9. Associations between CK and PCK

In terms of the relationship between CK and PCK, evidence was found of a statistically significant, if weak, positive correlation (see Table 6.11). This is consistent with other studies that have found that for groups of teachers with lower levels of CK (such as the BTs in this study), the correlation between CK and PCK appears to be lower (e.g. Krauss el al., 2008). This difference could be accounted for in terms of the very different approaches taken to the conduct of this study compared to Kraus et al.'s (2008). Assuming a comparison is possible however, one possible

reason for the lower level of correlation is that for BTs, factors other than CK have a more important bearing on their PCK, than is the case for more experienced teachers. High levels of CK and PCK are central to effective teaching but other forms of teachers' knowledge are also important and may be at particularly low levels for BTs who are new to teaching. As suggested in Section 3.4.1, BTs' self-confidence might also have a bearing on the relationship between CK and PCK. Some studies have suggested that one route to increasing BTs' self-confidence is to focus on developing their CK (Childs & McNicholl, 2007). It would be consistent with this finding to suggest that the low levels of CK identified in this study could be a source of low levels of self-confidence.

This study also found that the correlation between CK and PCK at the start of BTs' training was identical to the correlation at the end of their training. Following from the findings of Krauss et al. (2008), it might have been thought that the correlation would increase as a result of training and teaching experience. However the data in this study suggest that in the control group, the effect of teacher training on BTs' knowledge of price is relatively weak (with a large percentage showing no improvement in either CK or PCK). Therefore, at least in relation to the phenomenon of price, it is not reasonable to expect the correlation between the two to rise. The

small sample size in the Learning Study group did not allow a meaningful comparison to be undertaken with the correlation between CK and PCK in the control group.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Introduction

The main question that this study seeks to address is: what are the effects of Learning Study on BTs' CK and PCK? The impetus for focusing on this issue comes from two main directions.

First, there is an emerging body of literature that presents evidence of the benefits of Learning Study for both experienced and pre-service teachers (e.g. Pang, 2006; Ko., 2011; Cheng, 2014). However, this research has missed the opportunity to analyse these benefits in terms of the theory and methods of Learning Study itself (namely PVT). This opportunity arises because Learning Study is underpinned by a particular set of propositions about how to understand, measure and promote learning that have previously been mainly applied to *students'* learning but could be applied to *teachers'* learning. The application of PVT to teacher learning could address some of the limitations of previous studies into PCK. In particular, these studies have often only offered relatively weak theorisations of a framework for the evaluation of teacher development. In addition, they have generally involved small sample sizes and have not focused on comparisons between teachers (or BTs)

involved in Learning Study and teachers (or BTs) involved in alternative forms of teacher development. In drawing heavily on the quasi-experiments undertaken in previous research evaluating the impact of Learning Study on student learning (Pang & Marton, 2003, 2005), this study seeks to offer a stronger theoretical framework for the analysis of teacher learning and an alternative to previous small scale, case study approaches. This way of examining teachers' and BTs' learning in a Learning Study has not been undertaken before and therefore forms the basis of a contribution to the growing body of evidence in the field.

The second major impetus for the study is the potential offered by linking PVT and Learning Study with the more general debate on teachers' CK and PCK (Shulman, 1986a). This raises two questions. First, can any benefits of Learning Study to teachers (or BTs) be explained in terms of improvements in CK and PCK? In other words, what can an understanding of CK and PCK bring to the debate on PVT/Learning Study? Second, can PVT/Learning Study offer a way of defining, capturing and developing teachers' (or BTs') CK and PCK that can contribute to research findings, and policy and practice implications of the wider research into CK and PCK. In other words, what can an understanding of PVT/Learning Study bring to the debate on CK and PCK?

These questions resulted in the following supplementary research questions for this study:

i. How can BTs' CK and PCK be described?

i. What is the level of BTs' CK and PCK?

ii. What are the associations between BTs' CK and PCK?

Turning first to the small body of research that has explicitly linked PVT with CK/PCK, one study (Kellner et al., 2011) has used PVT to examine PCK (expressed in terms of students' misconceptions), one study (Attorps, 2003) has categorised teachers' understanding of a topic in mathematics (CK) and one study (Sperandeo-Mineo et al., 2006) has drawn on PVT to measure changes in BTs' CK. However, there do not seem to be any published studies that have attempted to use PVT to define *both* CK and PCK in terms of a hierarchy of qualitatively different conceptions. Studies that have examined the effects of Learning Study on teachers' and BTs' PCK have either not used PVT as a framework for the analysis (e.g. Nilsson, 2014) or have done a partial phenomenographic analysis. Sometimes this has involved categorising BT responses but not developing a hierarchy of conceptions (e.g. Ko, 2011). At other times it has meant identifying critical aspects of a phenomenon but

then analysing it in non-phenomenographic terms (e.g. van Bommel, 2012). This research set out to draw together all of these different approaches.

Turning next to the contribution of PVT to CK and PCK research, there is a good overlap between Shulman's original formulation of PCK and PVT. This is particularly true in terms of 'knowledge of students' learning difficulties' but also potentially in terms of 'knowledge of learning strategies' (through the sophistication of teachers' understanding of Learning Study). PVT offers a definition of PCK (and CK) that is theoretically coherent and linked to a ready-made method for gathering and interpreting evidence of learning. It also has a powerful way of operationalising learning (Learning Study) that expresses student learning and (potentially) teacher learning in the same terms. This has tremendous potential benefits for the improvement of teacher learning in general and BTs' learning in particular. It also addresses many of the challenges that are present in the wider debate on CK and PCK, such as how to define and measure CK and PCK (Kind, 2009).

This chapter begins by reviewing the main research question in the light of the evidence gathered in in this study. It then goes on to examine the supplementary research questions in the same way. Following from this, the limitations of the study

are explained, before a final section explores the implications of the conclusions for policy, practice and research.

8.2. What are the effects of Learning Study on BTs' CK and PCK?

This study provides evidence that Learning Study contributes to the development of BTs' CK and PCK in relation to a particular topic in business studies and economics. This confirms the findings of previous work in this area (e.g. Pang, 2006; Ko, 2011; Cheng, 2014). This study did not explore which aspects of Learning Study were instrumental in bringing this about. However, the results are consistent with the proposition that BTs' learning in a Learning Study occurs because of their experience of different forms of variation (see Section 4.2.2) resulting from the particular combination of features present in a Learning Study (see Section 4.3.2).

The evidence in this study is likely to understate the full benefits of Learning Study that are possible. This is because BTs were exposed to only one formal cycle of Learning Study (although BTs in the Learning Study group were encouraged to re-teach their lessons). Learning Studies typically spread across a number of cycles, giving teachers the opportunity to develop better knowledge of the underlying principles and processes. In PVT terms, repeated cycles of Learning Study allow BTs

to learn from the experience of variation *between* cycles as well as variation *within* a single cycle (as in this study). In Shulman's terms, practicing Learning Study might give BTs a better chance of developing their knowledge of instructional strategies. However, given that the focus of the Learning Study process is student learning, an increased knowledge of Learning Study is likely to simultaneously result in the development of BTs' knowledge of students' understanding (the other key aspect of PCK identified by Shulman). This is particularly the case as BTs are confronted by the powerful effects of: i) repeated, direct experience of student learning through classroom observations (or teaching) of the Learning Study lesson and, ii) the results of an analysis of the empirical evidence related to student understanding that forms a key part of the design and review of Learning Study lessons.

