

**THE USABILITY OF VIRTUAL PATIENTS
TO FACILITATE
CLINICAL REASONING IN PHYSIOTHERAPY.**

A thesis submitted for the degree of
Doctor of Education

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Abstract

Clinical reasoning is essential for effective physiotherapy practice, but its complexity makes it difficult to teach and learn. The literature suggests it is learnt within the practice environment and improves with patient-centred experience. However, physiotherapy education has a diminishing availability of practice-based learning. Patient simulation is used within medicine to counteract the decline in practice-based learning and to ease the theory-practice gap. This thesis explores the use of patient simulation to ease the theory-practice gap within physiotherapy. The literature relating to clinical reasoning, technology enhanced learning, simulation and virtual patients was reviewed. An institutional focus study was undertaken which explored the implementation of technology enhanced learning in physiotherapy education and detailed the development of a virtual patient simulation.

A case study approach was used to explore the usability of virtual patient simulation to facilitate clinical reasoning and ease the theory-practice gap. Twenty-six physiotherapy students participated. Three virtual patients were made available for three months for self-directed learning. Data was collected using focus groups and the think-aloud method was employed to capture the verbalised thought processes of nine participants while assessing a virtual patient. This was supported by electronic data capture methods within the virtual patient software. Thematic analysis was used to interpret the qualitative data sets.

Findings showed the fidelity of virtual patients facilitated clinical reasoning and eased the theory-practice gap. Participants perceived the virtual patient concept had merit and should be used in peer learning as part of their curriculum. Usability issues were identified and improvements suggested. The think-aloud method revealed the value of educators supervising physiotherapy students verbalise their clinical reasoning, to identify errors and improve learning.

Key words: virtual patient, clinical reasoning, simulation, technology enhanced learning.

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1.00 Chapter One: Introduction

At the beginning of this century society was changing rapidly and technology had become one of the most important features of the national and international economic, social and cultural landscape (Salmon, 2008). Technology impacted on numerous aspects of daily life via the increasing use of computers, mobile devices and the internet, for both domestic activities such as entertainment and banking, and within the changing work practices of many occupations, including those within healthcare. This was also true for those working and studying within higher education as technology provided new ways of accessing information and communicating ideas and this started to cause changes to the ways in which scholarship was undertaken (Somekh, 2007). This thesis was a product of those changes both within education and wider society and is set out as follows:

Chapter one: sets the scene for this thesis. It introduces me as the researcher, as well as the higher education institution and the specific physiotherapy programme of study that the research and institutional focus study undertaken for this thesis were located within.

Chapter two: reviews and analyses the literature relating to clinical reasoning, technology enhanced learning, simulation and virtual patients within pre-registration health education and specifically within physiotherapy. It examines the use of patient simulation and identifies a number of themes that focussed both the development of the virtual patient simulation used in the research and the design of the research study.

Chapter three: comprises of the Institutional Focus Study (IFS) which explores the issues surrounding the implementation of pedagogically based technology enhanced learning into the pre-registration physiotherapy programme. It shows how this led to the development of a bespoke physiotherapy virtual patient simulation and provides details of the rationale underlying this development.

Chapter four: explains the methodology and methods used in the exploratory case study undertaken and how the IFS shaped the research design.

Chapter five: presents and discusses the findings of the case study with reference to the research questions, the a priori themes from the literature review and the key themes from the IFS. It highlights the emergent findings from the case study.

Chapter six: discusses the emergent findings further and their implications for physiotherapy education, addresses the study's strengths and limitations, draws conclusions and makes suggestions for further research in this field.

Chapter seven: reference list

Chapter eight: the appendices

1.01 The wider context

At the beginning of the 21st century the National Audit Office (NAO) acknowledged that the shortage of registered health professionals within the United Kingdom (UK) meant the staffing levels needed for the National Health Service (NHS) were not being met (NAO, 2001). The NHS Plan (Department of Health (DH), 2000, p 50) pledged an 'unparalleled increase in the number of key staff over the next four years', along with doctors and nurses, this included over 6,500 therapists and other health professionals, with 4,450 more therapists and other key professional staff being trained by 2004. The NAO recommending an increase in pre-registration training provision (NAO, 2001) and the central government initiated a rapid increase in the number of qualifying programmes for nursing and allied health professionals (DH, 2000). Within England these qualifying programmes were funded by the Strategic Health Authorities who, under the central government directive, allocated funding to Higher Education Institutions to

provide new pre-registration programmes. Driven by the need to rapidly increase the numbers of health professionals within the NHS many of the programmes created were two year fast-track pre-registration programmes which were a faster alternative to the traditional three year full-time undergraduate programmes. The fast-track programmes enabled students with an applicable prior honours degree to be educated to Masters (MSc) level, and qualify to obtain professional registration within the appropriate health regulatory body. Although these fast-track pre-registration MSc programmes had been running successfully in Scotland for over a decade they were relatively new in England (Peacock and Hooper, 2007).

1.02 The specific context

One such Higher Education Institution (HEI) to receive funding under this initiative was a pre-1992 campus-based, research-intensive university, with a student enrolment of 10,000, hereafter referred to by the pseudonym Martias. Martias was funded to create and deliver fast-track pre-registration programmes in adult nursing, mental health nursing, speech and language therapy and physiotherapy. The pre-registration MSc physiotherapy programme is the focus of the following thesis as I was employed by Martias in 2004 as a lecturer in physiotherapy to develop and deliver the new pre-registration physiotherapy programme. I had previously worked as a physiotherapist in clinical practice for sixteen years in a variety of roles within musculo-skeletal settings. At Martias the specific academic role involved leading theoretical and practical skills-based teaching in musculo-skeletal physiotherapy and managing all the clinical placement activity; hereafter referred to as practice-based learning. The research undertaken for this thesis was thus shaped by the changing context of pre-registration physiotherapy education provision during the first decade of the 21st century and my role within it.

1.03 Pre-registration physiotherapy education

Physiotherapy began in the 1890s as a branch of nursing specialising in massage. It consisted of amalgamating separate courses that taught the

specific skills necessary to become a proficient practitioner (Barclay, 1994). The title Physiotherapy was adopted in 1943 in order to incorporate the use of other physical therapies, such as exercise and movement (Wiles and Barnard, 2001). In 1947, with the advent of the NHS, physiotherapy training became a three year hospital-based diploma course and stayed this way until the 1980's, when in common with that of other health professions, it began its transformation, from hospital based diploma training to HEI degree level education, becoming a totally graduate entry profession in 1992 (Barclay, 1994). The shift from training to education began in the 1980s partly because 1977 saw the Department of Health grant professional autonomy to physiotherapists which meant that by 1978 physiotherapists were legally allowed to treat patients without prior medical referral (Barclay, 1994). Initially the curriculum of physiotherapy degree courses followed the traditional diploma model. However, the shift from the hospital setting to the HEI enabled students to focus more on education than service provision (Rafferty, 1992) and enabled the development of more reflection and research content within the curriculum (Richardson, 1999). Thus, curriculum planning became more innovative as it was recognised that educational process was equally as important as subject content if the requirement for autonomous practitioners who were able to problem-solve, reflect and adapt were to be met (Brook, 1994). The importance of this was recognised by both the regulatory body, the Health and Care Professions Council (HCPC), who define the standards of education for physiotherapy, and the professional body; the Chartered Society of Physiotherapy (CSP).

HCPC approval is needed for a programme of study if qualifying students are to be able to register to practice in the UK. The HCPC (2012) curriculum standards 4.3, 4.4 and 4.6 respectively state:

- Integration of theory and practice must be central to the curriculum.
- The curriculum must remain relevant to current practice.
- The delivery of the programme must assist autonomous and reflective thinking.

While the Learning and Development Principles for CSP Accreditation of Qualifying Programmes in Physiotherapy (CSP, 2010) Principles 1, 3 and 4 respectively state that:

- Qualifying programmes should aim to develop the knowledge, skills, behaviour and values required to practise physiotherapy at newly qualified level, while nurturing the skills, behaviour and values that will enhance career-long development and practice.
- The learning process experienced by students should prepare them well for initial practice upon qualification, to promote continued learning and enable them to adapt to the challenges and opportunities of an ongoing career in physiotherapy.
- Learning, teaching and assessment approaches should be adopted that facilitate the development of high level cognitive skills.

1.04 The physiotherapy programme at Martias

To meet these requirements the fast-track pre-registration MSc physiotherapy programme (hereafter referred to as the physiotherapy programme) entailed two academic years; each forty-six weeks in duration. The first year was university-based while the second incorporated all the practice-based learning; the aim being to equip students with the core knowledge necessary to maximise learning within practice (van der Vleuten and Newbie, 1995). The programme adhered to a constructivist view of learning; emphasising understanding using interaction and collaboration (Tynjala, 1999). Teaching was not viewed as the transmission of knowledge to passive students but a facilitation of students actively constructing knowledge. The programme is summarised below in table 1.

Table 1: The MSc (pre-registration) physiotherapy programme

Year 1: - 46 weeks of university based learning			
Term	Physiotherapy specific university based learning	Inter-professional university based learning	Practice-based learning

1	Aims to introduce students to physiotherapy practice to prepare them for work within the clinical setting. Provides students with the opportunity to rehearse basic practical skills in a controlled environment and to study underpinning theory.	Introduces students to concepts of research methodology and critic.	
2	Introduces students to key concepts in physiotherapy assessment and evaluation of patients and provides opportunities for students to clarify and explore scientific measures as indicators of health and illness.	Introduces students to concepts of Inter-professional working. Continues to build on concepts of research methodology and critic.	
3	Introduces students to the use of physiotherapy to promote, maintain or restore wellbeing in patients by optimising function.	Continues to build on concepts of research methodology and critic.	
4	Continues to build on term 3	Continues to build on term 3	
Year 2: - 16 weeks of university based learning - 30 weeks practice based learning			
Term	Physiotherapy specific university based learning	Inter-professional university based learning	Practice-based learning
1	Allows students to apply the theory and practice of physiotherapy in practice settings and develops		350 hours

	students' abilities to analyse critically clinical data, make judgements and respond to patients.		
2	Continues to build on term 1	Introduces students to health systems and policy, and integrated governance. Continues to build on concepts of research methodology and critic.	350 hours
3	Continues to build on term 2	Continues to build on term 2	175 hours
4	Continues to build on term 3		175 hours

1.05 The academic element of study

During the first year of the physiotherapy programme the core knowledge and skills needed for physiotherapy practice were taught, building upon students' existing skills and knowledge from previous degrees and life experience. To facilitate this, in conjunction with practical skill-based teaching, problem-based learning (PBL) was used as an instructional strategy (Savin-Baden, 2007). PBL is linked to the theoretical framework of experiential learning, which defines learning as; 'the process whereby knowledge is created through the transformation of experience' (Kolb, 1984, p 41). It is a holistic model of the learning process drawn from the work of 20th century scholars, such as Dewey, Piaget, and Jung, and based on six propositions shared by them (Kolb, 1984). The six propositions are:

- Learning is a process not just an outcome- this process needs to include feedback on students' efforts.
- Learning is best facilitated by drawing out students' ideas about a topic so that they can be analysed, and integrated with more developed ideas.
- Learning requires the ability to both act and reflect.

- Learning involves thinking, feeling, perceiving and behaving; it is a holistic process.
- Learning results from synergic transactions between the student and the environment.
- Learning is the process of creating knowledge.

These principles were applied in the facilitation of student learning via problems, which were inherently scenarios of real world situations. Students worked in groups to manage these scenarios. They were not expected to acquire a predetermined series of 'right answers' but were expected to engage with the complex situation presented to them and decide what information they needed to learn, and what skills they needed to gain, in order to manage the scenario effectively. Students explored a wide range of information which they linked to their own learning needs and thus developed their skills of reflection and self-directed learning (Savin-Baden, 2000). The focus was on the students' personal engagement with the scenario, thus learning involved not just their existing knowledge but their values and feelings as well (Andresen, Boud and Cohen, 2000). Although PBL was not without its critics, who disputed its evidence-base (Tavakol, Dennick and Tavakol, 2009; Eksteen and Slabbert, 2001), it had for some time been widely accepted as an effective approach in physiotherapy education because it enhanced learning by contextualising the subject matter and developed problem-solving skills (Gunn, Hunter and Hass, 2012; Saarinen-Rahiika and Binkley, 1998; Graham, 1996). It had been developed by Barrows and Tamblyn (1980) to actively engage students in reflective and exploratory ways of learning, thereby developing clinical reasoning capabilities. It was developed in direct response to, what is now termed, the theory-practice gap: The term applied to the divergence between students' university learned knowledge-base and their actual experience of practice in the clinical setting (Roskell, Hewison, and Wildman, 1998). Clinical reasoning and the theory-practice gap are discussed in more detail later in the chapter.

1.06 Practice-based learning

Practice-based learning has no universally agreed definition, it is the term used to refer to learning that is explicitly designed to relate to professional practice standards and is interconnected with other educational activity, such as assessment (Quality Assurance Agency Scotland, 2011). Within physiotherapy in the UK the relevant standards are set by the HCPC, and practice-based learning comprises of placements within the clinical setting that enable the supervised acquisition of professional skills (Lekkas, Larsen, Kumar et al. 2007). During the second year of the physiotherapy programme at Martias students undertook six, five-week blocks of practice-based learning, interspersed with university-based study, to build on their existing knowledge base and develop their cognitive and practical skills to the breadth required to become a competent autonomous physiotherapist within the demanding environment of modern healthcare (CSP, 2010). Practice-based learning was widely recognised as a principal component of pre-registration physiotherapy within the accreditation of various national curricula (CSP, 2010; Australian Council of Physiotherapy Regulating Authorities, 2004; Canadian Physiotherapy Association, 2002). The curriculum framework in the UK required students undertook a minimum 1000 hours of practice-based learning in a range of settings including hospital wards, out-patient departments and community locations, thus providing opportunities for the development of a broad spectrum of skills and giving exposure to a variety of professional contexts (CSP, 2010). This was perceived as essential to the development of clinical skills, professional behaviour and communication as well as the thinking and decision making processes associated with clinical practice (Higgs and Jones, 2008). As for all UK qualifying physiotherapy programmes, in each practice setting a senior physiotherapist facilitated student learning and assessed the student's level of achievement against programme threshold requirements (Davies, Ramsay, Lindfield et al. 2005). These were within the areas of; interpersonal skills, professionalism, practical skills and clinical reasoning. This provided the opportunity for students to achieve the competence level needed for qualification by integrating their knowledge and skills at

progressively higher levels of performance under the guidance of experienced physiotherapists (Lekkas et al. 2007); thus facilitating the integration of university learned theory into clinical practice.

1.07 Clinical reasoning

Although practiced-based learning assessment requirements differentiated the areas of interpersonal skills, professionalism, practical skills and clinical reasoning. In reality clinical reasoning is an amalgamation of the first three areas; it is the thinking underlying clinical practice that enables an autonomous healthcare professional to take the best judged action in a specific context (Higgs, 2003). It is used to make a wide variety of clinical decisions in daily practice; although conceptually very simple, effective clinical reasoning can actually be very difficult (Jones, Jensen and Edwards, 2008). The terms clinical reasoning, clinical decision making, diagnostic thinking and diagnostic reasoning are often used interchangeably. All these terms refer to the same concept; the cognitive process that is necessary to evaluate and manage a patient's health problem (Barrows and Tamblyn, 1980). Hereafter the term clinical reasoning will be used within this thesis.

Clinical reasoning will be addressed in more depth in chapter two, but in a practical sense it begins with the data obtained from a patient referral and observation of the patient as they present for treatment, even before the more formal patient assessment procedure begins. The assessment consists of two components: the subjective assessment and the objective assessment. During the subjective assessment the physiotherapist questions the patient about their current problem and about other relevant aspects of their health and lifestyle. In the objective assessment a physical examination is undertaken of the relevant parts of the patient's body. While a degree of routine exists the assessment components are tailored to the patient's problem and needs. Clinical reasoning is an ongoing process throughout the assessment, as the information gleaned is evaluated by the physiotherapist and thus determines which questions are subsequently asked and which physical tests undertaken. The information gathering

continues until the identification of the source and underlying cause of the patient's problem is established and a management or treatment plan can be formulated with the patient. The clinical reasoning process continues throughout the treatment of the patient and will cause treatment changes and modifications (Jones, Jensen and Edwards, 2008). Clinical reasoning, has traditionally been honed during the thousand hours of supervised practice-based learning; during which students were expected to develop clinical reasoning skills by combining theoretical information learning within the university setting with clinical experience. However, there were issues with practice-based learning facilitating this integration. The literature suggested that students viewed practice-based learning as separate from the theory-based university teaching (Robertson, 1996) and more recent literature suggested that students viewed their learning of clinical reasoning as being an implicit component, of practice-based learning rather than university based learning. Students reported that their learning of clinical reasoning was inconsistently delivered and not guaranteed, as it was based on the variable educative skills and expertise of practice-based learning supervisors (Christensen, Black and Jensen, 2013).

1.08 The theory-practice gap

The theory-practice gap was a long acknowledged issue in healthcare education in relation to practical skills as well as students' clinical reasoning abilities (Michau, Roberts, Williams et al. 2009; Morgan, Cleave-Hogg, Desousa et al. 2006; Miller, 1985). In the 21st century the theory-practice gap had become increasingly problematic as student access to patients was becoming progressively more restrictive and practice-based learning had become a rather opportunistic process, in that students' learning depended on the clinical needs of the patient rather than the learning needs of the student. This problem was recognised internationally across the health professions, e.g. Health Professions Council of Australia (2004), and involved a variety of contributing factors. Specifically in the UK it was due to; increased patient rights and choice (Darzi, 2008), concerns over litigation, shorter hospital admissions and the increasing use of community care and

private providers (Michau et al. 2009; McCullum, 2007). Therefore, there were reduced opportunities for students to work with patients (Mulholland, Mallik, Moran et al. 2005) and the medical literature was increasingly reporting that the exposure to patients in the practice environment was not sufficient to create competent healthcare practitioners (Issenberg and McGaghie, 2013). The issues were compounded within physiotherapy by an imbalance in the increased numbers of students, due to the rise in commissioned training, thirty-two percent in 2002, (DH, 2005), without a corresponding rise in the number of experienced physiotherapists available to supervise them. Coupled with this, the provision of practice-based learning within England was at the discretion of individual physiotherapists and/or their manager and on-going issues regarding financial remuneration were contentious (Mulholland et al. 2005). This global and national issue was observable at a local level when managing the practice-based learning provision for students at Martias. Practice-based learning opportunities were difficult to source and students were reporting low numbers of patient interactions. Over the period of the study reported in this thesis these difficulties with sourcing practice-based learning have not improved and thus continue to potentially compound the theory-practice gap.

1.09 Bridging the theory-practice gap

The physiotherapy curriculum was designed to facilitate students gaining the knowledge and experience necessary to deal with situations that arose in practice. Students needed to learn specific propositional knowledge and then effectively integrate it within practice. The need for a propositional knowledge base was the reason for undertaking university based study before practice-based learning and, as previously mentioned, PBL and practical skills teaching was used to facilitate students assimilating knowledge, engaging with ideas, understanding concepts and linking those understandings with their knowledge base. However, the process of absorbing knowledge and linking it together was not sufficiently replicating practice where a more holistic understanding of process and procedure was needed. In this sense, students needed to arrive in practice not only with

sufficient knowledge of the parts of physiotherapy but also with a holistic knowledge of the whole. Learning within the university context was not replicating what was experienced in practice. This was not unique to Martias; indeed PBL had been conceived specifically to help bridge the theory-practice gap (Frost, 1996; Barrows and Tamblyn, 1980). However, although patient related, it relied on typical patient case scenarios that provided a pre-defined set of data, which, by their nature could not involve questioning and listening to the patient, or undertaking practical diagnostic tests. Therefore, they lacked a central feature of the clinical reasoning process: the patient-physiotherapist interaction and the need to make decisions of what data to collect and how to obtain it.