The evidence presented in this study gains an added significance when compared to the development of BTs' knowledge of CK and PCK observed in conventional teacher training in England. In contrast to those BTs undertaking a Learning Study, there were no significant gains in BT's CK or in their PCK (see Table 6.10). This does not mean that all aspects of conventional teacher training are likely to be ineffective since it is possible that within the 6 different universities studied there may have been pockets of good practice. Alternatively, training may have been effective in

other important areas of teachers' knowledge such as knowledge of the curriculum or knowledge of general pedagogy. However, that it was not possible to find any development in two critical areas of teacher knowledge in relation to a topic of such central importance to the subject domain could indicate that there may be weaknesses in conventional teacher training in England. This point is of particular importance given that all of the universities in this study had been accredited by the Office of Standards in Education as operating at the same quality level.

8.2.1. How can BTs' CK and PCK be described?

This study proposes a codified set of conceptions of CK and PCK related to a single phenomenon in a subject domain (see Table 6.0 and Table 6.1). Although conceptions of price have been developed in other studies, they have not previously been established for BTs. Qualitative differences between BTs' conceptions of student conceptions (as a measure of their PCK) have also not previously been established.

The categorisations of conceptions proposed in this study are likely to be of great benefit to teacher trainers in supporting the development of BTs and to BTs themselves in organising their own development. The categorisations support BTs'

learning because they provide a framework within which to make sense of the variation that BTs experience (Runnesson, 2013). Without such a framework, BTs (or their trainers) might not be able to distinguish between issues that are important for the development of BTs' CK and PCK and issues that are not. An inability to identify these issues could result in BTs experiencing 'too much' variation in non-critical aspects that could 'cloud' their understanding. This could explain the fall in levels of CK and PCK experienced by a number of BTs in the control group in the study (see Table 6.9).

The proposed conceptions relating to CK and PCK offer BTs the opportunity to align their understanding of student learning with their understanding of their own professional learning in a manner akin to the notion of 'constructive alignment' proposed by Biggs (1996). This involves developing a common framework and associated language with which to understand and discuss the nature of knowledge and knowledge improvement. This degree of coherence could be very powerful in terms of developing classroom teaching. If BTs see their own learning and student learning as two sides of the same coin, then they are more likely to make connections between those two sides. One important result of this is that BTs would be less likely to see teaching as doing things *to* students and more likely to see teaching as working

with students. In relation to CK, for example, PVT confronts BTs with the notion that the quality of their understanding of a phenomenon is explicitly on the same 'ladder' as that of their students.

Establishing a clear set of BTs' conceptions has a number of other related advantages. First, it could help avoid the relatively common situation in which strategies are suggested to BTs by trainers that are based on different assumptions about improving teaching and learning than those held by the BT. Second, for BTs, it could help provide an answer to the question 'how can I improve as a teacher?' that is not focused on what might seem to an individual BT to be an isolated aspect of teaching, but rather is one that explicitly links to a clear framework for professional development. Third, at an operational level, the identification of qualitative differences between conceptions makes it possible to accurately identify BTs' current conceptions of CK and PCK and develop clear targets in relation to these.

One strategy that has been used in teacher training is to focus on developing BTs' knowledge of student misconceptions. However, as Kellner et al. (2011) have argued, presenting BTs with descriptions of students' conceptions may be much less likely to change their approach to teaching than presenting them with descriptions of

their own conceptions. The beneficial effects of making BTs' conceptions explicit to them is likely to be augmented if CK and PCK are expressed in the same terms. This is because BTs can make quicker and more meaningful comparisons between CK and PCK. This is likely to allow them to reflect more effectively on their CK in the light of the PCK and their PCK in the light of their CK.

This study was designed to take explicit account of variation in the context of the phenomenon of price. The study found that conceptions related to both CK and PCK varied in quality along both the internal and the external horizons. This resulted in the conceptions being summarised in a grid format (see Table 6.0 and Table 6.1).

In theoretical terms, expressing conceptions in terms of components from the internal and external horizons is highly consistent with the relational ontology that underpins PVT. This study found that it was possible to distinguish between aspects of conceptions related to the internal horizon and aspects of conceptions related to the external horizon. One way in which this was demonstrated was by those BTs who displayed a high level conception along one horizon but a low level conception along another. Another way in which this was demonstrated was by those BTs who responded to a 'market' based question with a 'business' based conception and vice

versa. These BTs constitute evidence supportive of the idea that the external and internal horizons are related, but are able to be identified as empirically distinct.

8.2.2. What are the levels of BTs' CK and PK?

The findings of this study are that BTs' CK and PCK at entry into training are generally weak (see Table 6.8). This result is consistent with other studies (e.g. Davis, 2009; Nilsson, 2010). In addition, this study could not find any significant association between the classification of BTs' first degree and either their CK or their PCK. This result is also consistent with other studies in England that have not found any association between degree level and teaching quality (e.g. Slater, 2012).

Given that BTs in this study all had 'good' degrees related to economics and business studies, these results could be interpreted in two ways. Firstly, they could suggest that universities are not equipping graduates with the type of knowledge that is important for teachers in a school context. A second possibility is that universities are not equipping graduates with good levels of conceptual understanding per se. However, regardless of the reason, the results of this study suggest that teacher trainers cannot assume that BTs will start teacher training programmes with good levels of CK.

8.2.3. What are the associations between CK and PCK?

The theoretical assumption that high levels of CK are a necessary condition for high levels of PCK are supported in the findings of this study. A statistically significant correlation was found when comparing CK and PCK at both pre and post-test stages (see Table 6.11). This correlation appears lower than in some other studies such as Krauss et al. (2008). This might be explained by the low levels of CK generally demonstrated by BTs in this study. Alternatively it could be a result of BTs' possessing low levels of other forms of teachers' knowledge that, at higher levels, might serve to support the process of developing BTs' PCK.

8.3. Limitations of the study

There are a number of limitations in the design of this study.

Firstly, the study did not set out to record in great detail the nature of the Learning Studies that were undertaken. One issue this creates is that it is difficult to know how effectively the BTs applied PVT to their lessons and therefore how 'good' they were as Learning Studies. A more successful Learning Study, that contributes more

to student understanding, might be expected to contribute more to BTs' CK and PCK. Unfortunately, no comparative evidence was gathered in relation to the quality of student learning in each Learning Study in this study. This is in line with other studies that have used the same methodology as this study (e.g. Pang & Marton 2003, 2005). One implication of this is that it is difficult to say whether any positive results on BTs' CK and PCK identified in this study are at the top or bottom of the range of possible benefits. What is clear however, is that the BTs involved in the Learning Study groups did *attempt* to apply PVT and they were distinct from BTs in the control group who did not take part in the process of Learning Study.

Secondly, this study set out to gather evidence of both CK and PCK by asking BTs to express their understanding in propositional terms (see the questionnaires in Appendices 10.1 – 10.4). In other words, an assumption in the methodology of the study is that BTs are able to *consciously* access and reveal their knowledge. However, the possibility exists that such knowledge is held in ways that are not consciously accessible by all BTs. Eraut (2000) and Huberman (1993) have proposed that in learning to deal with the overwhelming demands of teaching, BTs make use of such tacit knowledge systems as a coping mechanism. BTs draw on such knowledge without the need for conscious thought, in the same way that people draw on their

tacit knowledge of how to ride a bicycle only when they are actually on one (Dudley, 2013). Therefore it is possible that some BTs did possess levels of CK and PCK that they were simply unable to reveal given the nature of the methodology in this study. This might be particularly true of PCK given its intimate links with the practice of teaching. However, whilst this explanation might go some way to explaining the low levels of PCK development observed in the study in the control group, it does not explain: i) why Learning Study BTs were able to demonstrate significant gains in their propositional knowledge in comparison to the control group and, ii) why some BTs were able to express their understanding in propositional terms whilst others were not.

A third limitation in the study is that it involved a comparison between Learning Study groups that focused on price and control groups that did not receive any specific training sessions on price in their universities. This means that it is not possible to compare the effects of Learning Study intervention with any other sort of intervention in relation to price. It is only possible to compare the effects of Learning Study on the BTs' knowledge in relation to price with the effects of general training on that knowledge in the control groups. This means that any benefits noted as a

result of Learning Study can only be said to be indicative of the general gains of the approach.

A fourth limitation is the relatively small sample size of the intervention group (n=18). However, in comparison to similar PVT studies exploring PCK, it is relatively large. In addition, the statistical tools that were chosen to perform the analysis are widely accepted to be appropriate for such sample sizes.

Fifthly, the data in this study was clustered in eight different universities and in two different schools. Any differences were not explicitly accounted for in the statistical analysis. This means that the study runs the risk that in aggregating results, university level or school level effects will be ignored. These effects were mitigated by selecting the universities and the schools according to pre-determined criteria.

The quality of conclusions in this study depend on the extent to which:

i. the conceptions of price identified are indicative of broad understanding within the subject domain.
ii. the highest conception exhibited by a BT is representative of their general understanding.

iii. a study focused on selected aspects of BTs' knowledge can be indicative of their general knowledge in relation to teaching.

iv. conceptions of price captured in a particular context can be regarded as indicative of a BT's understanding of that phenomenon.

v. the proposed conceptions of CK and PCK (in Tables 6.0 and 6.1) accurately represent BTs' conceptions.

In relation to point (i), price was chosen as a focus for this study because of its centrality to the subject domain of economics and business studies. This centrality is likely to ensure that it is representative of a general understanding of economics and business studies. However, a range of studies have indicated that teachers' knowledge can differ considerably between different topics within a subject domain (e.g. Lee, 2010; Watson & Nathan, 2010). Therefore additional tests of BTs' CK would be needed to confirm whether an understanding of price is or is not indicative of a general level of understanding in the subject domain. In its current form, this study is able, at the very least, to offer evidence in relation to the phenomenon of price.

Turning next to point (ii), there are good a priori grounds for taking the highest conception a BT expresses as a measure of their level of understanding. This is

because if qualitatively different conceptions are nested within each other (as they are in this study), a higher conception will necessarily encompass a lower level conception. This is the basis of the findings in relation to price in previous quasi-experimental studies into Learning Study (e.g. Pang & Marton, 2003, 2005). However, there are two potential challenges to these findings. Firstly, there is the complex and unstable nature of individuals' conceptions that has been observed empirically (Marton & Pong, 2005). This raises a question about how a conception can be assigned to an individual at one moment, if in the next moment it might have changed. One response to this is to question the basis on which phenomenographic conceptions should be seen as being any more volatile and unstable than other forms of knowledge. There do not currently appear to be comparative studies to suggest that they are, but this remains a potential challenge to the findings of the current study. Secondly, some interpretations of PVT suggest that it is not appropriate to match conceptions with individuals given that conceptions are non-psychological entities that are independent of the individual (see Section 2.4.2). Unfortunately, accepting this interpretation greatly restricts the usefulness of PVT in a practical teaching context. This may explain why leading authors in the field have not adopted it (e.g. Pang & Marton, 2003, 2005). This study follows Pang and Marton,

whilst recognising that the tension between some theoretical interpretations of PVT and the implications of putting it in to practice in Learning Study.

There are two aspects that are important in relation to point (iii) above. First, this study only focuses on one aspect of PCK, when other studies have identified other potential components of PCK, such as knowledge of educational ends and context knowledge (Depaepe et al., 2013). Second, the study only focuses on CK and one aspect of PCK, where other studies have identified other components of teachers' knowledge in general (e.g. Shulman, 1987).

In Section 3.5, arguments were put forward to support the assumption in this study that BTs' understanding of students' understanding is a more important influence on their PCK than BTs' knowledge of instructional strategies. However, that this study has focused on particular aspects of BTs' knowledge does not mean that other forms of BTs' knowledge are not important. Rather, the starting point for this study is that CK and PCK are necessary but not sufficient conditions for successful teaching (Cochran et al., 1993). In PVT terms, this means that good levels of CK and PCK are likely to be critical features of a high level conception of successful teaching. Results from a large number of studies (e.g. Griffin et al., 2009; Baumert et al., 2010) provide

supporting evidence for this. Therefore this study did not aim to capture the complete picture in relation to BTs' knowledge, but rather to contribute to understanding about a limited number of aspects of it. Thus for example, in terms of PCK, the conclusions from this study give an indication of the level of PCK it is possible for BTs to develop given a particular level of CK (even if that level might be constrained by knowledge of instructional strategies or other forms of knowledge).

In terms of point (iv), the study set out to establish the full range of the variation in BTs' understanding by systematically varying the context of the price problems that were set. This assumed that whilst the context would have a constraining effect on the type of responses BTs would produce, there was enough that was similar between the two contexts to ensure that the full range of possible conceptions would be revealed. This is likely to be a good assumption to make in providing a basis for the development of categories of description. However, using the same data to assess BTs' *levels* of conceptual understanding might be less appropriate. For example, a BT who responds to the price problem in the market context might have revealed a completely different level of understanding than if they had responded to the price problem in the business context. Since no BTs completed problems in both

contexts it is difficult to know how significant a challenge to the results this represents.

Finally, in relation to the last of the points above, there are two important issues. First, the results depend on the way in which conceptions were ranked. In this study, there is a strong rationale for this that is evidence based (see Section 6.5.1.3), but as this approach has not been used before in PVT research, some uncertainty remains. Second, there were particular challenges in interpreting the evidence from the PCK questionnaires. There were frequent inconsistencies in the ranking decisions made by BTs, as well as between proposed hierarchies of conceptions and the written rationale. In fact, BTs themselves saw completing the PCK questionnaire as a difficult task. In the 16 interviews conducted, seven commented without prompting on this. Additional research would be required to confirm the assumptions that were made in Section 6.4.1 concerning the treatment of the PCK data, but the results in this study need to be interpreted in the light of these assumptions.

8.4. Recommendations

8.4.1. Recommendations for Policy

This study found that BTs' first degree classification was a poor predictor of their CK or PCK. This evidence runs counter to recent government policy in England in relation to the recruitment of BTs. Current policy has emphasised the importance of attracting BTs with 'good' degrees into teaching and as a result no longer allows teacher training institutions to recruit graduates with third class honours degrees (Department for Education, 2011). This study casts some doubt on the effectiveness of policies designed to improve teaching by recruiting those with better degrees. Further analysis would have to be conducted to explore if there are any other distal measures that might constitute more reliable predictors of the quality of teachers' knowledge. A possibility might be to implement a phenomenographic 'test' of the kind used in this study. This would clearly be expensive to administer and would rely on the conceptions applicants revealed in relation to a particular topic being indicative of their general level of understanding. However, it may give a better indication of an individual's potential to develop as an effective teachers than their degree classification.