With regard to the teaching of practical skills the curriculum design at Martias involved the two components of patient assessment; subjective and objective, being taught in separate modules. Generic subjective assessment was taught in the first term, while objective assessment was taught in the second term and divided into the three clinical areas of respiratory, neurology and musculo-skeletal (MSK). There are similarities in physiotherapeutic patient assessment across all clinical areas but there are also numerous practical differences, and although clinical reasoning is considered a transferrable skill, gaining expertise is considered to be context specific (Jones et al. 2008). As previously mentioned I was an MSK subject expert and had responsibility for practice-based learning within the physiotherapy programme. In the latter capacity I developed and delivered a practice preparation week, immediately prior to the first practice-based learning block. One of the aims of this was to assist students to pull their knowledge and skills together into the more holistic patient assessment process needed in practice. During this period students anecdotally reported feeling under prepared and worried about their abilities to perform practically, and clinically reason at the level required. Although specific to nursing education, an interim report for the National Foundation for Educational Research (Jowett, Walton and Payne, 1992), had reported students having similar feelings of unpreparedness, anxiety, fear of making mistakes, and generally being dropped in at the deep end. Within

physiotherapy education various studies have aligned with the findings in nursing. Jones and Sheppard (2008) reported students found practice-based learning stressful because of the uncertainty around supervisor and patient expectation. More recent studies into practice-based learning by Blackford, McAllister and Alison (2015) and Watson, Wright, Morris et al (2012) have mirrored these findings. Thus the development of students' holistic patient assessment and clinical reasoning skills was identified as a specific area of need that existing teaching methods were struggling to meet, and was identified as in need of improvement.

This led to a review of the literature on clinical reasoning and subsequently simulation which is presented and discussed in the next chapter. As well as the development and implementation of virtual patient simulation discussed in the institutional focused study in chapter three and the exploratory case study research presented in chapters four, five and six. The study was exploratory and endeavoured to explore the educational significance of physiotherapy specific, computer-based virtual patient simulations and thereby to investigate the efficacy of using virtual patients as supplementary learning materials in facilitating physiotherapy students' learning of patient assessment and clinical reasoning during the pre-practice-based learning phase of their qualifying programme. The following research questions were initiated by the need to improve the students' learning at Martias, then further shaped by the literature review and the findings of the IFS. Although they are two separate questions they are inherently intertwined because of the complexity of usability. This will be discussed further in later chapters.

1.10 Research questions:

- Which factors affect the usability of physiotherapy virtual patient simulation?
- Can using a virtual patient simulation facilitate the learning of patient assessment and clinical reasoning skills to help bridge the theory-practice gap for pre-clinical physiotherapy students?

1.11 Summary

In summary the broader context of this thesis was the exacerbation of the widely acknowledged problem within physiotherapy education; the theory-practice gap. The context of both the IFS and the subsequent study was a new MSc pre-registration physiotherapy programme for small cohorts of students within a traditional university. I was a lecturer on the programme with responsibility for practice-based learning and an enthusiasm to improve and develop student learning. The specific focus was on patient assessment and clinical reasoning within musculo-skeletal physiotherapy and within this context patient simulation was proposed as a way to facilitate improved student learning. The thesis follows a standard structure, but with the inclusion of the IFS as chapter three, leading from this introduction into an analysis of the literature, to the IFS, to a rationale for the methodology chosen and presentation of results and discussion.

2.00 Chapter two: Literature review

To explore the literature pertaining to the use of virtual patient simulation as a learning resource for patient assessment and clinical reasoning with physiotherapy students the literature review focussed on technology-based patient simulation in the education of health professionals. This revealed some literature related to technology-based patient simulation but limited evidence of specific studies that evaluated virtual patient simulation resources especially within the field of physiotherapy. The literature was equivocal as much of it was written in editorial or commentary style pieces relating anecdotal information or giving descriptive accounts of specific simulation experiences within a particular higher education institution. There were few studies producing generalisable evidence of the pedagogical benefits of virtual patient simulation, though this is unsurprising as the introduction of any technology-based simulation usually involved altering several aspects of a curriculum, and thus single variable manipulation became difficult, and therefore measuring the effectiveness of the intervention problematic. Therefore, the literature surrounding technology enhanced learning and simulation generally was also explored, as research in these fields had shaped that of technology-based patient simulation. A body of literature on an array of clinical simulation was located, however it varied widely in focus and methodological rigour. A general review of the literature highlighted that the benefits of simulation appeared to be accepted somewhat uncritically, with a broad consensus that it provided an opportunity to practice skills which led to consolidation of knowledge and understanding and thus to improved learning and enhanced patient safety. Yet it was clear that the enthusiasm for simulation far exceeded empirical evidence of improved educational outcomes.

It was also necessary to review the literature on clinical reasoning and the teaching and learning of clinical reasoning as a depth of understanding of the nature of the clinical reasoning process, and how students learned it was the foundation for investigating the facilitation of learning in this area.

2.01 Seminal research in clinical reasoning

Research investigating the concept of clinical reasoning began within medicine with Elstein, Shulman and Sprafka (1978), who, in their research-based seminal text, coined the hypothetico-deductive reasoning model of clinical reasoning. This reasoning model starts with an initial impression which leads to the generation of hypotheses based on clinical data and knowledge, these hypothesis are tested through further inquiry to confirm or refute them, thereby enabling the hypotheses to be evaluated until ultimately all but one are discarded and the clinician is satisfied that the correct clinical decision is reached. Subsequently, Schmidt, Norman and Boshuizeu (1990) and Groen and Patel (1985) argued the hypothetico-deductive model was only a part of the practise of clinical reasoning. They reported that experts relied more on the pattern recognition approach; a model of clinical reasoning associated with rapidly identifying the significant features of a problem, which led directly to diagnosis. The accumulation of experience and knowledge in a particular domain, enabled clinicians to build a repertoire of patterns that enabled them to recognise problems they had previously encountered and therefore select the appropriate treatment in a rapid and efficient process. However, experts' use of pattern recognition has been shown to lead to error when overemphasis is placed on findings that adhere to a preferred hypothesis and this has been shown to be more likely to occur in more complex contexts (Durning, Artino, Pangaro et al. 2011).

Contemporary authorities in the field agree that both forms of reasoning are used; hypothetico-deductive reasoning is used by students, inexperienced clinicians and by experts, when faced with unfamiliar problems though experts most frequently use pattern recognition (Kempainen, Migeon and Wolf, 2003). However, although there is widespread agreement on the general steps involved, shown in figure 1, there still has been no universally accepted model that fully explains the psychology of clinical reasoning.

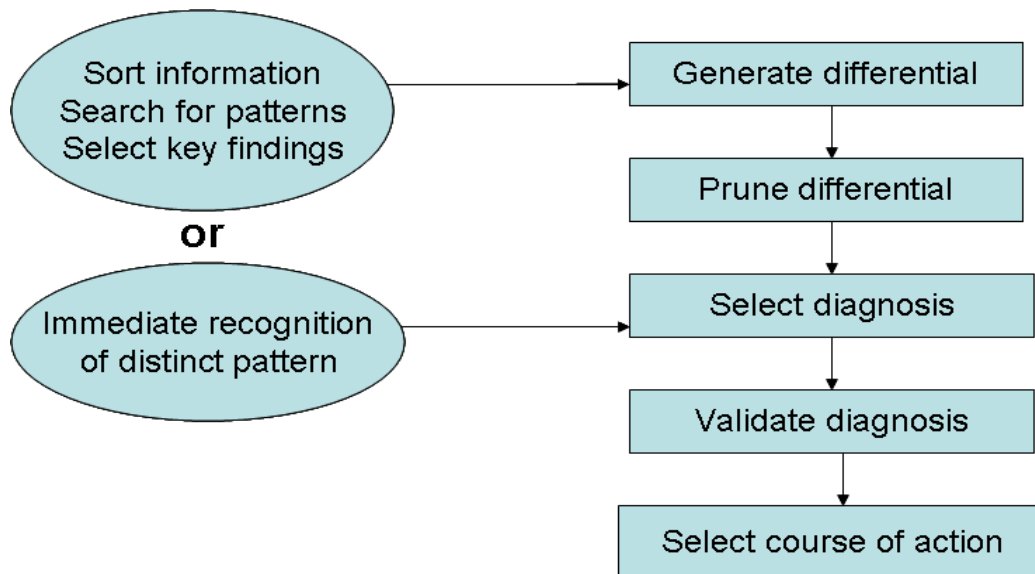


Figure 1: Approach to diagnostic reasoning (Kempainen et al. 2003)

Other health professions built on the research undertaken within medicine, and the clinical reasoning of physiotherapists became a research topic in its own right in the mid-1980s. Much of the leading literature around clinical reasoning within physiotherapy is Australian and to a lesser extent North American. However, the former has good transferability of findings to the UK as the systems of education and professional practice are very similar; the American systems differ more but are still similar enough to make findings viable. The terminology used in North American literature differs in that physiotherapy is called physical therapy, but for consistency in this thesis the term physiotherapy will be used.

2.02 Physiotherapy clinical reasoning research

Until the mid-1990s studies tended to use experimental methodologies to focus on the differences in the clinical reasoning processes outlined above between expert and novice physiotherapists (Patel and Arocha, 2000). This research provided evidence to support the notion that performance differs between expert and novice physiotherapists in similar ways to those of medicine (Jensen, Shepard and Hack, 1990; King and Bithell, 1998). However it should be noted that there appeared to be no consensus on what constituted an expert, either in terms of years of experience or

specialist training (Doody and McAteer, 2002), except that an expert is defined as having advanced clinical reasoning skills (King and Bithell, 1998). From the mid-1990s research began to include interpretive methodologies which highlighted differences in emphasis; showing that within physiotherapy, clinical reasoning had evolved from being centred solely on the diagnostic type reasoning processes generally seen in medicine, to a more on-going patient-centred approach advocating the collaboration of the physiotherapist and the patient within the reasoning process; termed collaborative reasoning (Jones et al. 2008; Jones and Rivett, 2004). Within this process the physiotherapist, interacts with the patient, and others such as family members or carers, to structure meaningful goals and health management strategies based on patient choices, as well as clinical data, professional judgment and knowledge (Higgs and Jones, 2008). This approach continues throughout the management of the patient thus clinical reasoning strategies can broadly be grouped under the headings; diagnosis or assessment, and on-going management or treatment (Jones et al. 2008). Mattingly (1991), who contributed extensively to clinical reasoning research within occupational therapy, also concluded that the diagnostic focus of reasoning in medicine was insufficient for health professions who interact personally in the patient's ongoing treatment i.e. occupational therapists and physiotherapists.

2.03 Clinical reasoning during assessment

Although the on-going clinical reasoning process is important within physiotherapy as a whole, within this literature review the clinical reasoning process during the initial physiotherapeutic assessment of a patient was of primary importance. Though it is acknowledged that the on-going use of collaborative reasoning shapes the initial patient assessment process and the reasoning used within it. Clinical reasoning in the initial assessment process is crucial as it is the foundation for the ongoing reasoning process and patient management. The decision to focus on the initial assessment process was driven by the findings of both Doody and McAteer (2002) and

James (2001) who suggested that physiotherapy students struggled to clinically reason at the assessment stage and recommended that physiotherapy students' clinical reasoning during musculo-skeletal patient assessment be investigated further.

The initial assessment reasoning process is a combination of hypothetico-deductive reasoning, pattern recognition, and narrative reasoning (Jones et al. 2008). Narrative reasoning seeks to understand the patient's motivations, context, beliefs and culture; to understand the patient as a unique person (Edwards, Jones, Carr et al. 2004; Neistadt, 1997). The extent of each component will be influenced by the patient, the context, the resources available, and the physiotherapist's specific knowledge and clinical reasoning expertise (Jones et al. 2008).

2.04 Measurement of clinical reasoning

This complexity of clinical reasoning means that there is not a reliable tool sensitive enough to measure clinical reasoning ability within physiotherapy (Downing and Hunter, 2003). Even within the more diagnostic clinical reasoning of medicine, although quantitative measures are used, 'no gold standard of measurement exists' (Bateman, Allen, Kidd et al. 2012, p 5) and the reliability of the measures used is debated; principally as to whether they actually measure clinical reasoning or other abilities such as knowledge retrieval (van der Vleuten and Newbie, 1995). The Diagnostic Thinking Inventory (DTI) devised by Bordage, Grant and Marsden (1990) is an example of such a measure. It is a self-reporting questionnaire using semantic scales to identify an individual's strengths and weaknesses in terms of flexibility and structure in diagnostic thinking, concepts which Barrows and Bennett (1972) advocated but did not substantiate with empirical research. Jones (1997) undertook a study that claimed to show a modified version of the DTI was a valid and reliable measure of diagnostic thinking within musculo-skeletal physiotherapy, however, the study had limitations which weaken this claim. It used the expert opinion of four clinicians to compare the way the DTI was completed by twenty-two

clinicians with at least two years of experience of practice, with the DTIs completed by twenty-six physiotherapy students who had had some practice-based learning experience. Jones (1997) showed that statistically mean scores for perceived expertise level, i.e. student versus practicing clinician, mirrored those in medicine but beyond that the study methodology could not show that the DTI measured changes in clinical reasoning ability within physiotherapy, either between individuals, or with learning in the same individual. This lack of reliable measurement has contributed to the clinical reasoning literature within physiotherapy predominately using qualitative methods of data collection to explore the complexity of the clinical reasoning process. For example think-aloud methods have been used by Doody and McAteer (2002), in-depth observation and interviews by James (2001) and stimulated recall by Ladyshevsky (2004).

2.05 Clinical reasoning and education

The literature within physiotherapy had not established exactly how experts learned their advanced clinical reasoning skills. It had shown that, although experience and expertise were not automatically related (King and Bithell, 1998) there did appear to be some association between experience, changes in thought processes and subsequent practice (Jensen et al. 1990). There was, however, little research directly linking the findings to pedagogical development in pre-registration education. Some of the literature showed specific issues with student's clinical reasoning and made suggestions for pre-registration education. An early study undertaken by Thomas-Edding (1987) compared student and expert physiotherapists' clinical reasoning during patient assessment and showed that experts spent more time evaluating information than students. The conclusion reached was that physiotherapy education should improve clinical reasoning by focusing on problem solving skills. However, as the complexity of skill acquisition within clinical reasoning has become more apparent that suggestion has been shown to be deficient. The medical literature had shown for some time a lack of transfer from theory-based problem solving to patient-based practice. Goran, Williamson and Connella (1973) found that

medical students did better on paper-based patient management problems than in real clinical practice. Those who did poorly on paper-based patient management problems, did poorly in clinical practice, but performing well on paper-based patient management problems, did not predict satisfactory clinical practice. More recently the findings of Auclair (2007) supported this as medical students could recognise a specific pathology when presented with a formulated problem but had more difficulty when presented with the original complex patient case. These findings indicate that pathological knowledge learning in paper-based PBL scenarios is potentially insufficient to enable clinical reasoning when confronted with actual patients who exhibit the signs and symptoms of the same pathologies. Admittedly, both these studies were within medicine not physiotherapy, but as clinical reasoning is considered more patient centred within physiotherapy this lack of transfer is likely to be exacerbated rather than reduced.

James (2001) combining in-depth observation and interviews, to explore three physiotherapy students' clinical reasoning during the assessment of a musculo-skeletal patient. Although the methodology makes the study non-generalisable, the study showed that the students struggled to clinically reason during patient assessment and therefore had difficulty devising a reasoned patient management plan. These findings were supported by both Wessel, Williams and Cole (2006) and Doody and McAteer (2002). Doody and McAteer (2002) reported that during patient assessment expert physiotherapists evaluated all information gleaned immediately while students could not always evaluate information gained nor confirm or refute their hypothesis so tended to guess how to proceed. They also noted that the experts spent considerably longer on the subjective assessment, which is where they generated the majority of their hypotheses, while the students spent more than twice as long on the objective examination. They concluded that students should start using the hypothetico-deductive process within the assessment of patients early in their programme and should be encouraged to place more emphasis on the subjective assessment to facilitate the learning and recognition of patterns. However, although focusing on the subjective assessment has merit, more

contemporary literature shows potential issues with the learning and recognition of patterns. In that, errors in clinical reasoning are often due to overemphasis of findings that adhere to a preferred hypothesis based on pattern recognition (Jones et al. 2008) and therefore emphasis on pattern recognition at the novice stage of clinical reasoning may be counterproductive. Christensen, Jones, Higgs et al. (2008) interviewed final year physiotherapy students on several American pre-registration programmes. Their findings were that students perceived that clinical reasoning was not really addressed in their physiotherapy education curricular. Christensen et al. (2008) concluded that there was a clear need for pre-registration physiotherapy education to increase the focus on clinical reasoning proficiency.

2.06 Curriculum development

Over the last two decades the literature within physiotherapy education has focused on curriculum development motivated by an interest in setting international standards of competence and concerns about the theory-practice gap (Broberg, Aars, Beckmann et al. 2003). There were, however, differences of opinion as to the cause of the theory-practice gap; there were claims the curriculum was too theoretical (Turnbull, 1994) and claims that it was too focused on technical skill acquisition (Shepard and Jensen, 1990). It was suggested that students viewed practice-based learning as separate from the theory-based university teaching (Robertson, 1996) and that clinicians who educated students in practice perceived a gap between education and practice based learning (Ohman, Hagg and Dahlgren, 1999). Emerging from concerns around the growing issue of the theory-practice gap the literature began to stress the importance of reflection within the curricular as a whole and within clinical reasoning specifically (White, 2004; Broberg et al. 2003; Donaghy and Morss, 2000). Although outside of the physiotherapy literature Schon's (1987; 1983) seminal work on reflective practice was highly influential in shaping physiotherapy education. Schon's notion of learning needing to include time and space to review and appreciate the interconnection between theory, intuition and practice, was

adopted and became a core concept of education, along with Kolb's (1984) work on experiential learning theory. As a result education moved from the more traditional model of 'competent clinician' to the 'reflective practitioner model' (Higgs, 2003 p 148).

2.07 The reflective practitioner

As a reflective practitioner the core elements needed to clinically reason are: knowledge, cognition (thinking) and meta-cognition (reflective thinking) (Jones and Rivett, 2004). A physiotherapist's specific knowledge base is divided into propositional, non-propositional knowledge and personal knowledge (Higgs, 2003). Propositional knowledge is derived from research and theory, while non-propositional knowledge is acquired primarily through practice and personal knowledge is tied up in the physiotherapist's beliefs and values (Higgs, 2003). Within the climate of evidence-based medicine a hierarchical relationship has developed valuing propositional knowledge more highly, however it is acknowledged that effective clinical reasoning is improved by constructing links between the different types of knowledge in the context of real patient problems (Jones and Rivett, 2004). Thus clinical reasoning is not a separate skill but acquired hand in hand with knowledge. In fact, a consistent finding in the medical literature was that the accuracy of clinical reasoning was dependent on the physician's knowledge and organisation of that knowledge (Norman, 2005; Elstein, Shulman and Sprafka, 1990; Groen and Patel, 1985). The component, metacognition, is reflective self-awareness; it involves the physiotherapist thinking about their thinking and the factors that limit it (Jones and Rivett, 2004; Higgs, 2003). Metacognition is a well-recognised characteristic of expertise, as the acquisition of knowledge and technical skill alone is insufficient, without reflective self-awareness expertise cannot develop (McAllister, 2003). Christensen et al. (2008) advocate that improvement in clinical reasoning ability is linked to self-directed reflection on practice, that capable and expert physiotherapists develop knowledge via reflective learning. They propose that the key elements of effective reflective learning involve the

integration and effective application of thinking and learning skills, collaborative learning and learning from clinical experience.