The results of this study indicate that for a large percentage of BTs, neither their CK nor their PCK showed any improvement between pre and post-testing. This was true of both Learning Study and control groups (see Table 6.9). This is important data for focusing teacher trainers' minds on the effectiveness of existing programmes. One possible implication for the recruitment of BTs is that added prominence should be given to assessing prospective teachers' susceptibility to conceptual change, rather than just focusing on their initial levels of CK (or PCK).

8.4.2. Recommendations for Practice

The focus of Learning Study is student learning. It is this focus that is often credited with causing the teacher learning that occurs in Learning Study (Pang, 2006). However, it would be consistent with the principles of PVT to focus on both student learning and teacher learning in a Learning Study. This could be done through gathering and analysing pre and post-test evidence of BTs' (or teachers') CK and PCK alongside evidence and analysis of students' CK. Although it would increase the resource demands of Learning Study, such a process has the potential to be very powerful in terms of BT (or teacher) learning because of the variation that BTs (or teachers) can experience between their own CK, students' CK and their PCK.

One practical outcome of establishing the conceptions of price presented in Table 6.0 and Table 6.1 is that they could result in more effective ways of teaching price. This is because of the positive effects on BTs' CK and PCK that might result from: i) BTs' experience of variation between their own conceptions and those conceptions proposed in the study and, ii) their trainers having a finer grained understanding of the critical features that need to be varied in order to help BTs develop a more sophisticated understanding.

Another interesting implication for the practice of Learning Study arises as a result of BTs who exhibited PCK conceptions in Column C (Table 6.1) in the pre-test. These BTs already had a good understanding of students' understanding since they put forward well-structured accounts of qualitative differences between students' conceptions. It seems likely that if more experienced teachers had been involved in the study then a greater proportion of them would have been able to do the same. A question therefore arises about the extent to which teachers who can accurately predict students' conceptions need to conduct the analysis of pre-test data that is a common feature of Learning Study. If some teachers do not, then this could significantly reduce the resource demands of Learning Study. In addition, it could allow Learning Study to become more embedded into teachers' routine practice than

is possible with current models, greatly extending its reach. This study provides a way of identifying those BTs (or teachers) who this might apply to. It also offers a way of developing other BTs' (or teachers) ability to predict students' conceptions by providing a framework for thinking about the structure of those conceptions (see Table 6.1). Exposure to Table 6.1, for example, may crystallise BTs' (or teachers) latent, and perhaps hazy, awareness of students' understanding in relation to this topic area, as well as providing a model for identifying qualitatively different conceptions in different topics.

In previous studies into conceptions of price it is not clear whether the 'gaps' between conceptions (in terms of their level of sophistication or 'difficulty') are equal throughout the hierarchy of conceptions, or whether they are not. Since the findings of this study are that BTs' conceptions are arranged in a grid, it became necessary to address the issue of the 'gaps' between conceptions in order to rank them. The study initially assigned rankings to conceptions on a priori grounds and then sought supporting evidence in an analysis of the frequencies of BTs' demonstration of different conceptions. There was found to be a good deal of consistency between these two and therefore the study suggests that some forms of conceptual change in relation to price are more 'difficult' than others. This matters because if the 'gaps' are

not equal, teacher trainers can improve their training if they know which variations in which critical features are likely to require particular attention. Perhaps at these points, trainers may need to expose their BTs to a greater number of variations in order to trigger conceptual change in a greater number of BTs. Achieving conceptual changes in BTs might require more careful attention for some conceptions than for others.

This study has shown that most BTs began their teacher training with low levels of CK in relation to price. One important implication of this is that teacher training courses cannot be organised around an assumption that BTs will arrive with high levels of CK. This may require a reorientation of training to include a greater focus on CK. This could involve extending the length of training or introducing a pre-course booster course in economics and business studies. There is already some precedent for this in the English teacher training system in the existence of Subject Knowledge Enhancement courses. To this point these courses been focused on what are perceived to be subject areas that struggle to attract applicants with good CK (Department for Education, 2015).

8.4.3. Recommendations for Research

In this study, conceptions of CK and PCK were found to vary along the internal and external horizons. This raises the question of whether an analysis of students' conceptions of price might reveal a similar distinction if, during the gathering of evidence, the context was systematically varied. Evidence in relation to other phenomena might also reveal a similar pattern. There is an unresolved question in PVT about how the external horizon should be taken in to account during the gathering of evidence of conceptions and in the presentation of those conceptions. This study has found one pattern, but it is conceivable that there may be others that could be established through additional research.

The main focus of this study in terms of PCK is BTs' knowledge of 'students' learning difficulties'. One potential challenge in relation to this is that a BT might have a good knowledge of student's learning difficulties but might be unable to operationalise that understanding because of a poor knowledge of instructional strategy (the other component of Shulman's original formulation of PCK). This would affect the quality of BTs' teaching. In PVT, 'knowledge of instructional strategy' can be equated with 'knowledge of Learning Study'. Therefore to complement the findings of this study, additional research would be needed into the

sophistication of BTs' conceptions of Learning Study. The small scale, pilot study described in Appendix 10.5 could provide a useful starting point for this research since it proposes a hierarchy of conceptions related to Learning Study based on a study involving BTs. These conceptions are expressed in a way that could also be applicable to the control group. For example, 'clarifying different levels of student understanding' and 'transforming student learning through conceptual change' (see Table 1, Appendix 10.5) are both potentially features of good teaching in general.

The conceptions of BTs' PCK proposed in Table 6.1 contain aspects that are expressed in terms that are not specific to a particular subject domain – both on the internal and the external horizon. Thus, for example, BT's ability to show structure or not to show structure in their thinking about students' conceptions could hold true across other subject domains. The features noted along the external horizon in relation to CK might also apply to other subject domains. Therefore a question arises as to whether Table 6.0 and Table 6.1 could form the basis for a more generalised set of conceptions of CK and/or PCK that might stretch across other subject domains and be used to support more topic focused descriptions. Additional research would be required to confirm this.

Previous quasi-experimental evaluations of Learning Study have not presented data at the student or teacher level. In doing this, the current study has brought into focus the issue of those BTs whose conceptions actually fell over the course of their training. It was suggested in Section 7.5 that this could be a result of BTs experiencing 'too much' variation. However, this assertion requires further investigation if it is to be substantiated. PVT does not appear to have an answer to this question currently.

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10. APPENDICES

10.1. Task A: Written test to determine BTs' CK (market context)

Task A – The Price of Coffee Beans

Over 2.25 billion cups of coffee are drunk in the world each day. Coffee is mainly grown by farmers in developing countries. In 2011 the price of coffee beans sold on the world market was about $6 a kilo. Why do you think that the price was about $6 a kilo? What could explain why the price was not $5 or $7 a kilo? What factors could affect the price? Please explain why the price of coffee was about $6 a kilo in as much detail as you can.

10.2. Task A: Written test to determine BTs' CK (business context)

Task A – The Price of a Cup of Coffee

Suppose that you were the new owner of the school canteen and were deciding what prices to charge. The previous owner charged £0.75 for a cup of coffee. What price would you set for a cup of coffee? Would you set the current price or a different price? What would you consider when you set the price? Please explain why you would set this price in as much detail as you can.

10.3. Task B: Written test to determine BTs' PCK (market context)

Task B – Student Understanding of the Price of Coffee Beans

1. You ask a group of 14 year old students the following question:
Over 2.25 billion cups of coffee are drunk in the world each day. Coffee is mainly grown by farmers in developing countries. In 2011 the price of coffee beans sold on the world market was about $6 a kilo. Why do you think that the price was about $6 a kilo? What could explain why the price was not $5 or $7 a kilo? What factors could affect the price? Please explain why the price of coffee was about $6 a kilo in as much detail as you can.
Please write below what you think would be the different ways in which students might think about why the price of coffee was about $6 a kilo and rank them in order of difficulty.
If you come up with two ways of thinking that might belong in the same CATEGORY, then please only write the category ONCE below.
You do not have to complete all rows in the table.

Possible student ways of thinking about why the price of coffee was about $6 a kilo		**Ranking of how sophisticated the way of thinking is (1 is the hardest)**
1		
2		
3		
4		
5		

2. Next, you ask a group of 21 year old students the same question as above.
Please write below any *other* CATEGORIES of ways of thinking that they may have about why the price of coffee was about $6 a kilo. Again please rank them in order of difficulty.
You do not have to complete all rows in the table.

Other more sophisticated ways of thinking about why the price of coffee was about $6 a kilo		**Ranking of how sophisticated the way of thinking is (1 is the hardest)**
1		
2		
3		

Please go to the second sheet

Looking at your answers to Questions 1 and 2 above, please explain why you have placed the ways that students might be thinking about price in the order that you have.

Have you taught a lesson on price? **Yes** **No**

About you	
First Degree title	
Classification of First Degree (1st, 2:1, 2:2 etc)	
Higher Degree title (if appropriate)	
Teaching Subject	

Many thanks for taking part in this study.

10.4. Task B: Written test to determine BTs' PCK (business context)

Task B – Student Understanding of the Price of Coffee

1. You ask a group of 14 year old students the following question:
Suppose that you were the new owner of the school canteen and were deciding what prices to charge. The previous owner charged £0.75 for a cup of coffee. What price would you set for a cup of coffee? Would you set the current price or a different price? What would you consider when you set the price? Please explain why you would set this price in as much detail as you can.
Please write below what you think would be the different ways in which students might think about why the price of a cup of coffee in the school canteen was set at the level it was and rank them in order of difficulty.
If you come up with two ways of thinking that might belong in the same CATEGORY, then please only write the category ONCE below.
You do not have to complete all rows in the table.

	Possible student ways of thinking about why the price of a cup of coffee in the school canteen was set at the level it was	**Ranking of how sophisticated the way of thinking is (1 is the hardest)**
1		
2		
3		
4		
5		

2. Next, you ask a group of 21 year old students the same question as above. Please write below any *other* CATEGORIES of ways of thinking that they may have of why the price of a cup of coffee in the school canteen was set at the level it was. Again please rank them in order of difficulty. You do not have to complete all rows in the table.

	Other more sophisticated ways of thinking about why the price of a cup of coffee in the school canteen was set at the level it was	**Ranking of how sophisticated the way of thinking is (1 is the hardest)**
1		
2		
3		

Please go to the second sheet

Looking at your answers to Questions 1 and 2 above, please explain why you have placed the ways that students might be thinking about price in the order that you have.

	Yes	No
Have you taught a lesson on price?		

About you	
First Degree title	
Classification of First Degree (1st, 2:1, 2:2 etc)	
Higher Degree title (if appropriate)	
Teaching Subject	

Many thanks for taking part in this study.

10.5. Report on a pilot study into conceptions of Learning Study

Beginner Teachers' understanding of Learning Study: variation and implications

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Introduction

Since variation in the effect of schooling on students' learning is largely attributable to differences between teachers (Nye, Konstantopoulos & Hedges, 2004; Rockoff, 2004), improving the quality of teaching is a major concern in educational policy. Learning Study has been proposed as an effective way of developing teachers' thinking and practice (Pang, 2006; Holmqvist, forthcoming) and improving students' learning (Pang & Marton, 2003, 2005).

There are two principal ways in which Learning Study could be used to develop teachers. In one model Learning Study is used to develop rigorous evidence of qualitative differences in conceptions of phenomena, examples of designing teaching in line with Variation theory and evidence of the relative effectiveness of these strategies in improving students' learning. This model is implicit in studies (e.g. Pang & Marton, 2003, 2005) which focus on comparing the outcomes of students' learning. Such an approach involves resource intensive interventions and the spread of practice by sharing evidence of conceptions of different phenomena and lesson designs.

A second model aims to embed the Learning Study approach in teachers' thinking and practice. In this model (e.g. Pang, 2006; Holmqvist, forthcoming) the spread of practice depends on changing the ways in which teachers *routinely* think about their work (Wood, 2000), whether or not they are teaching a topic for which evidence from prior Learning Studies is readily available.

Davies and Dunnill (2008) present evidence of how Learning Study can be influential in the development of teachers' thinking and practice during their initial teacher education. However, they also show that Learning Study involves considerable challenges for beginning teachers and that there are large differences in impact across individuals. This is perhaps not surprising given that changing teachers' conceptions of teaching is very difficult (Kagan, 1992; Valli, 1992). This paper aims to build on the work of Davies and Dunnill (2008), identify more precisely variation in the way that teachers understand Learning Study and consider the implications for developing more effective ways of introducing teachers to Learning Study.

Learning Study: Principles

Learning Study builds on Lesson Study. In Lesson Study, groups of teachers meet regularly over long periods of time (ranging from several months to a year) to work

on the design, implementation, testing and improvement of one or several 'research lessons'. Advocates of Lesson Study (Stigler & Hiebert, 1999) argue that it removes the difficulties in applying education research findings to a classroom whilst providing a consistent focus on the learning outcomes of lessons. It is also asserted that the collaborative nature of Lesson Study supports improvements in teachers' reflective learning. Stigler and Hiebert argue that Lesson Study is likely to be a key factor accounting for Japan's educational success.

Learning Study combines elements of experimental design with an analysis of learning in terms of Variation theory (Pang & Marton, 2003). According to Variation theory, qualitatively different ways of understanding a phenomenon are differentiated by the combination of features that are highlighted in an individual's awareness. Learning is therefore a shift in the way of seeing, brought about by a change in the pattern of discernment of the features of a phenomenon. Since discernment is said to take place through experience of variation, it follows that the task of the teacher is to structure learning activities such that the critical features of a target conception are highlighted through variation whilst non-critical features are suppressed through invariance. In Learning Study, teachers are expected to learn through the variation that they experience between designing lessons in their

conventional way and designing lessons through Learning Study. Pang and Marton (2003, 2005) present accounts of Learning Studies in which the comparison lessons were developed in a 'Lesson Study' format. Such comparisons are intended to highlight the features of Learning Study that are critical to the gains in learning that are expected for students.

According to Pang and Marton (2003), a Learning Study consists of five steps:

1. Choosing an object of learning (they provide examples of 'the concept of price, proficiency at essay writing, or developing empathy with people from other cultures').
2. Ascertaining students' pre-understandings (they suggest a pre-lesson test in order to identify students' conceptions of the phenomenon being taught).
3. Planning and implementing the lesson(s) with teachers working together to highlight the critical features for the desired way of understanding the phenomenon.
4. Evaluating and revising the lessons: analysing evidence from the lesson focusing on 'how the object of learning is handled'.
5. Reporting and disseminating the results.