2.08 Teaching clinical reasoning

Over two decades ago Terry and Higgs (1993), in an article on practice-based learning, stated that it was essential that physiotherapy education develop strategies for teaching clinical reasoning in an environment that promoted reflection and feedback. As helping students to learn metacognition and provide feedback on this process was invaluable in facilitating improved clinical reasoning. They also argued that the curricular expectation that students learn the skills of reflection and metacognition, and apply them during clinical reasoning initially within practiced-based learning was extremely challenging. Wessel et al. (2006) investigated the transfer of the university-taught clinical reasoning process into the first practice-based learning placement. The study was undertaken in Canada with pre-registration accelerated masters' physiotherapy students at McMaster University, where the curriculum is delivered via PBL. The study used a reflective patient-case-based clinical reasoning assignment as the intervention. Both the method of data collection and the measurement tool had limitations. The former as it was based on retrospective self-reporting so may not have accurately portrayed the students' actual clinical reasoning while assessing the patient. The latter because it was a devised assessment standard for both the student's clinical reasoning process and reflection on that process that the assignments were marked with, by three academics. However, Wessel et al. (2006) reported that during their first practice-based learning experience students did not use the clinical reasoning process taught within the university effectively. Students were better at clinical reasoning during the assessment process than when they were planning treatment and that less than half the students used narrative or collaborative reasoning to guide their treatment decisions. Nevertheless students believed they had clinically reasoned automatically and appropriately throughout. Therefore the authors suggested that students needed guidance with clinical reasoning and specific feedback on their

thought processes. The findings suggested that students' abilities to reflect on their own clinical reasoning are insufficient in themselves to identify the flaws and improve without external facilitation. Ladyshevsky (2004) explored the advantages of peer coaching on clinical reasoning during musculo-skeletal patient assessment, with students that had studied within the university setting but had not yet undertaken any practice-based learning. The findings showed that although working with a peer increased students' confidence and peer feedback was considered helpful by students, clinical reasoning ability during patient assessment was not appreciably different.

Research evaluating the application of physiotherapeutic skills developed through PBL within practice was undertaken by Gunn et al. (2012) via in-depth interviews with ten physiotherapists, who regularly supervised students during practice-based learning. Results suggested that although the physiotherapists believed that PBL fostered high levels of motivation and self-direction in the majority of students, students' ability to transfer problem-solving skills from PBL to practice was very variable. Therefore, although PBL had been conceived specifically to help bridge the theory-practice gap and facilitate clinical reasoning by working on patient problems in peer groups (Barrows and Tamblyn, 1980) the findings in the literature suggested that teaching students propositional knowledge, a clinical reasoning process and reflection methods via PBL did not sufficiently develop in students the overall skill of clinical reasoning even if it taught the component parts. Robertson (1996) suggested that students viewed theory-based university teaching and practice-based learning as separate entities, while the findings of Christensen et al. (2013) were that students viewed learning to clinically reason as a component of practice-based learning not university based learning. Students reported that their learning of clinical reasoning was inconsistently delivered and not guaranteed, as it was based on the variable educative skills and expertise of practice-based learning supervisors. However, a survey undertaken across thirty-nine HEIs in five English-speaking countries investigating the teaching of clinical reasoning within occupational therapy education reported that the primary teaching

strategy used was practice-based learning (Paterson and Adamson, 2001). This had relevance because occupational therapy and physiotherapy closely align, both in the educational context and within clinical practice. The survey also reported university-based teaching strategies used included PBL and patient simulation (Paterson and Adamson, 2001). PBL had already been addressed but simulation was further investigated.

2.09 Simulation

The literature revealed that simulation as a teaching technique was not a new concept within medical education. It had been used from at least 1582 when Hieronymus Fabricius described a mannequin used to teach the reduction of joint dislocations (Hoffman, 2009) and back in 1987 Schön described simulation as a 'virtual world, relatively free of the pressures, distractions and risks of the real one, to which it nevertheless refers' (Schön, 1987, p 37). More recently Professor Gaba from the Center for Immersive and Simulation-based Learning at Stanford University defined simulation as a teaching technique used 'to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner.' (Gaba, 2004, i2). However, the literature revealed that the term simulation covered a broad church of learning resources that encompassed an array of delivery methods incorporating people, mannequins, paper scenarios, role playing, the practice of technical skills upon peers and numerous computer technologies. Some simulations were used individually, while others involved team work; some were game-based while others entirely serious (Issenberg, McGaghie, Petrusa et al. 2005). Simulation had been used for skills-enhancement within professional training for some time, probably its most famous use being the flight simulator for pilot training. Within health education Abrahamson, Denson and Wolf (1969) reported successfully using a mannequin with computer program control, to teach medical students how to intravenously induce general anaesthesia and intubate a patient. Their findings showed that training using the simulation achieved proficiency faster than learning directly on patients. These findings were

supported in a comparative study (Issenberg, McGaghie, Brown et al. 2000) in which medical students learned cardiology bedside skills via either; two-weeks of technology-based simulation practice followed by two weeks of practice-based learning, or four weeks of practice-based learning. Results showed that the group using simulation increased their performance by 47 to 80 percent while the practice-based learning only group increased by 41 to 46 percent. Issenberg, McGaghie, Gordon et al. (2002) replicated this research with junior doctors and obtained comparable results. Since then the increasingly sophisticated and successful use of simulation has been reported within the education of medics (Sverdrup, Jensen, Solheim et al. 2010), nurses (Morgan, 2006) and paramedics (Bond, Kostenbader and McCarthy, 2001), as its use guaranteed exposure to a range of clinical situations, overcoming some of the, previously discussed, limitations of practice-based learning (Issenberg et al. 2005).

A worldwide survey in 2002 identified 158 simulation centres within medical education (Morgan and Cleave-Hogg, 2002) and encouragingly, the simulation laboratory at Georgetown University, endorsed simulation as a method of teaching that required students to apply theory to practice in an integrated way (Rauen, 2004). The literature on simulation within healthcare was generally in agreement that simulation could help bridge the theory-practice gap. This was based on the premise, indicative of experiential learning theory, that simulation actively engaged students in the learning process as they had to analyse the results of their actions, reformulate hypotheses and integrate results into previous knowledge, thus students were required to apply theory into practice (Holzinger, Kickmeier-Rust, Wassertheurer et al. 2009; McCullum, 2007; Morgan, 2006; Rauen, 2004; Weller, 2004). The oft-cited advantages of simulation were: that it focused on the learning needs of the student not the clinical needs of the patient, it allowed students to learn safely, letting them learn from their mistakes; thereby reducing the adverse events on real patients (Ziv, Ben-David and Ziv, 2005) and that it offered students an opportunity to learn through repeated practise aided by feedback and reflection (Morgan et al. 2006; Weller, 2004; Kneebone, 2003).

In fact, few studies had shown direct improvements in clinical outcomes from the use of simulation for training (Okuda, Bryson, DeMaria et al. 2009), although admittedly this is a complex area to show direct causality, and potentially has ethical implications. Thus the premise was, that practicing skills initially with simulation as opposed to on a real patient was safer for patients (Ziv et al. 2005). The Department of Health advocated using simulation as a route to improved patient care, recommending that healthcare professionals learn skills in a simulation environment before undertaking them in practice (DH, 2011). The Nursing and Midwifery Council (NMC) also advocated simulation as a safe and effective means of learning clinical skills and recommended it be used as an adjunct to practice-based learning. In addition the NMC allowed simulation to replace up to 300 hours of the required practice-based learning within qualifying programmes (NMC, 2007). However, the position of the CSP was that, without firm evidence, it did not support the use of simulated learning to replace practice-based learning but recognised the potential for simulated learning to enable students to be better prepared and confident when undertaking practice-based learning (CSP, 2014).

A general review of the literature highlighted that there was a body of literature on an array of clinical simulation techniques which varied widely in focus and methodological rigour. Simulation was generally viewed favourably, with a broad consensus that it provided an opportunity to practice skills, or test knowledge and understanding, eventually leading to consolidation of understanding and thus to deeper learning (Cook, Hamstra, Brydges et al. 2013; Lammers, 2007; Weller, 2004; Kneebone, 2003). However, much of the literature making these claims was in editorial style (e.g. Lammers, 2007; Kneebone, 2003). There were few studies producing robust generalisable evidence of the effectiveness of specific simulation techniques, though this is probably unsurprising as the introduction of simulation was generally resource intensive, involved altering several aspects of the curriculum, and due to the complexity involved, single variable manipulation to measure effectiveness was problematic. Issenberg

et al. (2005) undertook a systematic review of the research, undertaken between 1969 and 2003, within medical education investigating high fidelity simulation. The majority of this research addressed the acquisition of practical procedures. The review concluded that 80 percent of the reported research findings were equivocal, while 20 percent were likely to be reliable but were not unequivocal. The weight of the best available evidence suggested that high fidelity simulation particularly enhanced effective learning when it included feedback and repetitive practice. However, these features were advocated for effective learning by any method, in the much cited paper on the principles of good practice by Nicol and Macfarlane-Dick (2006). The claims of Issenberg et al. (2005) were based on prevalence in the literature rather than impact on educational outcomes. Nevertheless the claims were substantiated in a second review (McGaghie, Issenberg, Petrusa et al. 2010), albeit with the caveat that questions remain about the features of simulation that lead to effective learning, and about the most effective timing and delivery of feedback.

A further systematic review and meta-analysis was undertaken (Cook et al. 2013) specifically evaluating the effectiveness of instructional design. The review incorporated all health professions, evaluating studies that compared types of simulation. Of the 289 eligible studies, none were identifiable as physiotherapy specific. The authors concluded that the evidence supported the following as best practice in simulation education: a range of complexity and clinical variation, repeated practice, interactivity, individualised learning, feedback and time on task. However, they concluded that further research to clarify the mechanisms of effective simulation-based education was needed, as the comparative advantages of different simulation interventions remained unknown, as did which type of simulation was effective for whom in which contexts (Cook et al. 2013). Motola, Devine, Chung et al. (2013), informed by these systematic reviews, published a best practice guide for using simulation in healthcare education. They affirmed that simulation that lead to effective learning included; feedback and debriefing, deliberate practice, and curriculum integration. However, they were focused on high

fidelity practical skill based simulation, mainly within medicine, and did not address the learning of clinical reasoning.

2.10 Simulation models

The literature distinguished between symbolic and experiential simulations. Symbolic simulations represented a model of something that the student could experiment in using different variables and observing the results (Laurillard, 2002). Experiential simulations were based upon scenarios that included role-play and activity in an authentic environment that in some way or other reconstructed aspects of real-life tasks (Maharg and Owen, 2007). Within health education symbolic simulations existed i.e. the complex modelling of arterial blood flow by Holzinger et al. (2009), but the majority of stimulations used were experiential stimulations to reflect reality (Maran and Glavin, 2003). Reality was referred to as fidelity, which was categorised by its precision of reproduction, the extent to which the simulation attempted to convince users they were encountering real life (Seropian, Brown, Gavilanes et al. 2004). It was divided into three categories: low, moderate, and high. Low-fidelity simulators were also referred to as part task trainers (Jones and Sheppard, 2007) they lacked the detail and vitality of a living situation, replicating only part of a patient and were useful for introducing and practicing psychomotor skills i.e. mannequin use to practice basic life support. A moderate-fidelity simulator offered more realism i.e. a mannequin that had breath sounds and a pulse but lacked corresponding chest movement. These were useful for developing deeper understanding of specific, complex procedures. High-fidelity simulators produced the most realistic simulated-patient experiences; they usually included personality and allowed students to more closely identify with the simulation as real life, i.e. the use of computerised mannequins or actors to portray patients. The high-fidelity computerised mannequins usually had the outward appearance of reality (cosmetic fidelity), and reacted in realistic ways to student interventions (response fidelity) (Seropian et al. 2004). Thus increasing their psychological fidelity; how realistic the student finds the simulation and subsequently how they respond to it (Neary, 1994). In these simulations the

advances in technology had enabled the two categories of simulation to be integrated so that high-fidelity computerised mannequins were experiential simulations that often incorporated symbolic simulation. For example the high fidelity mannequins used in trauma and intensive care setting simulation incorporate physiological variables that can be manipulated to simulate clinically diverse situations. So, the term simulation was used broadly incorporating multiple methods across varying fidelities, from the low fidelity practice of learning chest compressions on a resuscitation mannequin, to high fidelity major disaster role-playing in a multi-user 3D virtual environment.

2.11 Simulation in physiotherapy

The majority of the medical literature cited above, including the systematic reviews (McGaghie et al. 2010; Issenberg et al. 2005) referred to high fidelity simulation used in the high stakes areas of medicine such as surgery, anaesthetics, and trauma management. In these contexts it was used mainly for practical skill based training and team working (Jones and Sheppard, 2007). In theory the creation of mannequin-based simulation used to teach practical cardio-respiratory skills, such as airway suction, to medics and nurses was able to be used within physiotherapy education for the same purpose due to the skill cross-over in this clinical area (Blackstock and Jull, 2007). A UK wide survey, in 2010, explored the application and extent of simulation use within cardiorespiratory physiotherapy postgraduate education (Gough, Abebaw, Thomas et al. 2012). The survey had a fifty-five percent response rate from the 280 NHS Intensive Care Units (ICU) providing emergency on-call physiotherapy services. The survey identified that although simulation was used to teach a wide variety of cardio-respiratory physiotherapy skills national inconsistencies in availability, fidelity and accessibility of simulation equipment were identified and the impact of using simulation in this context was unknown.

Jones and Sheppard (2007) attempted to review the evidence for the use of high and medium fidelity mannequin based simulation within physiotherapy

student education, but located just one respiratory skill focused study that met their criteria (Thomas, 2006), which, they reported being of poor quality with equivocal findings. However, all qualitative research was excluded from the review, which in such a ground-breaking field of study potentially excluded some enlightening exploratory investigation. Jones and Sheppard (2007) broadened the criteria to include all health professions but still equivocal findings were reported. Interestingly they noted that the studies that found positive results in favour of simulation over another method of training tended to be of poorer methodological quality than those reporting no difference between training methods. A recurrent issue across studies was the lack of reporting of the time participants undertook simulation training while studies that did report this often had very limited simulation interventions. Thus, making it difficult to determine if the simulation or the lack of time on task led to the lack of effectiveness.

A more contemporary systematic review appraising the literature on simulation based learning within physiotherapy curricula included articles that incorporated; physiotherapy students, simulation and an assessed intervention (Mori, Carnahan and Herold, 2015). The review concluded that simulation can facilitate skill development and clinical reasoning in an intensive care setting, can decrease student anxiety and has the potential to replace up to twenty-five percent of practice-based learning. However, the evidence for this claims was not entirely conclusive. Although the review included twenty-three papers, the majority of studies included had poor Medical Education Research Study Quality Instrument (MERSQI) scores, many collected only student self-reported attitudinal data and few were comparative with either usual teaching or differing simulation methods. The various methods used for data collection across the studies did not enable researchers to show measurable improvements in clinical reasoning due to simulation use.

The inclusion of some studies within a review of physiotherapy simulation literature was also debatable. Three studies included within the review were not physiotherapy specific but involved investigated inter-professional

students' attitudes and communication skills using high fidelity immersive gaming environments (Seefeldt, Mort, Brockevelt et al. 2012; Sabus, Sabata and Antonacci, 2011; Henry, Douglass and Kostiwa, 2007). These studies all had low MERSQI scores and measured student satisfaction with the intervention using no control group. They reported positive student attitudes and increased confidence to practice but also reported students finding challenges with using the technology.

Six studies investigated specific hands on musculoskeletal skills using equipment to measure the force of the technique (Snodgrass and Odelli, 2012; Chang, Chang, Chein et al 2007; van Zoest, Staes and Stappearts, 2007; Anson, Cook, Camacho et al. 2003; Gann, Rogers and Dudley, 2002; Lee, Moseley and Refshauge, 1990). While one used a pressure manometer to give feedback on manual lung inflation techniques (Hila, Ellis and Holmes, 2002). All seven studies found that the provision of measurement feedback improved student learning in the short-term but that benefits did not persist long-term, (Mori et al. 2015), in the case of manual lung inflation learning benefits lasted less than ten minutes (Hila et al. 2002). Within these studies it is arguable that the reality of practice was not replicated, as patients do not give measurement feedback on techniques, therefore their categorisation as simulation is contentious. However, Hassam and Williams (2003) also measured the force of chest percussion using a medium fidelity neonatal infant simulation. Their findings demonstrated improvement in technique performance of all participating students and knowledge retention of the key concepts of the technique five months later. The simulation used a mannequin of an intubated neonatal infant within an incubator and positioned realistically to allow percussion on the posterior chest wall. The simulation was used for data collection which consisted of rated student performance by observing experts as well as percussive force measured by a computerised force plate. Data was obtained before and after a traditional lecture style teaching session, no teaching was undertaken using the simulation. Interestingly, students who did not percuss the neonatal model but attended the same lecture, were less likely to retain the key concepts of the technique five months later. The

authors concluded that that the practical experience coupled with the educational session encouraged greater retention of the key concepts.

A further seven papers included in the review explored high and medium fidelity mannequin use in the cardiorespiratory and intensive care setting. Two of these, Jones and Sheppard (2011a; 2011b) reported a randomised controlled trial comparing physiotherapy students who underwent eight hours of cardiorespiratory skill training on a medium fidelity patient simulator with those who did not. Findings indicated that clinical ability was not improved by the simulation intervention beyond that of usual teaching. Reasons for this finding may include, lack of sensitivity of the measurement tool, or usual teaching training all students to the skill level required, however it highlights that that the assumption of learning effect from simulation may be misplaced. However, worryingly, findings showed that although students who received the simulation intervention were not clinically superior to those who did not, the intervention group overestimated their ability to treat patients throughout their subsequent practice-based learning placement (Jones and Sheppard, 2011a).

All five studies used high fidelity mannequin simulation reported high student satisfaction with simulation as well as student self-reported increases in confidence in their ability to treat patients. However, four of these studies did not use methods that measured students' learning gains with the simulation intervention beyond student self-reporting (Ohtake, Lazarus, Schillo et al. 2013; Silberman, Panzarella, and Melzer, 2013; Smith, Prybylo and Conner-Kerr, 2012; Shoemaker, Riemersma, and Perkins, 2009). Blackstock, Watson, Morris et al. (2013), however, undertook two randomised controlled trials that comparing replacing twenty-five percent of practice-based learning time with high fidelity simulation mannequin use. They delivered the same nine cardiorespiratory simulation scenarios via two models of intervention: Model one, students spent one week using simulation followed by three weeks of a traditional practice-based learning; Model two used fifty percent practice-based learning and fifty percent simulation for the first two weeks of the practice-based learning,

followed by two weeks of fulltime practice-based learning. Both models were compared with a control group of four weeks traditional practice-based learning. Findings showed no significant differences in student competency between the simulation and control groups in either study, although students in model two achieved a higher score in many aspects their practice-based learning assessment. Students rated the simulation positively and practice educators and patients reported comparability between groups. Smith et al. (2012) also compared two types of simulation for student learning of electrocardiographic (ECG) recognition, one involving a high fidelity mannequin and another involving a lecturer role playing a patient and using paper readouts. Findings showed that students preferred using the high fidelity mannequin, felt it was more realistic and felt it improved their learning more than the role play and more than usual lecture style teaching.

Role play simulation is a common instructional technique within the teaching of healthcare professionals and students typically learn by practicing scenarios with each other (Baile and Blatner, 2014). Four studies were included in the review by Mori et al. (2015) that involved student role-play, though all had low MERSQI scores and were generally old studies (Hewson and Friel, 2004; Kelly et al 1996; Smith, Scherer, Jones et al. 1996; Sanders and Ruvolo, 1981). One these four studies Smith et al. (1996) simulated an intensive care setting and findings showed improved confidence to treat and high satisfaction in student self-reported data. The other three studies involved role play in mock musculoskeletal clinics the findings of all three studies showed students perceived their abilities to treat patients had improved. However, only Kelly et al (1996) undertook a comparative study and collected non-self-reported data. Their results showed that while students in both the traditional practice-based learning group and students in the mock clinic intervention group achieved the programme objectives, the intervention group scored significantly higher in their practical exam as well as giving higher satisfaction ratings for their subsequent practice-based learning experience.

Few physiotherapy-based simulation studies were found outside of cardio-respiratory skill practice. Robust studies that moved beyond self-reported attitudinal data in musculoskeletal physiotherapy were few. However, two robust multi-site randomised controlled trials with large sample sizes were undertaken by Watson et al. (2012). They compared replacing twenty-five percent of practice-based learning time with simulation using actors to portray patients with musculoskeletal pathologies. They delivered the simulation via two models of intervention: Model one, students spent one week assessing the simulated patients followed by three weeks of a traditional practice-based learning; Model two used fifty percent practice-based learning and fifty percent simulation for the first two weeks of the practice-based learning, followed by two weeks of fulltime practice-based learning. Both models were compared with a control group of four weeks traditional practice-based learning. Findings showed no significant differences in student competency between the simulation and control groups in their final examination. Again this study found simulation increased students self-reported confidence levels immediately after the intervention, though the students in the traditional practice-based learning were not comparably asked about their confidence levels so it is not possible to say whether traditional practice-based learning increased confidence in the same way. The authors concluded that their findings supported the use of simulation to replace practice-based learning in situations where practice-based learning is hard to source.

A more recent comparative pilot study by Blackford et al. (2015) replaced the first week of a five week acute ward practice-based learning placement with simulation replicating an acute hospital ward via actors portraying conditions such as Parkinson's disease and cerebrovascular accident. The control group undertook five weeks practice-based learning in an acute ward. This study's findings mirrored Blackstock et al. (2013) and Watson et al. (2012) in that findings showed no significant differences in student competency between the simulation and control group at the end of their practice-based learning placement and simulation increased students self-reported confidence levels immediately after the intervention, though again

the students in the traditional practice-based learning were not comparably asked about their confidence levels. However this study also used focus groups to explore students' thoughts on the simulation experience. Findings from these showed students felt the simulation was realistic, it increased their confidence and that the interaction during the simulation week with staff and peers improved their learning experience.

Blackstock and Jull (2007), in an editorial paper on high fidelity simulation for the Australian Journal of Physiotherapy, acknowledged the lack of physiotherapy specific research in this field and called for physiotherapy specific research into simulation use within education to help ease the 'clinical education crisis' (Blackstock and Jull, 2007, p 3). Jones and Sheppard (2007) reported that their literature review indicated little research to indicate whether clinical reasoning is improved by the use of simulation. Therefore, the advantages of the types of simulation cited in the literature needed to be explored to identify the specifics of simulation with the potential to facilitate clinical reasoning within musculo-skeletal patient assessment for pre-registration physiotherapy students. The survey of teaching strategies used to facilitate clinical reasoning had reported the use of simulated patients (Paterson and Adamson, 2001) and they had been used in physiotherapy research investigating clinical reasoning (Ladyshevsy, 2002), and physiotherapy education (Liu, Schneider and Miyazaki, 1997). They were also mentioned within the Department of Health recommendation that healthcare professionals should learn skills in a simulation environment before undertaking them in practice-based learning (DH, 2011). Therefore the specific use of simulated patients was further explored.

2.12 Simulated patients

The term simulated patient encompassed various teaching strategies which generally involved either professional actors portraying patients or a patient simulated by technology. Actors portraying patients were referred to interchangeably as simulated and standardised patients, although the term

standardised patient also referred on occasions to a real patient trained to teach students about their condition (Wallace 1997). Hereafter, in this thesis, the term standardised patient is used to refer to a specifically trained person undertaking the role of a patient. There was ample empirical evidence to support the reliability and validity of standardised patients in medical education (Wallace 1997) and some within physiotherapy education (Ladyshevsky, Baker, Jones et al. 2000). Studies involving students assessing standardised patients to replace practice-based learning had reported that up to twenty-five percent of practice-based could be replaced with simulation of this type (Blackford et al. 2015; Blackstock et al. 2013; Watson et al. 2012). However, although Barrows (1993) had reported that, within medicine, a standardised patient could be trained in three hours, Ladyshevsky et al. (2000), while investigated the reliability and validity of a standardised patient as a tool for physiotherapy assessment, reported a total of thirty hours was needed to train the actor to the appropriate level of patient replication. This was attributed to the more in-depth assessment process used in physiotherapy. Authors such as Murphy, Imam and MacIntyre, (2015) and Watson et al. (2012) stated that the use of standardised patients was costly and potentially prohibitive. A survey, in 2009, of North American physiotherapy education programmes reported that only thirty percent used standardised patients. Eighty percent of those who did not use them cited costs as the main barrier (Pitzel, S. Edmond, S. and DeCaro, C. 2009). Costs include remuneration of actors' time for both training and simulating a patient as well as the time taken by lecturers to develop the patient cases and train the actors. A notable limitation of standardised patients is their inability to mimic actual pathology and physical signs (Watson et al. 2012). Murphy et al. (2015) compared the use of actors as standardised patients with volunteer genuine patients in student teaching sessions. They reported that the costs of a standardised patient was thrice that of a volunteer patient though both were equally well received by students. Mandrusiak, Isles, Chang et al. (2014) explored using final year physiotherapy students as standardised patients for more junior students. They reported one hour training time was needed and thus costs were

lower. However, although their results reported improved confidence to practice and high satisfaction this was junior student self-reported data.

Liu et al. (1997) investigated the use of a standardised patient assessment by groups of students and the use of video-taped assessment of a standardised patient by a qualified clinician. The study used quantitative measures to compare the effectiveness of the two teaching methods for teaching patient assessment skills to occupational therapy and physiotherapy students. The measures used were not validated; rating students' suggested patient treatment plans against expert opinion and student self-reporting of perceived learning. Findings showed that students preferred assessing the standardised patient themselves to watching a video of an assessment, although watching a clinician assess the patient led to better treatment plans. However, this did not necessarily indicate better clinical reasoning as it is likely that it is easier for students to rely on an experienced clinician's patient assessment to form a plan than to clinically reason the assessment process themselves.

The literature suggested that the use of standardised patients within physiotherapy education was reliable and effective (Ladyshevsky et al. 2000). It also suggested that their use was well received by students (Blackford et al. 2015; Murphy et al. 2015; Liu et al. 1997) and increased students' confidence to treat actual patients within practice (Blackford et al. 2015; Mandrusiak et al. 2014; Watson et al. 2012). Thus, although standardised patients themselves were not investigated further, due to the overall cost of this method of simulation being prohibitive for the physiotherapy programme at Martias, the concept appeared to have the potential to facilitate clinical reasoning. The literature showed that standardised patients had relevance when investigating other methods of patient simulation because the way they were devised by Barrows (1993) had influenced the design of technology-based methods of patient simulation e.g. Hubal, Kizakevich, Guinn et al. (2000), and that the standardised patient was often the yardstick used as in the measurement of effectiveness of these simulation techniques i.e. Rajj, Johnsen, Dickerson et

al. (2006). Therefore, computer-based patient simulation appeared to have potential and thus the use of technology within learning in higher education was explored.

2.13 Learning with technology

A literature search revealed a surfeit of studies related to the use of technology within higher education. However, learning delivered via technology did not have a commonly accepted title but was referred to interchangeably by terms such as online learning, computer-assisted learning and e-learning. These terms encompassed a broad spectrum of teaching techniques; from minimal technological enhancement such as PowerPoint lecture slides being made available online, to totally online multimedia rich, interactive and collaborative environments in Second Life. Early this century the literature most commonly used the term e-learning; which it defined as 'any learning that uses ICT' (Higher Education Funding Council for England (HEFCE), 2005 p 5). This vague definition covered a wide spectrum of educational styles and focused on the technology rather than any underpinning educational element. This technology-based approach masked the need for pedagogical principles to underpin the delivery of learning that used technology as a vehicle (Stefani, n.d.) and consequently there had been considerable criticism that technology was used merely as a repository for transmitting text based content (Moule, Ward, Shepherd et al. 2007; Sharpe, Benfield, Roberts et al. 2006) and thus replicating didactic face to face instruction rather than supporting learner-centred education (Chua and Dyson, 2004). The literature also frequently referred to blended learning, which again was ill-defined and had different meanings in different contexts (Oliver and Trigwell, 2005). However, the descriptions of blended learning as; the thoughtful integration of face-to-face learning with online learning experiences (Garrison and Kanuka, 2004), and; using the most appropriate medium to deliver different portions of learning within a programme (Hofmann, 2001) appeared to adhere to the reasons for using simulation within healthcare education.

2.14 Technology enhanced learning

The concept of best practice had evolved from the transmission of content to reflective and collaborative learning that emphasised the development of metacognitive skills (Nicholson, 2007) and had started to be referred to as Technology Enhanced Learning. Technology Enhanced Learning (TEL) was deemed the most accurate terminology within this thesis (except in citations where it should be noted that the term e-learning is used interchangeably). HEFCE (2009) named their revised e-learning strategy 'Enhancing learning and teaching through the use of technology' and the Department of Health (2011) published a Framework for Technology Enhance Learning. The former focused on embedding TEL in HEIs; the later within healthcare. Laurillard (2002) an authority within the literature pertaining to the design and use of technology within learning suggested that interactive and adaptive technologies facilitated learning that was difficult to achieve in traditional environments and helped students relate theory to practice. The term 'interactive' used in this sense indicated technology which supported reciprocal action between the technology and the student; the term adaptive referred to technology that enabled a student to adjust their actions in the light of results of previous actions i.e. technology which gave intrinsic feedback. However to add to the confusion of terminology the word interactive had also become synonymous with technology that the user navigated and selected content in any sequence; not strictly interactive, and was also used for discursive interacting online with other students in discussion forums. Thus, any literature pertaining to interactive technology needed to be carefully differentiated. Hereafter, within this thesis the term interactive will be considered to mean technology which supports reciprocal action enabling equality between it and the student (Barker, 2006). Interactive and adaptive technology was reportedly effective for: facilitating students use of the higher order skills in Bloom's Taxonomy (Bloom, 1956); evaluation, synthesis, analysis and application, and enabling self-paced repeated practise of skills in a safe environment to internalise processes (Laurillard, 2002). These attributes had the potential to assist students in

improving their clinical reasoning skills if harnessed to the appropriate knowledge content.

The literature surrounding TEL showed that advances in technology had not automatically led to learning enhancement; technology needed to be deployed with pedagogy, rather than technology, driving its design to actually achieve enhanced learning (Clark, 2004). A general review of the literature highlighted debate on the efficacy of TEL as, contrary to the much quoted benefits, high quality research that examined how students used TEL and its precise educational value was limited, and contradictory research findings were commonplace. This may have been a reflection of the array of TEL resources and techniques available or because evaluation had taken a secondary roll to resource development within project funding (Cotton and Gresty, 2006). It was also indicative of the lack of theoretical underpinning and methodological rigour of much of the research (Adams, 2004; Underwood, 2004). For example, a review of TEL within medical education reported half of the studies reviewed primarily used the potentially inaccurate measure of self-reported results of learning gains (Jwayyed, Stiffler, Wilber et al. 2011). Studies that relied solely on this type of data were of limited value. The literature had also highlighted debate on the appropriateness of using the 'gold standard' randomised controlled trial methodology, as various prolific authors within TEL argued that traditional teaching and innovative learning via technology were not valid interventions for comparison (Cook, 2005; Friedman, 1994; Clark, 1992). Their concerns were based on the multiple variables between the two interventions i.e. the use of different instructional methods and informational contents as well as the novelty effects of using technology to teach. Instead they advocated comparative studies of differing innovative technology methods.

2.15 Advantages of TEL

It had become a universally acknowledged truth that student education was enhanced by the use of technology, however, this premise was potentially but by no means inevitably correct. The most frequently quoted benefits of

TEL were communication, self-paced learning, problem-solving and transferable skills (JISC, 2008). Boud and Prosser (2002) authorities in adult learning developed a framework for appraising new technologies for learning. They suggested four key areas were incorporated in effective TEL; it engaged students at their current level of knowledge, it sited the learning in context, it challenged students to seek new knowledge, and it provided practice which involved feedback on the student's performance that encouraged reflection and subsequent practice. The ability to practice and receive feedback aligned with the stated benefits of simulation (Motola et al. 2013) and the ability to self-direct learning at a time and pace of the student's choosing (Race, 2005).

Feedback was reported as important feature of any form of effective learning by Nicol and Macfarlane-Dick (2006) and formative assessment, and its resulting feedback had been shown to have a statistically significant positive relationship with summative assessment marks (Velan, Jones, McNeil et al. 2008). Discontent with feedback provision had been identified as an ongoing prominent theme by the national student survey and one way to increase the amount of feedback on performance was to use formative computer assisted assessment (JISC, 2004). The literature recognised the beneficial features of formative feedback via computer-assisted assessment. It was generally agreed that it gave students greater ownership of their learning as they could take and retake the assessment whenever they wished and be provided with immediate feedback to inform their future learning (Qualifications and Curriculum Authority, n.d.). A qualitative study focussing on the use of a virtual learning environment (VLE) within a UK undergraduate physiotherapy programme established that students liked the formative assessment and the accessibility of course materials, however, they felt that the VLE was insufficiently interactive (Peacock and Hooper, 2007).

2.16 TEL within physiotherapy education

There was a dearth of published evidence on learning methods used within physiotherapy education and this was especially true in relation to TEL. Possible reasons for this include; the complexity of securing funding for educational research (Jones and Sheppard, 2008) and the focus within physiotherapy specific journals on evidence-based clinical practice. Thus, an overview of the literature revealed limited evidence to support or refute the use of TEL within physiotherapy education, though various editorial style papers discussed its usage and called for research to be undertaken (e.g. Blackstock and Jull, 2007; Jones and Sheppard, 2007). Two studies were located that evaluated TEL video resources designed to assist physiotherapy students with neurological patient assessment. Davies et al. (2005) undertook an exploratory study that incorporated TEL as part of usual teaching for all students, using videos of real patients in a self-directed learning approach as well as in online assessment. Students were positive about the use of patient video feeling it increased their confidence for patient interaction in practice-based learning. Preston, Ada, Dean et al. (2012) undertook a non-randomised controlled trial of a similar video based intervention. Findings showed that the summative assessment marks for practical skills in the intervention group were higher than the control. Although, the groups were consecutive cohorts over two years, the authors claim the usual teaching and assessment processes were adhered to, to decrease other variables. Again, students were positive about the benefits of using video both for learning and for preparing them for practice. The videos used in this study showed a clinician assessing a patient which, as previously discussed, students found less beneficial than assessing a standardised patient themselves (Liu et al. 1997). Suggesting that using TEL to actually conduct a patient assessment rather than watching one, may be well received by physiotherapy students. Sabus et al. (2011) had reported positive attitudinal results from occupational therapy and physiotherapy students using Second Life to conduct a simulated patient home assessment.

2.17 Computer-based patient simulations

The focus of the remainder of this literature review is computer-based patient simulations also known as virtual patients. A virtual patient is defined by Huang, Reynolds and Candler (2007) as; a computer-based program that simulates real-life clinical scenarios in which the learner acts as a health care professional obtaining a history and physical exam enabling them to make diagnostic and therapeutic decisions. However, the literature also used the term virtual patient not only to refer to the virtual characterisation of a patient but as a term for three other types of TEL. Firstly, for text based patient cases with branching logic, in which the student chose from a menu of responses to a scenario e.g. Round (2007). Secondly for descriptive patient cases within virtual hospitals e.g. Ellaway, Candler, Greene et al. (2006). Thirdly, for immersive three-dimensional environments which allowed the student, via a computer, to make clinical decisions based on gradually released information e.g. Alverson, Saiki, Caudell et al. (2005). Papers found to be referring to virtual hospitals and/or total immersive environments were generally excluded from the literature review as programs of this type were beyond the financial means of the physiotherapy programme at Martias. Research that focused on text based patient cases were also excluded as these focussed on a medical diagnosis being reached via a PBL type problem-solving approach rather than the more patient centred interactive assessment and clinical reasoning process needed for physiotherapy. They lacked the patient interaction element of the other forms of patient simulation. It should be noted, however, that it was difficult in some papers to ascertain in which context the term virtual patient was being used. Hereafter, in this thesis, the term virtual patient (VP) will be used to identify the interactive virtual personification of a patient by computer software.

2.18 Virtual patients

The majority of published literature on VPs was based within medicine and dentistry with one study reporting VP use in occupational therapy, one in pharmacy and one within physiotherapy. Therefore although it was difficult

to ascertain how much of the literature from medicine was applicable to physiotherapy for, as previously discussed, diagnostic clinical reasoning in medicine differs from clinical reasoning within physiotherapy, it was reasonable to assume that physiotherapy education could learn from the use of VPs within the education of other health professionals. As indeed physiotherapy orientated research into clinical reasoning had been based on the findings of research within medicine.

2.19 Virtual patient design and pedagogic rationale

Virtual patients incorporated, in varying degrees, a combination of textual information associated with other multimedia elements such as audio, video and animation. Two types of VP design predominated: a narrative approach and a problem-solving approach (Bearman, Cesnik and Liddell, 2001) though occasionally a hybrid approach that included elements of both narrative and problem-solving designs was used e.g. (Triola, Feldman, Kalet et al. 2006). The problem-solving approach was generally found in VP designs concerned with teaching clinical reasoning and diagnosis. They enabled the student to collect a range of information, usually from menus of possible questions, lab tests, and physical examinations and thus make diagnostic and management decisions based on their findings. The narrative approach, on the other hand, was often found in VP encounters which were concerned with cause and effect. This included programs that had an emphasis on decision making which resulted in various outcomes over time and presented as a series of interactions with a coherent storyline. From the student perspective the designs appeared very similar to use. The major difference between them being that the narrative design guided the student through the patient clinician interaction focusing on the impact of decisions or treatments as the simulation unfolds. Dependant on the student's choice of questions their path through the simulation would have consequences on the patient's manner and the outcome of the interaction. Thus, the number of choices that the student may have encountered varied enormously depending on how they interacted with the patient. The problem-solving design lacked much of this guidance and

allowed the student more freedom in the task of information gathering. Students still had to select suitable lines of questioning but all patient responses were independent of previous interactions. Thus the student was able to investigate the patient's problem via more diverse pathways (Bearman et al. 2001). From a physiotherapy perspective clinical reasoning incorporates problem solving to form a diagnosis and understanding of the cause and effect of communication and decision making with the patient. Thus the two design types had relevance within the context of simulation to facilitate the learning of clinical reasoning within physiotherapy.

Although the two design types were identified in the literature, many studies did not state the design type of the VP used and the reader was left to deduce this from the authors' description, for example, Dugas, Batschkus and Lyon (1999) described a VP which was suggestive of a problem-solving approach as it enabled students to diagnose a patient's problem by selecting questions from a list which were answered by text and images being displayed on the screen. Stansfield, Butkiewicz, Suma et al. (2005) described a VP designed to improve occupational therapy students' assessment of patients. Although, questions were also selected from a list, the avatar patient responded in narrative-style video clips, responding differently, depending on the student's choice of question, suggestive of the narrative approach. The articles by both Stansfield et al. (2005) and Dugas et al. (1999) were descriptive of the VPs developed rather than investigations of their effectiveness for student learning. This was true of much of the literature on VPs though several also reported attitudinal data which focused on the opinions and experiences of student users of a specific VP.

2.20 Student opinion on virtual patients

The literature generally reported positive student attitudes to virtual patients. For example, the narrative design approach was used in the creation of a psychiatric VP, created to assist medical students' bridge the theory-practice gap within psychiatric interviewing skills (Fitzmaurice, Armstrong,

Carroll et al. 2007). To interact with the VP students chose questions from a question menu which were answered by pre-programmed video clips of a standardised patient portraying depression. This particular simulation incorporated several feedback mechanisms. After each question was answered the simulation gave feedback on the type of question i.e. open or closed and the patient's response was summarised in clinical terms. Students also had the opportunity to watch a model interview with the patient and to view their own interview from beginning to end. An online quiz function allowed the student to conduct a mental state examination (Tombaugh and McIntyre, 1992) on the patient and receive feedback on their performance. Use of the VP was not mandatory but student usage was reportedly high, although Fitzmaurice et al. (2007) did not report the percentage of students who used it; they did report that the feedback questionnaire had 189 respondents, of those; seventy-six percent thought the VP was useful, sixty-five percent had used it more than once and fifty-five percent for longer than an hour. During a subsequent student user focus group additional VPs with differing pathologies were requested to further develop interviewing skills. This study appeared to rely on self-reporting data as opposed to the software collecting data on usage. This may account for the apparent ambiguity in its reported usefulness but limited usage. However, as the authors did not indicate their expectation of time on task to conduct an effective interview of the VP and use the feedback features constructively the apparent ambiguity is speculation based on experience of real patient interviewing.