Pang and Marton's focus is very much on learning outcomes for students rather than for teachers. However, one implication of variation theory is that teachers will experience Learning Study differently according to their awareness of its critical features. Effective induction of teachers into a 'Learning Study' group requires, from this perspective, that teachers will be made aware of those features of Learning Study that are critical to understanding it in the way described by Pang and Marton (2003, 2005). If we can identify qualitatively different ways of understanding Learning Study then there is a firmer basis for explaining how and why it is successful (or not) in a particular instance. If, at a subsequent point, ways of understanding Learning Study can be linked to ways of understanding teaching in general, then this can contribute to a greater understanding of any 'spill-over' benefits that Learning Study might have in a teacher's regular teaching and thus the effectiveness of the 'embedded' model of Learning Study outlined earlier. Finally, it can allow the development of better ways of presenting Learning Study to teachers, particularly if the critical features required to bring different conceptions into teachers' awareness can be identified.

Method

Initially, we need to clarify the approach we have taken towards the relationship between 'critical features' of a phenomenon and a conception of a phenomenon. The approach adopted by Pang and Marton (2003) treats critical features as either being highlighted or not highlighted to the individual in any particular conception. However, in an investigation of ways of experiencing being a university researcher, Åkerlind (2005) adopts a different approach to the relationship between critical features and ways of understanding. She presents a table in which each critical feature may take any of several values. In this construction, critical features are not simply 'on' or 'off'. They take a different categorical meaning for each conception of a phenomenon.

This distinction can be illustrated through an example taken from Pang and Marton (2003). In this example of Learning Study teachers were trying to improve students' conception of the effects of a sales tax. One conception of the effect of a sales tax is referred to by Pang and Marton (2003, p.186) as 'the sales tax …would be shared due to elastic demand'. This treats 'elasticity of demand' (the relationship between a change in the quantity of a product which is demanded and a change in the price of that product) as a feature that *may* or *may not* appear in a student's awareness of a

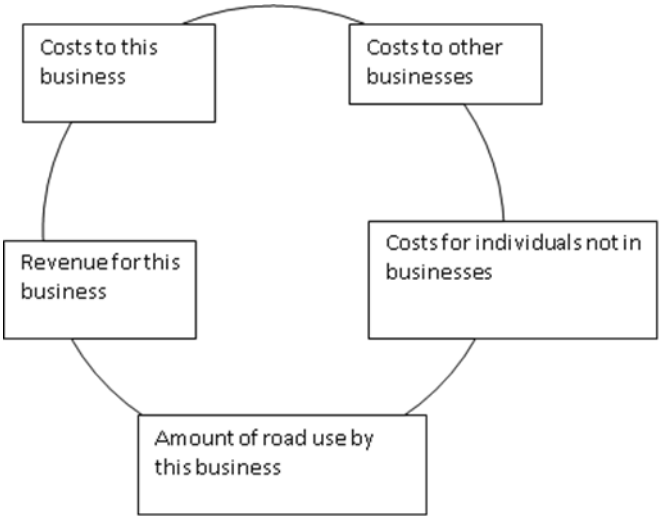
sales tax. However, it would also be reasonable to ask 'what different conceptions do students hold of elasticity of demand?'. This would be the approach suggested by Åkerlind's construction of the problem. In this study we follow the less fine-grained approach used by Pang and Marton, although we recognise that more detailed analysis might well reveal insights which are glossed over here.

Teachers in this study were introduced to Learning Study through examples illustrating the five stages of the approach, supported by a detailed written briefing. Groups of teachers were given time to select the phenomenon that they wished to teach and subsequently to discuss variation in ways of understanding that phenomenon. They then designed teaching activities that allowed a staged variation in critical features to take place. We have normally allocated a full day for this or the equivalent in time (about seven hours or so). Our intention is that teachers use Learning Study to develop their thinking and practice and to provide them with a model of professional development that could become embedded in their routine practice. Therefore, the selection of a phenomenon has been delegated to the teachers with the expectation that these would be drawn from their usual curricula at the time when the Learning Study teaching took place.

Two features of the approach taken to Learning Study may be distinctive. First, to a large degree we have encouraged teachers to develop their own categories of description based on their understanding of students' conceptions of a phenomenon. In other words we have not insisted that teachers undertake any pre-testing of student conceptions. This has been an essentially pragmatic decision in the light of the extensive demands Learning Study makes of teachers.

Second, utilising a suggestion by Davies and Dunnill (2008), the teachers were encouraged to use 'Learning Outcome Circles' to articulate their thinking about features of a conception that are critical to different ways of understanding. Here teachers are asked to identify the critical features, map them onto a circle and then explore the interrelationships between them. The intention is to help teachers to relate the design of the lesson to their objective by clarifying the variation and the invariance that they want to present to students. The resulting design of lesson, in which the pattern of variation and invariance is directed by the most complex, target way of understanding the phenomenon is broadly the same as that used by Pang and Marton (2003, 2005) in their Learning Studies. An example of a Learning Outcome Circle relating to the phenomenon of externalities in economics is given in Figure 1 below.

Figure 1 – A Learning Outcome Circle



This study draws on three sets of teachers that we have worked with on Learning Study. These groups are:

1. Twenty-seven teachers of Business Studies and Design and Technology in secondary schools in England who took part in a Learning Study project between 2007 and 2009 funded by the Training and Development Agency for Schools. All teachers volunteered to take part in the project. Three of the Business Studies teachers were recent graduates (within three years) of an initial teacher education programme in which they had experienced Learning Study. Three other Business Studies teachers had experience of mentoring trainee teachers on this programme. Most of the teachers had a position of

responsibility (usually head of department) within their schools, although there was considerable variation in the number of years' experience of teaching.

2. Trainee teachers involved Postgraduate Certificate of Education programmes in Business Studies and Design and Technology in one English university, in which up to thirty seven trainees are enrolled. Learning Study constitutes a central part of the educational and professional issues aspect of these courses and trainees take part in two Learning Study cycles during the nine month programme.
3. A small number of other Learning Study groups based in secondary schools in the West Midlands of the UK that have been set up and run in association with a UK university.

In this paper we report on in-depth interviews with eleven of these teachers. Interviewees were selected to try to include a full range of the variation in the sample (on the basis of teachers' written comments at the end of the project) whilst working within constraints imposed by teachers' availability.

Following discussions about the structure and style of the interviews, the first two were conducted jointly by the two researchers involved. This was done in order to standardise the approach to the interviewing process and provide some training for the less experienced researcher. Our analysis of the transcripts followed a standard phenomenographic process and involved multiple refinements of the categories of description.

Results - Categories of Description of Learning Study

The different conceptions of Learning Study and the critical features highlighted in these conceptions are summarised in Table 1. Thus, the first conception, 'Working as a group of teachers to enhance student learning' highlights teachers' experience in planning, teaching and reviewing lessons together in Learning Study. When a critical feature is highlighted in a conception, this is denoted by 'Yes' in Table 1.