A VP based on the problem-solving design approach was described in detail by Zary, Johnson, Boberg et al. (2006). The design was based on the problem-solving approach to facilitate the learning of clinical reasoning for medics, dentists and pharmacists. A specific premise of their development strategy was to make the software user-friendly enough for subject experts within the academic staff to be able to create patients themselves, as opposed to programmers being needed. To achieve this the software was created using templates that incorporated question menus and text-based patient responses accompanied by still photography. The authors

acknowledged that incorporating pre-formed questions was a trade-off between ease of use for academics and best design educationally, as the latter would have been served better by students having to input their own questions. Zary et al. (2006) undertook a pilot evaluation across the three student groups all of whom reported positively on it as a learning tool and on its ease of use.

2.21 Outcome-based studies of VPs

Studies have also investigated learning specific outcomes. Bearman et al. (2001) undertook a randomised trial comparing the same patient case delivered via the two types of VP design; narrative and problem solving. Within the context of teaching clinical communication the study compared the effectiveness of using a VP during one tutorial. Although usage was not mandatory 255 students from a total of 284, ninety percent, used their allocated VP. The outcome of the VP use was assessed by evaluation of an interview with a standardised patient. The results indicated that although there was no significant difference in the communication skills of students using the different VP designs, the narrative design appeared to teach some aspects of communication better than the problem solving design e.g. better use of open ended questions and appropriate language. The effects of the narrative versus the problem-solving design may have been more usefully quantified if students had used their VP more than once as it seems probable that communication skills would be improved with repeated practice. A lack of a control group also meant there was no evidence that VPs had any benefit over traditional teaching of communication skills. However, Bearman et al. (2001) concluded that their results showed a strong enough case for developers to seriously consider the role of narrative in the creation of any VP, and that it is likely that the two different VP designs need to be used in conjunction to replicate patient interaction. To further explore the complexity of the impact of VP interaction on medical student learning Bearman (2003) conducted a phenomenological study, interviewing twelve pre-clinical medical students to investigate their experiences of using the two designs of VP. The findings suggested that the

VPs initiated students into the complexities of the clinical world but that they found picking from a pre-set list of questions artificial and frustrating.

Triola et al. (2006) undertook a study using a randomised pre and post-test design to compare a hybrid design VP, incorporating elements of both the narrative and problem-solving approach, with a standardised patient. The VP was accessed using a standard computer keyboard and the participants selected questions from a list which the VP responded to via a narrative video clip. Interestingly the authors do not specify whether participants assessing the standardised patients also picked from a list of questions, but it infers not. This study differed from those previously discussed in that participants were not students but qualified healthcare providers (n 55) from various disciplines attending a continuing education course on diagnosing and treating individuals experiencing post-disaster psychosocial disorders. All aspects of the course were identical except that participants were randomised to receive either four standardised patient cases (n 32) or two VP and two standardised patient cases (n 23). Results showed that improvements in diagnostic abilities were equivalent in the participant groups and that those participants who experienced both the VPs and the standardised patients rated them as equally effective. However, interestingly, participants who had used the VPs reported feeling much higher levels of preparedness to address psychosocial issues in real patients. This finding was supported by a previous comparative study (Fleetwood, Vaught, Feldman et al. 2000) which reported that medical students who used VPs in addition to standardised patients felt more prepared and were more satisfied with the learning intervention. This may reflect the true intent of simulations, that participants can progress from the least intimidating virtual environments where mistakes have no clinical consequence, to realistic live standardised patients where the stakes are higher, and finally to real clinical situations. Thus learners who experience all three modalities may have better insight into the progression of and improvement in their clinical skills as they practice and reinforce them. However, within the Triola et al. (2006) study, it is also possible that the pre-formed question lists used when working with the VPs cued the participants

and enabled them to undertake a more successful assessment, thus increasing their confidence in their abilities.

A perceived pedagogical weakness of the VPs in the studies outlined is the use of question menus (Zary et al. 2006) as this does not simulate the real world of patient-clinician interaction. In the real clinical environment the student is neither cued as to which questions to ask nor restricted in their questioning to a predetermined pathway. Authors often denied cueing, for example, Fitzmaurice et al. (2007) claimed that the student's ability to select the questions asked, places them in control of the virtual interview. While Nielson, Maloney and Robinson (2003) argued that as their question list contained many questions that were irrelevant users must discern which questions were relevant. Even Zary et al. (2006) who stated that it was a design trade off to use a question list, then claimed information was not cued as there was no direction from the program format as to which order the questions should be asked in. Nevertheless, despite these claims, all the questions that could be used were given to the student which limited their decision-making and as reported by Bearman (2003) students found pre-set question lists both artificial and frustrating.

2.22 Free-text VPs

The literature showed that such matters had led to the development of a few VPs that gave students the ability to type free-text questions via a keyboard making it necessary for the student to rely upon their own knowledge base for their question choice. The development of such patients started in the 1990s, the most well-known was developed by Marshall University School of Medicine, to facilitate continuing medical education. Hayes and Lehmann (1996) described the rationale for, and the development of, this VP as well as some of the spontaneous feedback provided by users. They reported that more than ninety-five percent of the comments were positive, requesting more patients be added to the resource. This VP design included the ability to obtain the patient's laboratory test results, and perform tasks such as auscultation via audio with pictures of the patient serving as image

maps. The student could select a diagnosis from a list of twenty-five choices and a treatment from a similar sized list. Once these choices were submitted the software then provided feedback on whether the chosen diagnosis and treatment plan were correct. This reversion to multiple choice formats for the diagnosis and treatment seemed at odds with the free-text patient assessment phase, but Hayes and Lehmann (1996) did not give a rationale for this variation.

Also within medical education, Bergin and Fors (2003) described an advanced series of VP cases which used free-text questioning as well as interactive physiological examination procedures and laboratory test results. This resource gave students detailed feedback on completion of each patient scenario and twenty patient cases were reportedly developed in both Swedish and English. The resource took a decade to develop and the researchers gathered attitudinal data, in this case using questionnaires and interviews to gauge students' opinions of the resource. Opinions were mainly positive, eighty percent of respondents rated it as realistic, commenting favourably on the ability to ask any question in any order and the ability to perform physical examinations. Conversely, they reported negatively on the VPs inability to understand all their free-text questions.

Chesher (2004) developed a narrative approach VP to support medics learning about the diagnosis and on-going management of chronic illness. Although it used the narrative approach it was entirely text-based, containing no images, video or sound; there was no visual personification of the patient. Nevertheless the computer responded as the patient in an interactive way. Initially the design attempted to incorporate only free-text questions to minimising student prompting but the natural language recognition did not perform satisfactorily and only fifty percent of questions asked were recognised by the software. Therefore, alternative list-based questions were added. Chesher (2004) noted that during the observation of participants in the think-aloud sessions most started by trying to use the free-text method of asking questions but resorted to the question lists in frustration. The VP enabled students to assess the patient, request and

review investigations and choose appropriate management strategies over a number of consultations; the patient outcome being dependant on the management strategy selected by the student. A layer of reflection was added to the consultative process so that while interacting with the VP students could formulate and test their clinical hypotheses as well as record their observations and thoughts. At the end of each patient consultation, students could review their actions and rate their own performance in managing the patient and compare their activity to their peers or an expert.

Chesher (2004) undertook extensive usability evaluation of the software using observation with a think-aloud method followed by the administration of a questionnaire. The participants were ten medical students, five general practitioners and two specialists. Results of the observations demonstrated that the simulation could be used with minimal training. Questionnaire results showed participants thought it was engaging and that it supported the reflective process. The medical students, in particular, thought it had potential as a tool for practice, particularly in the climate of limited patient experience and especially for less commonly encountered pathologies.

One issue emerging from the literature is that of the evaluation of student learning. Both Chesher (2004) and Bergin and Fors (2003) undertook usability evaluations of their respective software and the results reported user satisfaction and positive opinion on the VPs effectiveness for learning. In general studies seeking student opinion on VPs reported high approval ratings (Kneebone, 2003) and student approval is an important consideration in determining the effectiveness of VP resources. If students do not like VPs they will not use them and if they do not use them they will not learn from them. However, approval in itself does not provide enough insight into their ability to facilitate student learning.

2.23 Quantitative evaluation of free-text VPs

The literature reporting comparative research using VPs was sparse. Schitteck-Janda, Mattheos, Nattestad et al. (2004) undertook a randomised

controlled trial (RCT) that aimed to measure the learning facilitated by using a free-text VP during the teaching of subjective assessment skills to dental students (n39). They compared the compulsory use of the VP with standard teaching. The data collection consisted of measurements of time taken to subjectively assess a real patient, analysis of questions asked of this real patient and expert opinion on the student's professional behaviour during the assessment of the real patient. The quantitative results indicated that students who practiced their subject assessment with the VP asked more relevant questions and spent more time on patient issues thus performing a more complete subject assessment and, interestingly, demonstrating more empathy when they encountered actual patients. The study did not gather data on students' opinions of the VP resource, but the authors reported that anecdotally students expressed frustration when the VP did not understand their questions. However, the authors also reported that students felt this caused them to reflect on how they posed questions to patients which ultimately they considered to be a useful experience.

As previously mentioned various authors have argued that traditional teaching and TEL were not valid interventions for comparison due to the different instructional methods and the novelty effects of technology, advocating instead comparative studies of differing TEL methods (Cook, 2005; Friedman, 1994; Clark, 1992). However, their argument assumed a model of 'traditional' teaching. Although few authors actually define what they mean by 'traditional', 'usual' or 'standard' teaching, it should not be a static concept, for instance learning via the standardised patient began in medical education in 1963 but may not be considered traditional teaching by many.

Raij et al. (2006) minimised the confounding factors mentioned previously in several ways. They undertook a comparative study examining medical students' experiences when undertaking the subjective assessment of a VP versus a standardised patient. Both patients portraying an identical medical condition, both were life-size, both recognised normal speech and gestures. These were achieved in the VP by using a large wall mounted viewing screen, voice recognition software and head and index finger tracking to

allow recognition of gestures, while the standardised patient, as previously stated, was an actor portraying a patient. Results showed subtle differences in the participants' rapport with the patient but overall task performance was similar, as were students' perceptions of the educational value of the interaction. Some students expressed a preference for the VP as they felt less pressure and were more comfortable that making a mistake was an acceptable part of the learning process. Raij et al. (2006) concluded that overall the VP had a strong correlation with a real patient and could sufficiently perform the patient role when teaching the subjective assessment of patients. However, the VP used by Raij et al. (2006) was extremely high fidelity, such cutting-edge technology was usually only reported in the training of the American military and disaster-response paramedics (Freeman, Thompson, Allely et al. 2001). Research reporting the use of such high fidelity VPs within medicine was sparse, within the education of other health professions negligible and within physiotherapy non-existent. This was probably due to cost, as the cost of such technology would be beyond the means of most qualifying physiotherapy programmes.

Although not VP specific, Gordon, Wilkerson, Shaffer et al. (2001) reported that medical student opinion of teaching using high fidelity simulation was generally enthusiastic and Weller (2004) demonstrated high satisfaction using medium fidelity simulation. However, high student satisfaction may be due to the previously mentioned novelty effects of such technology and, to justify the expense of simulation, it would be desirable to demonstrate that students learned was improved by using it. For instance, within medical education a high fidelity fully immersive, interactive virtual reality system that had taken several years to develop was compared with traditional PBL methods (Alverson et al. 2005). The authors reported high student satisfaction with the simulation but no difference in student knowledge gain between the two groups. However, subject-content knowledge gain was perhaps not the most appropriate learning expectation and measure for high fidelity simulation as content knowledge gain was shown to be more effectively learnt via traditional learning formats by Holzinger et al. (2009) and Schwartz and Griffin (1993).

2.24 Beneficial elements of simulation

Although not a VP simulation the results of a quasi-experimental study using a symbolic simulation of the complex modelling of arterial blood flow, by Holzinger et al. (2009), suggested that formalised instruction is needed to guide students through knowledge acquisition to enable them to make the most of simulation. The study compared the learning performance of ninety-six medical students for three interventions: conventional text-based instruction; simulation alone and simulation with additional material and support. Results showed that the first two groups produced equivalent results, but the combination of simulation with additional support yielded a significantly higher learning performance. These results suggested that simulations can be beneficial for learning complex concepts (clinical reasoning fits this category); however, successful application of simulations requires additional guidance and a certain amount of previous knowledge on the part of the learners.

The purpose of the research by Schwartz and Griffin (1993) was to examine the relative efficacies of three types of performance feedback used with medical students learning via a computer how to diagnose abdominal pain. To compare the three types of feedback final-year medical students (n 75) were pre-tested for domain knowledge and diagnostic skill in the area of acute abdominal pain. The students were also asked to indicate their confidence in their diagnosis. Following these pre-tests, the students were randomly divided into five groups of fifteen students. One group received a traditional question-and-explanation format, with no feedback. The other four groups received different methods of delivery to learn diagnostic accuracy, and one of three types of performance feedback (which differed considerably in the amounts of information imparted). One group received VP cases and outcome feedback, one received VP cases and Bayesian feedback, one received VP cases and Bayesian plus rules feedback and one received Delphic instruction and Bayesian plus rules feedback. Post-tests results showed that contrary to expectation the different types of

feedback were equally effective. They also showed that the students in the traditional learning group significantly improved their performance in knowledge based multiple-choice questions, by fifty-eight percent, compared with the other groups of students who had six to ten percent improvement. However, the traditional learning group students did not improve their diagnostic performance but declined by one percent. In contrast, the groups that used virtual-patient cases with feedback, of all types, improved their diagnostic accuracy by as much as sixteen percent. The students using the VPs also increased their diagnostic confidence from pre-test to post-test, although interestingly this was regardless of their actual performance. Although the study was not designed to investigate the effectiveness of VPs it inadvertently threw light on their effectiveness in facilitating diagnostic skills as it suggested that VPs with incorporated feedback could improve the diagnostic abilities of final year medical students without appreciably improving their knowledge base as assessed by multiple choice questions.

2.25 Evidence in opposition to VPs

Evidence against the use of VPs was sparse although one criticism was that it was inherently unrealistic and could not provide the richness of experience that would be found in a real patient encounter (Friedman, 1994). This general point was not in dispute: simulation generally and VPs specifically were not an alternative to real practice-based experience but a preparation for it (Issenberg et al. 2005). Gordon (1982 cited in Cioffi, 2001) suggested that simulations may not generate the same cognitive strain as clinical experience and so could not provide practice in real clinical reasoning and Neary (1994) suggested that as students were aware the simulation was not a real patient they did not feel the same pressure burdens or respond as they would with a real patient. More recently, however, Kneebone, Kidd, Nestel et al. (2002) considered content validity in computer-based patient simulations and found that students experienced the simulation as highly realistic often feeling the anxiety and confusion of a real patient encounter, while Davis (2005) reported students crying if the

simulated-patient died. This difference in views on the realism of simulation may well be due to the huge technological advances of the last two decades, but nevertheless a potential issue in the simulated environment is psychological fidelity; students behaving differently than they would in the practice setting.

Flanagan, Nestel and Joseph (2004) suggested that this took two forms; students either became hyper-vigilant; they anticipated an adverse response and were overly cautious, or they exhibited cavalier behaviour and casual interactions due to the lack of real consequences. The latter is somewhat concerning as Schwartz and Griffin (1993) showed that working with VPs appeared to improve students' confidence in their abilities regardless of whether their performance improves. However, a psychology based study reported that people tended to respond to avatars as they would to real people with similar characteristics; the same feelings and principles that shape their real-world interactions are a factor in their virtual interactions (Dotsch and Wigboldus, 2008). Thus hyper-vigilance or casualness may inherently be a student's personality rather than specifically related to using simulation. Thus, uncovering these behaviours could be viewed as a learning opportunity both for students and for educators. The student can reflect on, and improve their performance. Indeed, one of the main appeals of simulation is that, unlike in the real clinical situation, mistakes can be learned from and this gives an opportunity to explore the limits of situations rather than having to stay within the zone of clinical safety (Good, 2003). Educators can address inappropriate student behaviour before it affects real patient care. Interestingly Ashoorion, Liaghatdar and Adibi (2012), who investigated the association of; critical thinking, personality and emotional intelligence, with clinical reasoning, suggested that emotional intelligence was the only one of the three linked to clinical reasoning ability. Thus using VP could demonstrate the need for improvement in emotional intelligence before working in practice with real patients. However, students in professional healthcare programmes should be expected to use VPs appropriately as learning is a two-way process in

which it is the educator's responsibility to create the conditions for learning, and the student's responsibility to take advantage of them (Laurillard, 2002).

This issue of professional behaviour also pertains to the way a VP is presented, it must be underpinned by professional attitudes (Kneebone, 2003). Some of the VPs described within the literature used question options that appeared somewhat frivolous for learning within professional health education as well as condescending to student users. For example, Stansfield et al. (2005) the choices for initiating an initial subjective assessment were:

- a) Good morning, are you Mr. Jones?
- b) Good morning, Steve. Are you ready to go?
- c) Hey, man, how's the morning going?
- d) Hope you need coffee as much as I do.

While another, though actually a branching logic VP created by Round, (2007) begins:

It is your first day as a paediatrician. You have found the cafeteria and you are half way through a curry when the crash bleep goes off: "Paediatric cardiac arrest in A+E". What would you like to do?

- a) Finish your curry.
- b) Run to A+E.

VPs developed in this way appear unlikely to cause the psychological fidelity required, and to potentially promote the cavalier behaviour and casual interactions suggested by Flanagan et al. (2004). This lack of professional context may be aligned to the difficulties experienced in VP software development. Those who have the skills and resources to develop VPs are often technology developers, rather than subject matter experts, and this may make it difficult for them to understand the complex nature of the professional healthcare patient interaction as well as the pedagogical objectives of using simulation to practice it.

2.26 VPs in physiotherapy

The review has shown a dearth of studies dealing specifically with the use of VPs within physiotherapy, although an American-based pilot study, was located (Huhn, Anderson and Deutsch, 2008). It used a mixed methods approach to investigate the efficacy and efficiency of a VP simulation to teach clinical reasoning skills to physiotherapy students. An existing bespoke medical VP software from within the same HEI was modified, adding functional and physiotherapy intervention categories. It used a series of question menus to enable students to assess and diagnose a patient. Students (n 36) were randomly divided into two groups, nineteen completed three VP cases and seventeen completed three identical cases using the traditional text-based cases in facilitator led PBL groups. Qualitative data demonstrated high student satisfaction with the VPs and a preference for learning with computers. Quantitative clinical reasoning scores did not change significantly for either group. However, as previously discussed clinical reasoning is notoriously hard to measure especially with smaller scale changes and the measure used within this study had not been shown to be a valid measure for clinical reasoning. The authors reported a trend towards significant improvement in the simulation group which appeared to carry over into practical exam scores, though without statistical significance this was not considered a valid finding. Thus the pilot study did not show that the VP used was an effective way for physiotherapy students to learn to clinically reason. However although this may well have been due to methodological limitations, neither did results show it was less effective than PBL.

2.27 VP innovation

The literature demonstrated that the effective use of VPs within health education is limited and lags behind the fast pace of technological innovation. This lack of research into their effectiveness mirrored their lack of availability as they appeared to be rarely employed, as either a commercial product or as open-source bespoke system, beyond the

settings in which they were designed. It is likely that for VP software to be commercially viable it would have to be generic enough to suit multiple types of healthcare students and a program this nonspecific may well suit no one. Many of the VPs were funded and developed within innovative environments in prestigious medical schools (Fishman, Soloway, Krajcik et al. 2001). However, within areas of health education where there was not the same focused attention and support, the VP was not becoming part of everyday learning practice. This may have been due to their complexity and cost alone, or the lack of evidence to support their effectiveness may have limited the funds and resources allocated to them. However, particularly in the early phases educational innovations, by their very nature, seldom have high levels of evidence to support their effectiveness. The dichotomy of the situation lies in the need for robust evidence to demonstrate the value of VPs to obtain resources and funding for development, and the need for VPs to be developed to enable researchers to amass an evidence base (Srinivasan, Hwang, West et al. 2006).

Both Cotton and Gresty (2006) and Laurillard (2002) stated that an insignificant amount of learning technology funding had been used for evaluating technological learning resources as invariably the development costs expand to commandeer the entire budget. This may account for the heavy emphasis on descriptive articles of the technology and design of individual simulations rather than research into their effect on student learning. This could well be due to the fast-moving, technology-dominated field, with research inevitably trailed behind innovation, meaning that published research was potentially out of sync with the technological advances. Those who have the skills and resources to develop VPs are not necessarily driven by the same agendas as those who wish to use them to facilitate learning. This may account for why much of the literature within medicine focused on high fidelity VP simulation. Literature that compared the effectiveness of levels and types of fidelity was not located. Therefore, the template based system that enables subject matter experts to produce VPs independently as created by Zary et al. (2006) may be important as

VP software represents a finished product for a developer while for a researcher within education, it is only the beginning (Kneebone, 2003).

Furthermore educational research is constrained by its need to exist within the context of courses and curricula. Thus, small sample sizes, difficulties with randomisation and control and lack of opportunities for longitudinal investigation cause problems with validation. These tensions were reflected in the literature, where descriptive papers reporting learners' opinions outnumber studies that, using any method, demonstrated gains in learning. That is not to negate research of learners' opinions, this has been and will continue to be essential to developing both new technologies and refining the understanding of the learning process. However, in isolation it is insufficient for clarifying whether VPs can add value to health education and if so their most valuable uses. Research ascertaining whether VPs are more effective than other teaching methods and which VP design is most beneficial in which context are both necessary

2.28 Summary of literature

There is a lack of published literature addressing the use of virtual patients within physiotherapy pre-registration education and the use of virtual patients to facilitate clinical reasoning. However, the literature review identified key themes within clinical reasoning and the use of simulation within healthcare education. The lack of research literature reporting the use of VPs in physiotherapy meant that extrapolations had to be made from research in medicine and dentistry. Some of these may be invalid, but physiotherapy is not so unique that it has nothing to learn from the use of VPs in the education of other health professionals. In other areas of health-education related research, such as clinical reasoning, subsequent physiotherapy orientated research has been based on the findings of research within medicine. The key themes pertaining to student learning within the literature on clinical reasoning, simulation and virtual patients helped to shape the subsequent institutional focus study and research detailed in this thesis.

The key themes within the clinical reasoning literature pertaining to student learning were as follows:

1. Clinical reasoning is complex and involves synthesising knowledge, cognition and reflection.
2. Patient assessment involves the clinical reasoning strategies: hypothetico-deductive reasoning, pattern recognition and narrative reasoning. Students primarily use hypothetico-deductive reasoning, using less pattern recognition and narrative reasoning than experienced physiotherapists as well as spending less time on the subjective assessment and more on the objective assessment than experienced physiotherapists.
3. Students struggle to bridge the theory-practice gap and apply the clinical reasoning taught within university teaching during patient assessment within practice. They have difficulty with differential diagnosis and therefore, to create reasoned management plans. However students perceive they automatically use appropriate clinical reasoning and do not recognise their own errors.

The key themes within the health education simulation literature pertaining to student learning were:

1. Simulation which includes feedback and repeated practice improves learning.
2. Using patient simulation improves student confidence in their abilities regardless of whether their performance improves.
3. Students had a positive attitude to simulated patients as they give a realistic patient assessment experience with less pressure than a real patient. Students feel assessing a simulated patient is more useful than watching someone else assess a patient.

The key themes within the use of VPs were:

1. Students had positive attitudes to VPs and wanted more of them.
2. Students favouring the ability to ask their own questions over question menus.
3. VPs that incorporated feedback appeared to improve diagnostic ability, and a problem-solving approach to VP design was suggested to be appropriate for clinical reasoning.

2.29 Conclusion

While there was some evidence that using VPs can facilitate student learning, this was far from a simple equation. The studies cited represented a range of different settings, interventions and outcomes and were therefore not directly comparable as much appeared to depend on the learning context and the qualities of the particular VP. Each VP design may well have a range of strengths and weaknesses, but often only one characteristic had been studied. It may be that a VP that is effective in one dimension is of low quality in another. Therefore, more in depth exploratory research is needed to investigate the range of possible strengths and weaknesses of specific resources. Given that simulation can be technologically and often graphically appealing there is an inclination to apply it enthusiastically and potentially uncritically, but many questions remain as to the best design for the most effective learning in specific contexts.

This is not to say that VPs do not have educational value but rather that their value is not backed up by substantive evidence. The complexity of design issues raises the importance of gaining insight into their use for effective learning and highlights the importance of context specific, user-centred development and evaluation. Studies often used student self-reporting attitudinal data which showed improvements in confidence. However, increases in self-confidence have been shown not to correlate with increased ability. The key measure of the worth of VPs should be their ability to effectively educate the appropriate students, but there are comparatively few outcome-based studies investigating the educational

value of VPs, and those undertaken often lack a control group for comparison. Thereby, even when educational improvement was found it was unclear whether the VP facilitated learning because it was more effective than other methods or because of other variables i.e. increased time on task. Consequently studies generally raise hypothesis but few definitive answers.

Therefore physiotherapy specific research was needed. Calls for research into simulation use within physiotherapy education were increasing (e.g. Blackstock and Jull, 2007), as were recommendations that physiotherapy students' clinical reasoning during musculo-skeletal patient assessment be investigated further outside of the clinical area James (2001). Although there was some emerging literature in physiotherapy the research linking clinical reasoning and VPs was primarily from medical education where the emphasis of clinical reasoning differs. Thus the study presented in chapters four, five and six aimed to explore the use of virtual patient simulation by physiotherapy students, to investigate the efficacy of using VPs to facilitate the learning of musculo-skeletal patient assessment and clinical reasoning.

3.00 Chapter three: Institutional Focus Study

3.01 Introduction

The institutional focus study (IFS) is required as part of the submitted thesis for a Doctor of Education degree. It is expected to be undertaken prior to the main research study, focused on professional activities related to that research and conducted within the education institution that the subsequent research will be undertaken in. It provides an opportunity to reflect on, and develop understanding of both professional role and research expertise, as well as provide an opportunity to apply expertise in a practical way. I chose to use the IFS to explore and gain a better understanding of how to implement the use of technology based learning to smooth the identified clinical reasoning theory-practice gap during patient assessment, by facilitating physiotherapy students' clinical reasoning skills before they commenced practice-based learning. The IFS was based within the pre-registration physiotherapy programme at Martias University.

The literature on facilitating clinical reasoning within physiotherapy pre-registration education was sparse and provided little explicit evidence of effective ways to use technology to enhance learning in this area, although there was some evidence that clinical reasoning skills could be enhanced by the use of standardised patients (Ladyshevsky et al. 2000). Searches of the literature pertaining to physiotherapy revealed no evidence that using virtual patient (VP) simulation could facilitate students' learning of patient assessment skills or clinical reasoning, however, there was some evidence within dentistry (Schitteck-Janda et al. 2004) and medicine (Raij et al. 2006). Raij et al. (2006) had also shown a high fidelity virtual patient was as effective as a standardised patient for teaching assessment skills within medical education. Therefore, it was deemed reasonable to explore the implementation of VP simulation within the physiotherapy programme.

The implementation of TEL was, however, a complex area. The desire to develop innovative TEL at Martias raised several issues and this IFS

explores these issues. At Martias innovative TEL was a low priority, this was illustrated by a lack of resources and development support. There was generally a low demand for TEL from academics and most crucially a lack of the skills needed to develop TEL as well as insufficient provision of skilled support staff to remedy this.

The lack of a commercially available physiotherapy specific VP, resulted in the development of a bespoke physiotherapy VP and the limited availability of appropriate resources for TEL caused a project approach to be adopted. The literature reported that the student perspective had been largely overlooked during the designing of TEL resources but student feedback to enhance TEL had been shown to be indispensable (Sharpe, Benfield, Lessner et al. 2005). Laurillard (2002) argued that it was crucial to involve students in the development and design of any educational resource. I felt this was especially true of a resource as complex as a VP. The literature showed that students had positive attitudes to VPs and wanted more of them (Fitzmaurice et al. 2007; Chesher, 2004; Hayes and Lehmann, 1996). However, obtaining students' views before and during development as well as after was likely to enable a more effective VP design especially in the area of usability. The ideas and issues raised by the students in some instances matched those advocated by the literature; free-text inputting of questions, feedback and multiple patients. The students' ideas along with the findings from the literature on VPs, simulation, and clinical reasoning were considered and, to a greater or lesser extent, incorporated in the design of the physiotherapy VP at Martias and the design of the subsequent research reported in this thesis.

3.02 Technology enhanced learning: a definition

Technology Enhanced Learning was previously explored in the literature review. Within this IFS the following definition of Technology Enhanced Learning was devised: *Technology enhanced learning uses technology to facilitate self-directed learning offering students the option of time, place, and pace, to maximise learning within the context of programme design.*

The aim was to embed technology as a component of learning within the programme delivery, using it to enhance students' ability to clinically reason before embarking on their practice-based learning. This approach adhered to contemporary national educational policy which strove to embed learning technologies in mainstream higher education to enhance learning (Leitch, 2005).

3.03 National drivers for TEL

When the physiotherapy programme commenced, in 2004, significant national policy directives were driving the use of technology within learning and the political pressure on UK HEIs to adopt TEL was substantial. Yet, the ability to actually accomplish this was more complex. Subsequent to the higher education and technological improvements recommended by Fryer (1997) and Dearing (1997) a plethora of documents and strategies were published. The Department for Education and Skills (DfES) advocated an increase in TEL, in order to provide more flexible learning opportunities (DfES, 2004). The Higher Education Academy (HEA) and HEFCE in alliance with JISC adopted a strategy to embed TEL in all HEIs in a sustainable way by 2010. They aimed to do this by encouraging strategic, institution wide planning and implementation, supporting extended learning environments and encouraging learner centred approaches (HEFCE, 2005). The Government's widening participation agenda also promoted the use of TEL (DfES, 2005), to transform higher education by using interactive technologies to create and provide integrated support services for all learners. There was also pressure to adopt TEL to modernise curricula and teaching methods from the Bologna reforms (European Higher Education area, 1999) and the Lisbon Agenda (European Parliament, 2000). Thus technology was a key component of the UK government's vision for the transformation of the education system. In an inquiry set up by Tony Blair to report to the labour party, Stevenson (1997) predicted that by 2007 technology would be embedded within education and DfES, in 2003, envisaged that by 2013 effective learning would be synonymous with access to technology. However, Somekh (2007), an internationally

renowned professor of education and expert on the impact of TEL and change management, argued that policymakers assumed teaching to be the unproblematic transfer of knowledge from expert to learner. Thus, technology was seen as a means of transferring knowledge to the masses in a cost effective way rather than an innovation to enhance learning, and this shaped both which technology was introduced and how it was embedded within HEIs.

3.04 TEL at Martias

Martias had responded to the national policy drivers in the form of strategy formulation and the provision of centrally managed commercial software. This was in line with the majority of UK universities (Organisation for Economic Co-operation and Development, 2005). In common with many HEIs the management at Martias chose a commercial virtual learning environment (VLE) software that allowed the hosting of programme-specific content materials and a commercial computer-assisted assessment (CAA) software which enabled the creation of multiple choice question banks with incorporated marking and feedback.

Although the successful implementation of both national policy and institutional strategy needed the support of academics, little attention within UK HEIs, including Martias, was given to the support needed to use learning technologies within teaching (Somekh, 2007). Despite Dearing (1997) recommended that HEIs should review the changing role of staff due to technology and ensure that staff received appropriate training and support the usual approach within higher education was to expect academics to develop their own TEL resources utilising the technology provided (Weigel, 2002). Martias was no exception as, along with many HEIs, it underestimated the differences in learning culture between traditional and computer-based learning (Robertson, 2008; Greenhalgh, 2001).

Martias, as part of the institutional strategy on TEL centrally employed staff whose remit was to offer expert support and training to academic staff in the pedagogic use of learning technologies and to work with them to design, implement and evaluate resources to support the effective use of TEL. However, in reality the approach to TEL development at Martias focused on teaching staff how to operate the centrally provided VLE and CAA software. Thus, the premise that TEL developments would be driven by pedagogical considerations rather than technological ones was not recognised. This was not unique to Martias, it was widely acknowledged that the focus was often on a specific technology and how it might be used for education, rather than on the best way of teaching a particular topic and how technology might be used to enhance this teaching. This had been reported as typical across education contexts (HEFCE, 2009; Badge, Cann and Scott, 2005; Clark, 2004; Weigel, 2002; Fishman et al. 2001) and was argued to be due to incompatibility between those who managed the technology, who tended to presume that it would be incorporated into existing practice; the transmission model of pedagogy, and those wanting to use technology innovatively and therefore move beyond existing practice (Somekh, 2007).

Although it was recognised that familiarity with a particular technology was a prerequisite for using it to improve student learning, knowing how to use it technically was not the same as knowing how to apply it pedagogically (Laurillard, 2002). Nevertheless in terms of the implementation of a VP, gaining familiarity with the VLE and CAA did establish that the institutionally provided technology at Martias was not suitable. The potential of the CAA software for creating a branching logic type VP as per those described by Round (2007) was investigated, even though this was not the most appropriate VP design format for physiotherapy. However, the CCA software functionality could not support this type of complex usage. The VLE was also unusable as it assumed the transmission model of pedagogy and was inherently designed to deliver primarily textual content (Currier, Brown and Ekmekioglu, 2001) which was, in many ways, predictable as teaching had primarily been a print-based paradigm since Gutenberg invented the printing press. Although few academics engaged with TEL in

any form at Martias, those that did tended to use the VLE as an electronic document repository of lecture-based PowerPoint presentations and other text-based material. Again this tendency was widely reported (MacKeogh and Fox, 2009; Moule, Ward and Shepherd, 2008). The nature of the VLE increased the likelihood that unsupported academics' with under-developed technological skills would duplicate their existing teaching practices (Somekh, 2007). This was demonstrated by academics teaching on the physiotherapy programme at Martias, who were not comfortable with technology and did not have the skills or the inclination to explore and develop TEL. Nevertheless, one of the advantages of using the VLE in this way was that within a spiral curriculum, such as that of the physiotherapy programme, it enabled content to be easily accessed and built upon by students and empirical evidence from another UK HEI had suggested that physiotherapy students found it useful to revisit previous learning resources (Peacock and Hooper, 2007).

3.05 Staff development

Authoritative authors were calling for staff development to move beyond providing academics with technical skill training (Sclater, 2008; JISC, 2007; Laurillard, 2002). It had been argued for some time that academics needed help to understand how students learnt through different technologies as well as how to critically appraise technology to select or create TEL that was interactive and motivated students (Chickering and Ehrmann, 1996). Many academics may not have learnt via technology during their own education (Laurillard, 2002) and their use of TEL was likely to be influenced by their level of comfort with technology (Somekh, 2007). The literature exploring academics' attitudes to TEL reported a reluctance to expose their perceived weaknesses with technology to others (Maiden, Penfold, McCoy et al. 2007) and a strong commitment to face-to-face teaching, allied with scepticism about technology was identified, as well as a widespread lack of awareness of the potential of TEL or the pedagogical philosophy underpinning it (MacKeogh and Fox, 2009). This was mirrored at Martias and the cliché 'it's not broken why fix it?' was often cited by academics. If staff used

technology at all they saw it in a supporting role to usual teaching rather than as an enhancement of learning. Langley, Marriott, Belcher et al. (2004) found that less than half the pharmacology lecturers interviewed at one UK university used the VLE provided, reporting that they needed training to enable them to use technology as part of their teaching. Thus, without pedagogically driven staff development the kinds of technologies generally being adopted were those that supported the didactic paradigm of teaching (Laurillard, 2002), such as the VLE and motivation to use it was decreased by inadequate technical support and lack of time (MacKeogh and Fox, 2009). However MacKeogh and Fox (2009) also found there was evidence of enthusiasm and expertise among some staff, with recognition of the need for new approaches to learning. These early adopters of new technologies were often referred to as champions (Moule et al. 2008; Somekh, 2007).

3.06 The champion role

Having established that the creation of a VP at Martias was not possible via the institutionally provided technology, and that pedagogically focused technology support was not available, it was necessary to assume a lone champion role. It was acknowledged within the TEL literature that champions needed to be highly self-motivated to accomplish any TEL implementation, especially if they worked in a culture where TEL development was not a high priority (Moule et al. 2008; Somekh, 2007) and as Martias, in common with other research intensive institutions (MacKeogh and Fox, 2009; Sclater, 2008; Dearing, 1997) valued research more highly than innovative teaching, there was little incentive for staff to focus on developing new teaching strategies. The lone champion approach meant that it entailed an immense commitment of time, as at Martias the development of TEL resources was in addition to an academic's existing workload. This was reported as widespread practice within HEIs and frequently cited as a barrier (JISC, 2008; Sclater, 2008; Laurillard, 2002; Passmore, 2000). The VP project at Martias was unfunded and thus resources were limited. Nevertheless the development of a VP software had to start from scratch as there was not any pre-existing software to adapt or

build upon. I undertook the pedagogically design and provided the patient data for the virtual patients. A computer programmer agreed to create the bespoke software needed to deliver this design as a VP. However, it was difficult to develop TEL that supported innovative ways of learning without colleagues ready to embrace it. Though it was undoubtedly difficult for them to envisage how they could benefit from a VP being developed, having not experienced using a VP nor seen any evidence to show their worth. It was recognised that ultimately change would only occur once a VP had demonstrated improvement for academics and students (Weigel, 2002).

3.07 The student perspective

A systematic review undertaken for JISC of research published since 2000 that focused on students' experiences of TEL, demonstrated that the learner perspective had been largely overlooked during the design phase and student opinion was usually only sought to evaluate an end product (Sharpe et al. 2005). However, the use of student evaluation feedback to enhance TEL had been shown to be indispensable (Sharpe et al. 2006) and Laurillard (2002) argued that it was crucial to involve students in the development and design of any educational resource, and this was deemed especially true of a resource as complex as a VP. The literature showed that students', albeit mainly medical students, had positive attitudes to VPs and wanted more of them (Fitzmaurice et al. 2007; Chesher, 2004; Hayes and Lehmann, 1996). However, obtaining students' views before and during development as well as after was likely to enable a more effective VP design. This was specifically true in the area of usability. The International Organisation for Standardisation (1998) stated that usability consisted of three components: effectiveness, efficiency and user satisfaction. Effectiveness referred to the accuracy with which the goals of use were achieved, efficiency was the ratio of resources expended and achievements gained, and satisfaction reflected users' attitudes to it. In terms of the VP at Martias usability would thus involve the ease of development as well as the ease of students using it to enhance learning. Usability from the students' perspective was important, firstly because across the higher education

sector there had been considerable criticism from students of the usability of TEL systems (Chua and Dyson 2004); anecdotally students at Martias often unfavourably compared the VLE to Facebook. Secondly, research with healthcare students had shown a strong positive relationship between the perceived ease of initial use and usage of TEL (Lee, Hong and Ling, 2002; Wharrad, Cook, and Poussa, 2005) and thus the time span for obtaining student engagement with a VP was potentially limited and ease of initial use was probably important if it was to facilitate learning. Therefore the VP development started with general discussions with students at Martias and academics at various HEIs to gain their ideas about the concept. Although little evidence of VP use within physiotherapy education had been located, communication with academic counterparts at other HEIs revealed that one HEI had recently developed a bespoke VP interviewing software system that they would grant permission to use to investigate developmental ideas and enhance understanding for a physiotherapy specific VP resource. The ability to evaluate an existing software system with students was invaluable as it was difficult to imagine how technology might facilitate learning without having experienced anything similar (JISC, 2007).