Table 1 – Teacher Conceptions of Learning Study

		How Learning Study is experienced			
		1	2	3	4
		Working as a group of teachers to enhance student learning	Facilitating students taking responsibility for their own learning	Clarifying different levels of student understanding	Transforming student learning through conceptual change
Critical Features	Planning, teaching and reviewing together	YES	NO	NO	NO
	Focusing on student activity in lessons	NO	YES	YES	YES
	Determining teaching objectives by reference to levels of student understanding	NO	NO	YES	YES
	Focusing on the features critical to each level of student understanding	NO	NO	NO	YES
	Varying critical features in a conscious way	NO	NO	NO	YES

Category of Description 1 – Working as a group of teachers to enhance student learning

Teachers with this conception of Learning Study believed that the quality of the lesson would be higher because of the larger pool of ideas and the potential synergies resulting from working with others. In the words of one beginning teacher:

> *…….. we taught a lesson that was on advertising and how to communicate with customers and we taught the lesson to begin with and we didn't teach it very well to be honest. We assumed too much from the students and the task was a little unfocused. Within fifteen minutes we sat down and reviewed it at the end of the lesson, made our changes, changed the resources, added new bits in, took bits away and between the break time we then got back into the teacher mode and taught it again to a new group. There was a significant improvement because we each contributed our perspective of the lesson. From where I was stood when I was speaking about me, my mind was on other things apart from necessarily me whereas other people were seeing the mistakes that I had made. So being able to sit down for fifteen minutes and change things and make suggestions to each other and agree as a group where things went wrong it made a big difference to the way the second lesson was delivered.*

In this extract there is a sense of the shared effort in Learning Study with the term 'we' being used no less than eight times. A 'significant improvement' is emphasised along with reference to the 'big difference' made by collectively reviewing the lesson, as well as the fact that as a result of this lesson students were 'more successful'.

Category of Description 2 – Facilitating students taking responsibility for their own learning

In this category, Learning Study was seen as a way of empowering students by giving them more responsibility in lessons to work things out for themselves through the completion of relatively open ended tasks. It is regarded by the teacher as a move away from seeing teaching as 'delivery' towards seeing it as 'facilitation'. It is about making student learning the central measure of the success of a lesson and frequently also about taking their experiences into account in designing that lesson. As one experienced teacher said:

The main difference is that the students did the learning and did the work 100% rather than me having to do it. Many times it feels like I have got to deliver it, I have got to check that they have understood it, I have got to confirm that they have understood it as well. Whereas today it was completely different, yes of course I prepared the lesson but then they take responsibility for learning it and getting the outcomes that I expected them to get. That is the primary difference. I thought the level of involvement was a lot greater than what I would usually see …… Normally if I pose a question to the class there will always be two or three hands that shoot up and only two or three voices that I will hear. Whereas with this task everyone was given the opportunity to show exactly how they understood a particular concept even if that wasn't directly through answering the question - it was through the activity that we did…… I have had lessons when I didn't have to do much and the students would achieve the outcomes without me having to knock them on their heads and saying 'this is what you are trying to do so don't get distracted'. I suppose I have got used to the idea that I have got to be doing this and I have got to be leading them all the time. It felt quite good and nice to see that they are independent learners and I can trust them with it. I don't need to be their mother all the time.

In the above extract the teacher is very focused on their own role and how their previously held habitual conception of teaching has been challenged. Learning Study appears to have had a significant impact on how this teacher views herself. It may be significant that there is a reference, in the fifth line, to the way in which '***I*** prepared the lesson'. In fact the lesson was produced with three other teachers (although this teacher did present it to students). For this teacher then, the collaborative influence of the Lesson Study aspects of the process appear to be entirely absent.

Category of Description 3 – Clarifying different levels of student understanding

The major feature of this category is the distinction drawn between the object of learning itself and ways of thinking about it. Teachers in this category claimed that, in comparison to their usual teaching, their planning in the Learning Study was more carefully focused on different conceptions of the object of learning. They also claimed that this enabled them to differentiate between the needs of different students more effectively.

So for me the contrast between that and the way you traditionally prepare a lesson is that rather than focusing on specifically what needs to be understood or taught to cover that particular aspect of the syllabus you would rather think about the wider context and the idea which you are trying to communicate and consider the different levels of sophistication that a learner could understand that idea by and trying to develop the sophistication of that understanding …. Also actually having a really clear framework for differentiation based on the sophistication of understanding isn't maybe something I would… I would like to say that I did it more but if I am being honest I would say in the worst aspect of my teaching that just doesn't seem to happen. The idea of differentiation is just giving them easier questions or just giving them a more straight forward case study but actually it is not linked to this idea of starting at a lower level of sophistication of understanding and progressing them through that system. So for me that is a big difference because, just to try and explain that a little fuller, the way I look at differentiating my lessons wouldn't be based on sophisticated levels of understanding it was based on giving them something easier to do…. I find it extraordinarily difficult [Learning Study], a lot harder than I thought it was going to be. I don't think I have actually ever considered an idea in my subject as fully until I tried to think about different levels of sophistication.

The idea of working with qualitatively different conceptions is frequently referred to in the above quotation in this teachers' use of the phrase 'levels of sophistication'. This critical feature would appear to build cumulatively on that identified in Conception 2. No reference at all is made to collaboration and again this was typical across those individuals who held this conception.

Category of Description 4 – Transforming student learning through conceptual change

The final category focuses on encouraging conceptual change in students by moving them from one level of understanding to a higher one. The crucial vehicle for this way of thinking about Learning Study is an identification of the critical features that distinguish one conception from another. Activities within a lesson are designed to highlight variation in individual critical features before allowing all features to vary simultaneously. Teachers reporting this conception often described the experience as invigorating because they believed it had encouraged them to re-examine exactly why it is important to teach a particular phenomenon to students.

I think in terms of varying, in a controlled and progressive way, elements of an activity and trying to maintain the control over the activity and the way that you design the activity in terms of varying one element at a time and then gradually moving through, I think actually has become for me really quite difficult. Although I think we have made progress in the last learning study lesson that we put together and actually almost laying out a grid and writing down what elements we have actually changed. In the last learning study we said 'yes, we have changed that and that, hang on a minute in actual fact we have changed three elements – no, no, no redesign slightly, re -jig'. I think in terms of having that awareness of how that impact upon the mechanics of the lesson i.e., an activity within the lesson I think is important to maintain the control of the direction of lesson and maintaining control of the progression in terms of learning of the students. Again it comes back to without that element I have just designed an activity and I can do that. There is actually a control mechanism i.e., the Variation theory which I am sure is controlling what and why things happen within a particular activity or a series of activities through the lesson. Again it has quite an impact on the design of the lesson but it also makes you think about where the students are going and why they are going from x to y to z rather than 'okay I can do that, then they will do that, that's a great activity, the kids will enjoy it'.

Discussion

Challenges in identifying the phenomenon to be taught

Pang and Marton (2003, 2005) report Learning Study interventions in which the object of study - the phenomenon - is identified by the researchers and teachers are asked, by way of preliminary activity, to discover the different conceptions of this phenomenon that students may hold. However, if Learning Study is to become routinely embedded in teachers' thinking and practice they need to be able to identify phenomena for themselves and it appears from this study that this can be quite problematic.

Teachers in our study found it difficult to distinguish between the phenomenon which they want students to understand and conventional representations of that phenomenon in textbooks and curriculum specifications. For example, teachers of Business Studies in the current study initially identified one phenomenon as 'the marketing mix'. However, after considerable discussion they decided that their real focus was 'strategies to increase sales' and that 'the marketing mix' was simply one (textbook) way of understanding that phenomenon. This issue proved to be consistently challenging. In the view of one teacher, 'I think the main [difficulty with

Learning Study] ….. is how you are going to create the phenomenon, to decide what that is going to be and then work out your levels from that because there are lots of different ways you could go down' .