The software had been created to help medical students improve their subjective interviewing technique. The VPs were of narrative design using video clips of four standardised patients portraying four different personalities and pathologies. To interact with the VPs students used a standard computer and chose from a question menu; the VP answered via pre-programmed video clips. Once the clip finished a list of questions reappeared and the student picked another question initiating a further video clip. This process continued until the student concluded the interview at which point a video clip ran in which the VP gave the student some general feedback on their performance. This feedback scenario is improbable in clinical practice but the rationale stemmed from the medical standardised patient model created by Barrows (1993), in which the actor was trained to give students feedback on their performance. The question menus were limited to the initial part of a subjective assessment i.e. the

current issue and social history and adhered to the medical model of diagnostic style questioning.

3.08 Evaluation of the VPs

The views of physiotherapy students studying at Martias were sought on the usability of the system. Ethical approval was sought and granted by Martias. For recruitment and consent documentation used see appendices one and two. Nine students volunteered to spend an hour in a computer lab independently using the VPs followed by a focus group to investigate their views on its usability, and usefulness. Their prioritised suggestions were also sought for the development of a physiotherapy specific VP. Thematic analysis of the focus group data was undertaken to establish students' opinions on the interviewing software and features they thought a physiotherapy specific resource should incorporate. (A discussion of the data collection methods and analysis was examined in the previous portfolio submission). The findings are presented in tables and with supporting quotes. The students' ideas for a physiotherapy specific VP are displayed using quotes and are prioritised in table

Overall students thought the VP software was useful.

Yvonne: *'It would have been quite a nice stepping stone, doing something like what we did today and then progressing onto an actual subjective assessment in real life, so I think it is definitely useful'*. (64)

Lex: *'I think though in terms of just learning how to do a subjective assessment, it would probably be really good and beneficial to do that'*. (386)

They thought it was a good adjunct to learning. This mirrored the findings of JISC (2007) which showed students believed that technology should support face to face teaching, not replace it.

Ayla: *'You couldn't use it in isolation, you would have to give it with like a lecture, because you would still need to know what should be asked in a subjective assessment, it would have something that is an adjunct to another type of learning.'* (543)

They identified that the VPs felt real and was more useful than classroom role-playing.

Lex: *'I thought it was really good cos then you could look at their expression and then respond to that as well as their answer, whereas we are interviewing each other in class, we don't really act all the time and em, I thought it was a lot better.'* (150)

Samir: *'I did think it was good, it makes you, it acknowledges that you have to treat a patient holistically and they are not just going to come in and, say with a sprained ankle, there is going to be a lot of different things going on in their lives that you need to be aware of and that you need to deal with, so I think it is good in that sense.'* (651)

Table 2: Students' likes of the VP software

Likes
It encompassed the physical and the psychological, treating a patient holistically
It felt real and created emotion
It made you think about the process of interviewing a patient
A good adjunct to usual teaching
Good hearing the voices rather than a typed response
Better than role-playing in the classroom
The visual clues from the video

However, students specifically disliked some aspect of the design; mainly the question menus.

Donna: *'But then it makes you ask the questions that it wants you to ask, do you know what I mean?'* (190)

Ayla: *It is like very prescribed.* (192)

Samir: *Which seems to go against the sort of Masters course that we are doing, this sort of exercise, very prescribed very like here are the answers, whereas we are being taught as Masters students to go and find the answers for ourselves, so it kinda contradicts the programme.* (193)

They wanted to be in control of the interview.

Samir: *'I didn't want to choose any of the options, there's nothing you can do, you have to choose one, so it is not really your interview is it?'* (420)

They also felt that the fact the software told them what was wrong with the patient before the interview was unrealistic in physiotherapy and that the performance feedback was generic and inaccurate.

Table 3: Students' dislikes of the VP software.

Dislikes
Multiple choice question format
Lack of specific feedback
Not being able to see the whole patient
The system told you what was wrong with the patient

The students wanted to be able to control the assessment of the VP by typing in their own questions. Though they felt this was vitally important if a VP was to be used to practise physiotherapeutic patient assessment, they were also somewhat cognisant of the programming difficulties this would entail.

Yvonne: *'I think if there was an option, like I don't know if it is capable of typing it, what you wanted to say and then the computer responded how, the most appropriate response back to what you were saying.'* (86)

They had commented favourably on the fact that the VP software had patients of different ages and wanted a variety of VPs to assess.

Donna: *'It was quite nice to have a go with people different ages as well, cos obviously we are all like a similar sort of age and it was quite nice to interview a 14 year old boy and whatever, I thought that was quite good'.* (106)

Ayla: *'I think that if there were a lot of people it would be handy for us to use on the course, so having someone who is 65 or 87, to someone who is 8, so I think it would be quite handy in that respect that we don't actually have much contact, especially in the first year of like real potential patients'.* (244)

In general they had found the visual and audial aspects of the VP software helpful. It was acknowledged that free-text questions and video clip answers was not practically possible and therefore suggested using an initial video clip.

Mike: *'But if you couldn't combine the two, I would prefer a more texty way'.* (705)

Donna: *'Would it be possible to show a video clip at the beginning, if you are in an outpatient setting, of seeing the patient walk in and you can pick up visual clues from that and then be able to free type'.* (737)

Although the students put usability lower on their list, their comments on the question menus suggested in reality usability was important but integrated in their thought processes with the other features.

Denis: *'Some of the questions I asked, I got back "what do you mean" and I couldn't, there wasn't an option to explain what you meant and then you would say something else and it would be "what do you mean" and then "what do you mean", so then I had to come out of it, because I was going round in circles'.* (161)

The other feature they considered important was feedback on their performance. They were unimpressed with the feedback given by the VP software as they felt it repeated the same generic feedback, however good or bad their interviews were in actuality. Their suggestions for improvement were:

Yvonne: *'To have a history of your conversation' and 'have the profile at the end, to see what you should have got'.* (724)

Table 4: Attributes for a VP resource

Prioritised list of attributes for a VP resource.
The ability to ask own questions
Increased variety of patients
Video of the patient
High usability of the interface
More detailed feedback on performance
Audio of patient

The ideas and issues raised by the students in some instances matched those advocated by the literature; free-text inputting of questions, feedback and multiple patients. The students' ideas along with the findings from the literature on VPs, simulation, and clinical reasoning were considered and, to a greater or lesser extent, incorporated in the design of the physiotherapy VP at Martias.

3.09 Designing a physiotherapy VP

Laurillard (2002) in her work on developing TEL maintained that the key to effective learning design was first understanding the students' needs and motivations and balancing those perspectives with the learning objectives of the programme of study. The inclusion of pedagogical theory into the design of any simulation was considered essential by various leading authors within the field (e.g. Maharg and Owen, 2007; Yellowlees and Marks, 2006). Therefore the pedagogical approach adhered to for the VP developed at Martias was experiential learning theory (Kolb, 1984) as this was aligned with the physiotherapy programme as a whole, as advocated by Boud and Prosser (2002). While there is no identified learning theory complete

enough to guarantee bridging the theory-practice gap the VP design aimed to provide the right content, at the appropriate complexity in an engaging and user friendly way.

Experiential learning theory, as outlined in chapter one, is a holistic model of learning. The process is portrayed as a learning cycle in which the learner; experiences, reflects, thinks and acts, in a recurrent process that is responsive to both what is being learned and the situation it is being learning in (Kolb and Kolb, 2005). The process is highly relevant within clinical reasoning. The VP was designed to facilitate the student using the cycle both as clinical reasoning in the assessment process and as a process for learning to clinically reason. In the former the student is actively involved in the experience of assessing the VP; they gain information from the VP which they reflect on, they integrate this into their previous knowledge to create a hypothesis, then use the hypothesis to make decisions about how to proceed with the assessment and thus they test their hypothesis in experience, continuing around the cycle until they conclude the assessment. In the latter the student is actively involved in the experience of assessing a VP, they get feedback on their assessment performance and reflect on it, they integrate this into previous knowledge of assessment and make decisions on how to improve their clinical reasoning and assessment process, they test these by assessing a VP, continuing around the learning cycle. Through this cycle deep-learning is facilitated by deliberate, recursive practice on areas that are related to the student's goals (Kolb and Kolb, 2005); in this case improving their patient assessment skills before their practice-based learning. The design of the VP aimed to facilitate learning by bringing the thought processes of reflection in contact with the action of experience which the literature had shown to be important in improving clinical reasoning within physiotherapy (Christensen et al. 2008). The VP was developed incorporating several best-practice principles that had emerged within the higher education literature, such as those outlined by Boud and Prosser (2002) for high quality learning design and the principles of good feedback recommended by Nicol and Macfarlane-Dick

(2006). These will be integrated in the discussion of the VP design, later in the chapter.

The VP was designed as an adjunct to the existing curricular teaching of the skills of patient assessment and clinical reasoning. This aligned with the pedagogical concepts of experiential and constructivist learning that the physiotherapy programme adhered to. The programme was delivered at MSc level via a PBL curriculum in which students are expected to be active agents of their own learning. The VP aimed to build on this capacity; an oft cited attribute of TEL was its ability to facilitate practice, at the time, place and pace of the student's choosing (Race, 2005; Laurillard, 2002). Aligned with this the task-performance-feedback cycle, inherent in the VP design, was reported to develop the self-directed learning skills needed to prepare for lifelong learning (Nicol and Macfarlane-Dick, 2006). As a mandatory requirement for physiotherapists to maintain professional registration with the HCPC is the ability to self-direct their learning, developing this skill was essential. To effectively develop as an autonomous physiotherapist it was crucial that students learn to reflectively self-assess their learning. The VP design aimed to facilitate the development of these abilities in physiotherapy students.

Musculoskeletal patient problems were appropriate for the VP as in this area of practice physiotherapists work as sole practitioners rather than as part of a multidisciplinary team, as they would within a hospital ward. Therefore, using musculoskeletal patients within the VP provided an environment that mimicked a real physiotherapy intervention, thus creating a learning activity in which students could rehearse the skills that were typical of physiotherapy professional practice. In the following sections the functionality of the VP is described from the student's perspective and the pedagogical rationale for its design explained.

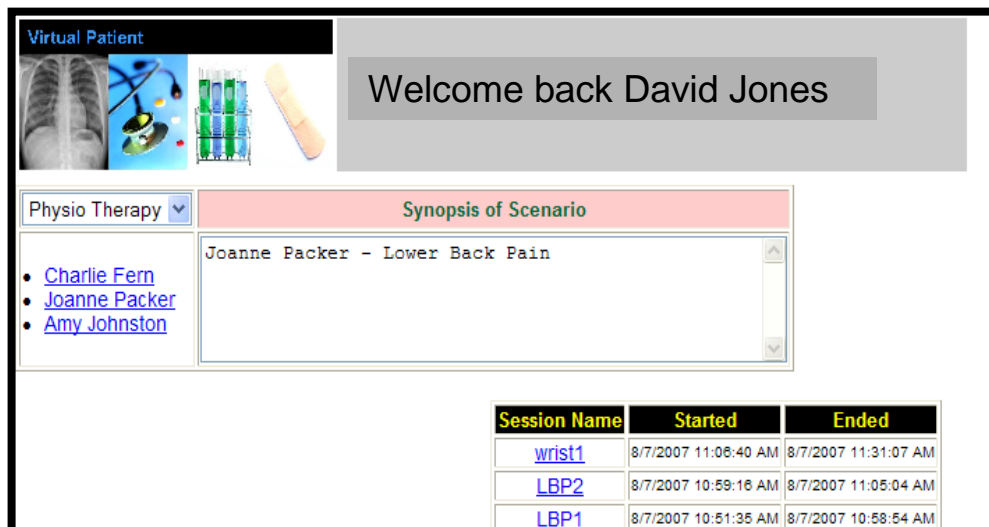
3.10 The VP design

Students had identified a user friendly interface as important in a VP and the design of the VP at Martias attempted to deliver on this. From a student's perspective, the VP could be considered as four functional units:

1. logging in and selecting a patient
2. undertaking a virtual assessment of the patient
3. devising a management plan for the patient
4. reviewing feedback on the patient assessment and management plan

3.11 Logging in and selecting a patient

The student accessed the software via a personal login. The resource welcomed the student and displayed three patient names. See figure 2 The personal login allowed a confidential log of each student's patient assessments which they could review at any time by clicking on the feedback report, these can be seen at the bottom of figure 2 From an academic's perspective the use of student logins enabled the tracking of usage by individual students via the administrator functions.



The screenshot shows the 'Virtual Patient' software interface. At the top left, there is a header 'Virtual Patient' with a collage of medical icons including a chest X-ray, a stethoscope, test tubes, and a bandage. To the right, a grey box says 'Welcome back David Jones'. Below this, there is a dropdown menu set to 'Physio Therapy' and a red header for 'Synopsis of Scenario'. The scenario text reads 'Joanne Packer - Lower Back Pain'. To the left of this text is a list of three names: Charlie Fern, Joanne Packer, and Amy Johnston, each with a blue dot and a link. At the bottom right, there is a table with three columns: 'Session Name', 'Started', and 'Ended'.

Session Name	Started	Ended
wrist1	8/7/2007 11:06:40 AM	8/7/2007 11:31:07 AM
LBP2	8/7/2007 10:59:16 AM	8/7/2007 11:05:04 AM
LBP1	8/7/2007 10:51:35 AM	8/7/2007 10:58:54 AM

Figure 2: The welcome screen

The student selected a patient by clicking on their name. This displayed minimal information on the patient's musculoskeletal problem and ran a short video of the initial patient contact:

- **Charlie Fern**, a teenage boy with a football related left knee injury; his video showed him standing up from his seat in a hospital waiting area and hopping on crutches towards the treatment room (see still image in fig 3).
- **Joanne Packer**, a mother in her thirties with insidious low back pain; her video showed her standing up from her seat in a hospital waiting area and walking towards the treatment room.
- **Amy Johnson**, a lady in her nineties with a left wrist injury; her video showed her opening the front door of her flat to allow the physiotherapist to enter and then walking to her chair. She can be seen to be wearing a splint on her left wrist.



Figure 3. Charlie Fern entering the treatment area

3.12 Pedagogical rationale

At the point of initial contact between the student and the VP several features of the design aimed to increase patient fidelity, to adhere to the concept of real-world learning promoted by experiential learning theory (Kolb, 1984). The videos aimed to achieve some cosmetic fidelity; siting students in a professional context, and giving students a sense of the patient as a real person. During their evaluation of the interviewing software

students had identified visual clues as an attribute and suggested the introductory video. The videos were twenty seconds in length, as Laurillard (2002) maintained that user control is fundamental in interactive media and a video of more than thirty seconds reverts the student to being the viewer rather than the active participant (Laurillard, 1984). The patients were designed to represent common, but varied, musculo-skeletal conditions which students would see in their practice-based learning. The display of only the patients name with minimal information on their problem was realistic for a musculoskeletal setting where patients often self-refer and therefore have no diagnosis. This was suggested as more realistic by students from Martias during the evaluation of the VP interviewing system. The patients all had appropriate personalities with response fidelity. They were developed with different demographics and pathologies that required students to use differing knowledge and skills when interacting with each of them. The literature suggested that the level of fidelity needed to simulate a patient interaction should be real enough to enable the students using it to feel involved in practice and cause the psychological fidelity required to promote professional behaviour (Kneebone, 2003). The focus on demographics and response fidelity aimed to facilitate the student viewing the patient holistically rather than just as a pathological problem. Thereby, endeavouring to facilitate narrative clinical reasoning; incorporating the patient's views rather than centring solely on the students perspective (Jones et al. 2008), thus aiming to replicate practice. It seemed appropriate that the demands placed on students by the VP aligned with the level of learning required and were compatible with the pedagogic intentions. Thus the fidelity was determined by the learning objective, as the goal was to create, not the highest fidelity, but the best learning (Lammers, 2007), although it is acknowledged that resource issues also dictated the fidelity level.

Learning to clinically reason is complex and therefore takes time and practice (Higgs and Jones, 2008). Although not discussed in the literature pertaining to VPs the literature around simulation had shown that optimal learning was facilitated when students began at an appropriate level and

then worked at progressively increasing levels of difficulty via a variety of patients (Issenberg et al. 2005). Thus the virtual patients had varying levels of complexity; the least complex was Charlie, with Joanne being the most complex. Student participants in various studies within the literature had requested multiple patients (Fitzmaurice et al. 2007; Chesher, 2004; Hayes and Lehmann, 1996) and the students at Martias identified multiple patients as important during their evaluation of the VP interviewing software.

3.13 Undertaking an assessment of a VP

When the video finished the screen in figure appeared and the student began an assessment of their patient. The features shown are: **start** which returned to the patient names in order to start again. **Assess the patient:** which returned to the current patient assessment after using other functions such as **review this session**, which showed all the questions asked along with the corresponding answers. **Conclusions and treatment** was for creating the patient management plan, discussed later, and **finish** generated a feedback report on the assessment, also discussed later. The **My notes** section allowed students to record notes on what they thought they should remember to do later, or thoughts on hypotheses etc.

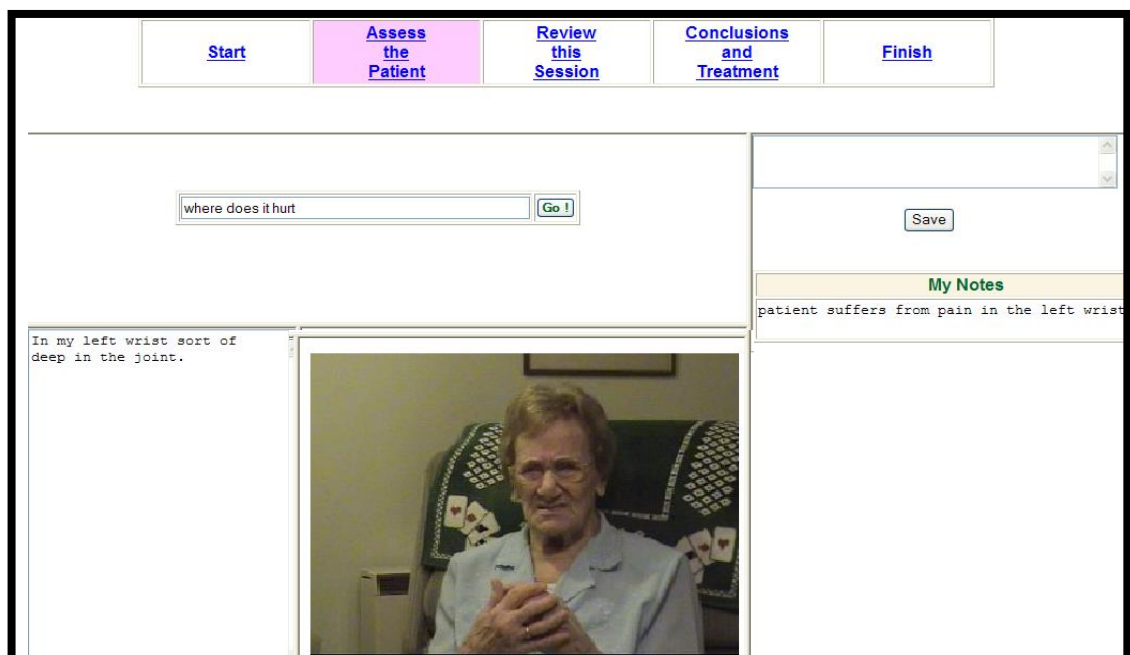


Figure 4: The assessment screen

The student typed assessment questions in the box provided. The computer responded as the patient, displaying the answer in text format accompanied by a photograph of the patient's facial expression; for example if the patient was reporting pain the patient's expression was distressful. See figure 4. This process continued until the student felt they had completed their assessment.