Teachers who believe that conventional conceptions (such as the marketing mix) *are* the phenomena tend to find it very difficult to work with the idea of identifying different conceptions in general. To them, students either have the required conception or they do not; they either understand what the marketing mix is or they do not. This could explain why some teachers feel that Learning Study challenges their professional competence, their subject knowledge, so deeply. It might also help us understand why some are frustrated and irritated by the way in which Learning Study seems to distract them from teaching directly what they feel they should be teaching.

Learning Study requires that participating teachers and researchers have a shared sense of the object of learning. We have found that divergent views as to the nature of the phenomenon frequently develop during the Learning Study process and that this issue does not seem to be easily addressed by applying the principles of either

Learning Study or Variation theory. Facing this challenge is critical to the process of embedding Learning Study in teachers' thinking.

Challenges in identifying student conceptions

An 'embedding' model for teacher development through Learning Study precludes the intensive resource demands of the interventions described in Pang and Marton's studies (2003, 2005), but it is still necessary for teachers to have an understanding of differences between conceptions and the features of phenomena that are critical to these conceptions (Holmqvist forthcoming). Systematic and rigorous evidence of qualitative differences and critical features is currently only available for a minority of the phenomena which form the objects of learning in schooling. Even after experiencing a researcher-led Learning Study, teachers may lack the skills (as well as the time) to carry out the research necessary to establish differences between conceptions. The challenges faced in training researchers to undertake phenomenographic research are substantial (Walsh, 2000) and may also have significant cost implications.

So how can teachers be encouraged to be attentive to qualitative differences between conceptions and the associated critical features without undertaking rigorous, time

intensive analysis? In our approach there were two phases to this. First, teachers were asked to develop their own tentative descriptions of the qualitatively different conceptions of a particular phenomenon. This was based on their experience of learning the phenomenon and on their experience of working with students. A target conception was then decided on for a particular lesson. In the second phase, teachers were encouraged to make use of 'Learning Outcome Circles' to map out features of the phenomenon that were critical to their own understanding of the phenomenon and the way of understanding typically presented in textbooks.

For individual teachers variation occurred between their understanding of the phenomenon and their perception of 'textbook understanding' as well as between their experience of learning the phenomenon and their perception, as teachers, of different levels of student understanding. In addition, there was significant variation along both these dimensions between the teachers in the group. This was all sufficient to generate lively and productive debate about different ways of understanding the phenomenon and features of it that were critical to the way of understanding identified as the target of teaching.

On the basis of this discussion and the representations of understanding that arose, the teachers were encouraged to gather some data in their own schools to discover conceptions held by the students prior to the Learning Study lesson. Even if the data that teachers collected were partial and unreliable by the standards expected in phenomenographic research, the task of collecting data was important to those teachers who subsequently expressed Conception 4. Teachers expressing Conceptions 1 and 2 did not refer to the prior collection of data at all and the process of using the Learning Outcome Circles to analyse conceptions was not critical to their understanding of Learning Study.

For the 'embedding' approach to Learning Study to be effective, teachers need to be able to identify student conceptions of a given phenomenon and the associated critical features without detailed phenomenographic research. We do not have specific data on how accurately the teachers in our study did this. We can say, however, that there is an important role for the collection of some data both before and after the teaching of the lesson in terms of developing higher conceptions of Learning Study. We might also point out that the possibility exists that refinements in the description of conceptions and critical features might occur during the review phase of Learning Study if inaccuracies were found.

The role of collaboration in Learning Study

The minority of teachers who understood Learning Study in terms of Conception 1 viewed the experience only in terms of its collaborative nature. The other features of Learning Study which were critical to Conception 4 (such as 'Focusing on features critical to students' conceptions', through Learning Outcome Circles) were as much sources of variation for these teachers as for the other teachers, yet they do not appear to have 'discerned' them in their experience. As with evidence of students' learning presented by Pang and Marton (2003, 2005) exposure to variation in features of a phenomenon critical to the 'highest' conception is sufficient to help some learners develop that way of thinking, but not all. There are a number of possible explanations for this:

1. The greater the difference between an initial conception and a target conception, the less likely that the learner will be to change to the target conception.
2. The apparent inability of some teachers to reach the higher conception of Learning Study may have been a result of the way in which teachers were inducted to it. Conceptions of Learning Study, its critical features and the

implications of variation theory did not form an explicit focus in our preparations for introducing Learning Study.

3. The emotional 'heat' generated by variation in one critical feature may tend to absorb all of a learner's attention. Teachers who were used to collaborating (at least sometimes) in preparing, teaching or reviewing lessons tended not even to notice this feature of Learning Study.

However, for teachers for whom this was an unusual experience, it assumed an over-riding significance. Learning Study may raise questions about teachers' sense of professional identity: the nature of their expertise and their independence. This challenge lies at the heart of its potential, but it also helps to explain why some teachers may not develop a complete understanding of Learning Study.

The absence of collaboration in the critical features highlighted by teachers expressing conceptions of Learning Study other than Conception 1 raises the question of whether the collaborative element is, in fact, necessary for teachers to develop a sophisticated conception of Learning Study. In the studies conducted by Pang and Marton (2003, 2005) a comparison is made between the outcomes of 'Lesson Study' and 'Learning Study' lessons. In both these cases teachers are working

in small groups, so the collaborative element is not highlighted in the comparison. The researchers do not discuss how they managed to suppress teachers' comparisons with their usual practice. Nonetheless, the main point here is that collaborative work is important to the Learning Study process even though it may not be a 'critical feature' of Learning Study. In the present study the collaborative element was important for generating difference in conceptions of the object of learning during teachers' preparation. It was also central to creating the conditions under which teachers could gather and reflect on data on students' learning from the lessons.

Conclusion

Given the importance of teacher effectiveness to the impact of schooling on outcomes for students it is important to evaluate the role that interventions can play in developing teachers. Research on Learning Study provides encouraging evidence on impacts for students (e.g. Pang & Marton, 2003, 2005) and indications of impacts for teachers (Pang, 2006; Davies & Dunnill, 2008). This study examines the challenges to be faced in using Learning Study in teacher development using an 'embedding' model: aiming to use teachers' experience of Learning Study to develop their way of thinking about teaching and their routine practice. In order to achieve this aim this research enquires into the teachers' conceptions of Learning Study using in-depth

interviews after they have completed a 'Learning Study Cycle' of analysing conceptions, gathering data, preparing, teaching and reviewing lessons together. Using evidence of these conceptions it should be easier to design ways of introducing teachers to Learning Study which make it more likely that they will become aware of the features of the experience that are suggested as critical by the originators of this approach (Pang & Marton, 2003, 2005).

We have found four main ways in which teachers experience Learning Study and five critical features. When teachers are being introduced to Learning Study it is desirable that their attention (perhaps through a comparison of two specific examples of lesson preparation) is focused on four critical features: i) the extent to which learning objectives for the lesson are derived from evidence of qualitative difference between ways of understanding the object of learning, ii) the way in which critical features of the object of learning are identifying during lesson planning, iii) the way in which features of the object of learning are varied or invariant in the design of activities for students and, iv) students' level of responsibility for their own learning in their activity in the lesson.

However, there is always another, and very important, basis for teachers' comparison: their own routine practice. Since the intention of an 'embedding approach' to Learning Study is intended to affect routine practice it is important to make this basis of comparison explicit – and the object of reflection. So, rather than presenting teachers with a comparison of two lessons prepared and taught by others there is a case for asking teachers to prepare a lesson themselves and then to compare this with the preparation and lesson design of a Learning Study lesson with the same object of learning.

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