3.14 Pedagogical rationale for the assessment

Consistent with patient assessment in practice, as explained in chapter one, the VP design divided the assessment into subjective assessment and objective assessment. The subjective expected the student to communicate with the VP in lay terms, as they would a real patient. Medical jargon was not recognised by the VP because it is not recognised by patients. This was in line with the training of standardised patients who are not taught medical jargon so they thoroughly replicate a real patient (Ladyshevsky et al. 2000). Questions had to be a complete sentence. Requests of one word i.e. pain were rejected, with the phrase "sorry I do not know how to answer that". However, the VP, unlike patients, could not remember the context of the last question so each question must stand alone. For example: if asked "What is the problem?" and the answer was, "I broke my leg", a second question "How did you do that?" would not be recognised, it would need to be asked as "How did you break your leg?" this did not mimic real life entirely but was necessary due to the programming challenges of using free-text. However, students could phrase questions in a multitude of ways within this remit and questions could be undertaken in any sequence. Although, a logical sequence was perceived as best practice as will be explained later.

During the objective assessment the student typed in the specific examination procedure they wished to obtain the result of. In reality these are not things a student would ask the patient but examination procedures they would carry out on them, therefore the objective used medical

terminology, specifying the test or type of movement, and precise body part, i.e. cervical passive left rotation or right knee Lachman's test. Abbreviations were not recognised by the software as best-practice guidelines within healthcare do not condone their use in patient records. The need for precise instructions to the computer on the test being performed was deemed important in ensuring students were accurate in their learning and usage of physical testing. The use of medical terminology aimed to embed it in the students' knowledge base as they need the ability to communicate these terms both within the written medical record and orally to colleagues.

The integration of free-text questions rather than question lists created a more realistic physiotherapist-patient interaction and aimed to facilitate the learning of the clinical reasoning process as, unlike question menus, the use of free-text inputs meant that the student needed to apply their knowledge and reasoning skills to determine what their next action should be rather than being cued (Chesher, 2004). This required more sophisticated programming but was more authentic. Traditionally textbooks encouraged students to systematically collect a large amount of assessment information before making a possible diagnoses (Round, 2001). However the unreasoned use of data collection routines was impractical within the reality of healthcare practice. Although physiotherapists begin by obtaining fairly routine information that gives initial hypotheses about the patient's problem, there is no preordained script; assessment is an individual process varying from patient to patient (Doody and McAteer, 2002) and from clinician to clinician (van der Vleuten and Newbie, 1995). Facilitating a reasoned assessment was one reason Barrows advocated using standardised patients (Wallace, 1997) and in this vein using free-text question inputting for the VP aimed to facilitate students clinical reasoning skills to decide which questions were the most relevant to ask the specific patient they were assessing and thus preparing them for undertaking patient assessments within the reality of practice.

The students from Martias evaluating the VP interviewing software had disliked the question menus and their top priority for a VP was to assess

using their own questions. Within the literature this view was also reported to be true of medical students (Chesher, 2004; Bergin and Fors, 2003). Free-text inputting also may have relevance as Schitteck-Janda et al. (2004) reported that students using free-text inputting perceived that it caused them to reflect on how they posed questions to patients. This suggested that the use of free-text questioning facilitated learning indicative of Kolb's (1984) experiential learning cycle and Schön's (1996) concept of reflection-in-action; both of which were highly relevant in facilitating clinical reasoning.

During their evaluation of the VP interviewing software the students cited video and the corresponding audio as attributes for a VP and this was a feature of some of the VPs described within the literature (e.g. Fitzmaurice et al. 2007). The resource implications of using video for patient answers with free-text questioning made the two incompatible and students, evaluating the interviewing software, had prioritised the visual over the audio. The use of patient images was deemed important for fidelity within a simulation environment (Maharg and Owen, 2007) and the psychology literature reported that people tend to respond within virtual settings as they would respond to real people with similar characteristics (Dotsch and Wigboldus, 2008). Thus still images were used to give a visual sense of the VPs.

3.15 Devising a management plan for the patient

Once the student felt they had completed their assessment they created a management plan for the patient comprising of a problem list, short and long-term treatment goals and a treatment plan; as they would in practice. This was created in a screen template, figure 5. The template enabled students to input individual points in each section by clicking add after each point to create four lists.

Start	Assess the Patient	Review this Session	Conclusions and Treatment
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<p style="text-align: center; background-color: black; color: yellow; margin: 0;">Problem List</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> <input style="width: 90%;" type="text"/> <input type="button" value="Add"/> </div> <hr/>	<p style="text-align: center; background-color: black; color: yellow; margin: 0;">Treatment Plan</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="background-color: black; color: yellow;">Treatment Item</th> <th style="background-color: black; color: yellow;">Problems(s) #</th> </tr> </thead> <tbody> <tr> <td style="height: 20px;"><input style="width: 95%;" type="text"/></td> <td style="width: 5%;"><input style="width: 90%;" type="text"/></td> </tr> <tr> <td colspan="2" style="text-align: center;"><input type="button" value="Add"/></td> </tr> </tbody> </table> <hr/>	Treatment Item	Problems(s) #	<input style="width: 95%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input type="button" value="Add"/>							
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Figure 5: The patient management plan

3.16 Pedagogical rationale for the management plan

The devising of a management plan was consistent with practice, but with one fundamental difference; there was no collaboration with the patient. This was not ideal as clinical reasoning within physiotherapy is a collaboration process (Jones and Rivett, 2004). However, this was too complex to program. To address this issue in part, and in a manner realistic with the narrative reasoning of practice, the student could ask the VP during their assessment about the activities they wished to resume, so the setting of short and long-term goals aimed to develop the student thinking collaboratively by incorporating the patients answers.

Devising the management plan was a fundamental part of the clinical reasoning process as it involved synthesis of the non-propositional knowledge gained from the patient assessment with the student's propositional knowledge from university-based teaching i.e. anatomy, contraindications to treatment techniques etc. The information gleaned from a patient assessment alone was insufficient to devise an appropriate management plan.

In the literature VP designs used option menus to choose diagnoses and prescribe treatment i.e. Hayes and Lehmann (1996). Though this may well be because the VPs were not physiotherapy specific and medics do not use the same type of patient problem and goal orientated management planning. The rationale for free-text inputting here was based on two findings in the literature. Firstly, research into the testing effect suggested that assessments requiring more effortful written answers generally produced greater learning benefits than multiple-choice tests (McDaniel, Roediger and McDermott, 2007). Secondly, the literature on physiotherapy students' patient assessment suggested that students struggled to clinically reason during patient assessment and therefore could not form a reasoned on-going management plan but tended to guess at treatment interventions (Doody and McAteer, 2002; James, 2001). Therefore the management plan template was designed to enable feedback while giving minimal cueing to the students, as figure 5 shows, only the headings of the four sections were given and an indication that students should have knowledge of the timeframes involved in their plan. It was perceived that this would encourage a more considered approach to creating the plan as opposed to choosing from a pre-prepared menu of choices. Once the student had completed the management plan to their satisfaction the software generated a feedback report on their performance.

3.17 Feedback

The student received the generated feedback instantly on the screen. The report stated the date, time and patient assessed and how long it took to complete the assessment. It stated the normal time allocation for that type of patient assessment within clinical practice. It showed a chronological list of all the student's questions and examinations along with the VP's corresponding answers and it showed any notes that the student made within this sequence. See Figure 6 which shows an edited version of a feedback report (See appendix 8.03 for a full report example). The report also showed the devised management plan with feedback. The student

could print it or email it, and it was saved in their password protected area within the VP software so that they could review it at any time.

<p>User: David Jones</p> <p>Date: 13/03/2008 10:58:37</p> <p>Patient: Amy Johnston - Wrist Injury</p> <p>Session Name: Wrist2 13/3/08</p> <p>Duration: 00:42:04 (As a Junior Physiotherapist, you would normally have 30 minutes to assess this patient)</p> <p>Session Summary: You requested 17 items that were not understood and 36 that were understood. Whilst some misunderstood requests are due to the limitations of the computer program one should try to use clear unambiguous language whenever possible.</p> <p>Standard Protocol Compliance: You did not ask the patient for their consent to be assessed. You did not verify the patient's identity. You did not confirm the patient's current GP. Contacting the patient's GP may be required and this information can also be helpful to keep the patient's records up to date.</p> <p>Timing of Assessment Requests: The sequence in which your Subjective requests were made is consistent with the sequence deemed appropriate by an expert panel. The sequence in which your Objective requests were made is consistent with the sequence deemed appropriate by an expert panel.</p> <p>You requested 1 item(s) which are either inappropriate or potentially dangerous for this patient/condition. Please review your assessment and attempt to identify those item(s). If in doubt, please speak with your tutor for further assistance.</p> <p>Chronological patient assessment</p> <table border="1"> <thead> <tr> <th>Time</th> <th>Request</th> <th>Type</th> <th>Response</th> <th>Notes</th> </tr> </thead> <tbody> <tr> <td>10:13:13</td> <td>Why have you come to physio today?</td> <td>Subjective</td> <td>I'd like to be free of this back pain.</td> <td></td> </tr> <tr> <td>10:13:28</td> <td>Where is the pain</td> <td>Subjective</td> <td>In the left side of my lower back</td> <td></td> </tr> <tr> <td>10:14:17</td> <td>Does your pain come and go or is it constant?</td> <td>Subjective</td> <td>Intermittent I guess</td> <td></td> </tr> <tr> <td>10:14:45</td> <td></td> <td></td> <td></td> <td>Left lower back pain, , intermittent</td> </tr> </tbody> </table>					Time	Request	Type	Response	Notes	10:13:13	Why have you come to physio today?	Subjective	I'd like to be free of this back pain.		10:13:28	Where is the pain	Subjective	In the left side of my lower back		10:14:17	Does your pain come and go or is it constant?	Subjective	Intermittent I guess		10:14:45				Left lower back pain, , intermittent
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Figure 6: Computer generated feedback report

3.18 Pedagogical rationale for the feedback

The literature on feedback was unequivocal; it was essential for learning (Race, 2005; Hounsell, 2003; Laurillard, 2002). The literature on VPs showed that incorporating feedback improved medical students' diagnostic ability (Schwartz and Griffin, 1993) and when evaluating the VP interviewing software students from Martias felt detailed performance feedback was a priority in VP design. However, although recognised as important the specifics of the most effective type of feedback and ways of delivery were unsubstantiated (Issenberg et al. 2005). Therefore, the feedback principles applied to the design of the VP were the general principles outlined for Kolb's (1984) experiential learning cycle and Schön's (1996; 1987) concepts of reflection in and on action as well as drawing on the assessment principles of Nicol and Macfarlane-Dick (2006) and the testing effects reported by McDaniel et al. (2007).

The need for improvements in feedback provision had been a recurrent theme identified by the national student survey and formative computer-assisted assessment (CAA) was acknowledged as a way to increase the delivery of performance feedback to students (Qualifications and Curriculum Authority, n.d.). In this IFS Sadler's concept of formative assessment was adopted 'assessment that is specifically intended to provide feedback on performance to improve and accelerate learning' (Sadler, 1998 p 77). Formative assessment had been shown to have a statistically significant positive relationship with summative assessment marks (Velan et al. 2008) and formative CAA had been shown to improve student learning (Russell, 2006).

Drawing on the assessment principles of Nicol and Macfarlane-Dick (2006), closing the gap between current and desired performance is about providing opportunities to repeat the task-performance-feedback cycle. Through engaging students with accessible formative assessment and feedback geared to providing information about progress and achievement, students can work to improve their performance when repeating the same task, thus

obtaining further feedback which demonstrates whether they have improved their performance or not (Boud, 2000). The VP supported opportunities to repeat the task-performance-feedback cycle, as students could repeat any patient assessment as many times as they wished and gain feedback on every assessment. The feedback aimed to motivate students to undertake another VP assessment and use the feedback to focus their efforts on improving their assessment and clinical reasoning. Nicol and Macfarlane-Dick (2006) report that this use of student centred formative assessment and feedback could empower students to develop the self-directed learning skills needed to prepare them for lifelong learning. This conformed to the need for physiotherapy students to obtain these skills to maintain their registered status as physiotherapists.

The VP provided an experiential learning environment within which students could receive formative feedback both as intrinsic feedback on their actions and immediate extrinsic feedback on their performance. The intrinsic feedback was a natural consequence of their actions as when they posed a question they received a response, if their request was appropriate and accurate they received the required information, if not, they did not. Thus the simulation gave intrinsic feedback on a student's actions which aimed to facilitate Schön's (1996) reflection-in-action. The extrinsic feedback in the report received at the end of the patient interaction was designed to encourage reflection-on-action (Schön, 1987) and enable students to improve subsequent patient interactions (Kolb, 1984). The immediacy of feedback from the VP was deemed important as feedback received within the learning situation had been reported to produce greater learning benefits than delayed feedback i.e. that occurring in tutor marked work (McDaniel et al. 2007).

The feedback given within the VP was based on national guidelines and expert clinician opinion on best practice during the assessment of patients with musculoskeletal problems. The use of expert clinical opinion was the basis for the feedback on VP interactions within medicine (Zary et al. 2006; Chesher, 2004). The computer generated feedback was derived from a

comparison of the student's assessment inputs against desired questions, examinations and management plan data. Butler (1987) argued that commentary feedback without a mark is more likely to motivate students to improve, than feedback with a mark and this concept was adhered to within the VP design. This fits with professional practice where, within patient assessment and clinical reasoning, there are difficulties with absolute right and wrong, as different clinicians collect different amounts of information via different pathways (Doody and McAteer, 2002; van der Vleuten and Newbie, 1995;). For, as previously, discussed clinical reasoning processes are experience dependent as well as patient specific and like much in professional practice are judgement based rather than precise techniques. Therefore the VP feedback could not give the right answer *per se* because there is not one right answer.

To deal with this issue all questions that could be asked of a patient and all examinations that could be requested for a patient were assigned a priority score and a relevance score by the subject expert author of the patient as in the VP developed by Chesher (2004). The priority score indicated within which part of the assessment a particular question should be asked or an examination should be requested. Although there is no absolute order when assessing a patient, assessment should be systematic, and therefore the priority scoring allowed the feedback to advise the student whether their assessment sequence was consistent with the sequence deemed appropriate by an expert. The relevance score assigned by the author of the patient case denoted how important it was that the question or examination was carried out during the assessment. Critical items were regarded as those items that were critical within the assessment of the specific patient, relevant items were considered to be those that were important to know about, but not essential, non-relevant items were those that were not necessary in that particular patient assessment and definite no's should not be undertaken for that specific patient. This allowed the feedback to show the relevance and quantity of questions asked and examinations requested against the total possible questions and examinations deemed appropriate by the expert author. While these discrete categories were used they were

not considered definitive. This reflected the uncertainty inherent in physiotherapy practice and hopefully encouraged meta-cognition.

Table 5: Relevance of assessment requests

	Subjective			Objective		
	Possible	Requested	Remaining	Possible	Requested	Remaining
Critical	20	10	10	35	22	13
Relevant	35	12	23	25	17	8

The report also broke down feedback information into general topic areas and showed the quantity of questions and examinations requested against the total possible.

Table 6: Quantity of requests per topic area

Subjective			Objective		
Topic	Possible	Requested	Topic	Possible	Requested
Pain	12	5	Range of movement	40	25
Drugs	9	4	Strength	30	9
Occupation	5	3	Special tests	5	5

Within a management plan it was important that students had considered not only the pathological problem, but that they had viewed the patient holistically. Acknowledging the views expressed by the patient as well as any relevant psychosocial issues for the specific patient. They should have estimated the likely outcome of the treatment planned and considered the timeframe in terms of their knowledge of the underlying pathological process, healing times etc., as well as any necessary precautions and contraindications to that treatment. The report gave feedback on the management plan advising the student of the number of items they considered relevant for the patient that were also deemed as good practice by the expert. Again this was contentious but reflected physiotherapy practice and hopefully encouraged meta-cognition.

Problem List:

You included 2 out of 5 possible items in your list that were deemed as good practice by an expert panel.

- 1 left lower back pain
- 2 decreased active range of movement in right side flexion

Treatment Plan:

You included 2 out of 6 possible items in your list that were deemed as good practice by an expert panel.

- 1 Stretching right side flexion 4 times daily with 45 second hold
- 2 Stretching into lumbar flexion 4 times daily with 45 second hold

Short-Term Goals:

You included 2 out of 6 possible items in your list that were deemed as good practice by an expert panel.

1. decrease pain in lower back from 6/10 on VAS to 3/10 14 days
2. increase range of movement in right side flexion by 2cm in 14 days

Long-Term Goals:

You included 1 out of 4 possible items in your list that were deemed as good practice by an expert panel.

- 1 to be able to drive for 20 miles without pain in 30 days

Figure 7: Feedback on management plan

There were certain aspects of patient assessment that were deemed necessary for all patient interactions as they adhered to laws or policies and were vital components of safe practice. The feedback told the student whether they had adhered to these expectations e.g. obtaining patient consent for assessment. In addition, if the student requested a 'definite no' this triggered feedback specifying this, suggesting they review their assessment and attempt to identify the item and if in doubt speak with their tutor for further assistance, see figure 7. Thus without giving the student the 'correct' answers the feedback aimed to facilitate reflection and encourage further practise by showing comparisons that helped the student determine whether their current approach to assessment should continue or if some type of change was necessary.

3.19 Beta testing

Once the programmer had created the VP software using the pedagogical design and musculoskeletal content previously detailed. The VP underwent beta testing, as per normal procedure in software development, to test usability and the technological equipment. Physiotherapy students at Martias were invited to be involved in the beta testing of the VP. To enable multiple users hosting of the VP on the server at Martias was requested, however permission to use the server for a bespoke software was declined, so a compromise solution was devised to host the VP on the physiotherapy lecturer's networked personal computer to enable students to access it.

Although the process was part of the evaluation process for the software rather than research, ethical approval was sought and granted from Martias. To attempt to safeguard against students feeling obliged to participate consent was sought. The consent procedures were carried out as detailed for the research described in the next chapter, relevant documentation can be viewed in appendices four and five. Participants were a first year cohort of twenty-six physiotherapy students, who were a year behind the cohort evaluating the virtual interviewing software and a year ahead of those who participated in the later research. All students consented to using the VP and completing a Diagnostic Thinking Inventory (DTI) and 13 students also consented to participate in the focus group. The DTI used was the modified version that Jones (1997) claimed was a valid and reliable measure of diagnostic thinking within musculo-skeletal physiotherapy see appendix 8.06. The purpose of using it in the beta testing was to ascertain whether it was useful in student self-assessment of performance with the VP. Each student completed it independently just prior to using the VP.

The aim during beta testing was for students to work independently using the VP, however, using a computer to host the software prohibited synchronous use by more than ten students. Consequently, less students accessed it independently and the computer repeatedly crashed, so

students worked in groups using one computer. Nevertheless the students spent two hours using the VP while the researcher remained in situ to observe. The following day the researcher facilitated a focus group comprising of seven female and six male students. The focus group was facilitated as described in the methods chapter. This was a large focus group but all thirteen students were keen to be involved and one of the reasons for using the large number of students for the beta test was to gather as much data as possible to aid developing the VP, thus enabling the VP to be refined for future use.

Recorded data from the focus group was transcribed and thematically analysed specifically for themes relating to the usability and development of the VP. Despite the technical issues, data from the focus group revealed that students thought the VP would be a useful adjunct to their studies, though the dominant theme was the problem with the recognition of the free-text questions. Although this issue had been anticipated the scale of the problem had not, but one of the reasons for attempting to have the large number of students use the VP in the beta testing was to gather data on the way questions were asked, thus enabling the programmer to refine the question recognition further and improve the VP. The students identified ideas around usability and development which they thought could improve the VP, see table 7. The programmer endeavoured to undertake the suggested improvements to the question recognition and feedback. However, no further VPs were developed as resources were limited and it was deemed more beneficially to improve the usability of the existing three before creating further VPs. However, it should be noted that the VP software was developed in such a way that subject experts could create VPs using existing questions etc. already recognised by the software.

Table 7: Improvement ideas for VP

Improvement ideas
Improve question recognition
Improve feedback on performance
Add multiple patients of varying complexity across all clinical specialities

The data also showed that students perceived the VP facilitated their learning of patient assessment and the clinical reasoning process. For example:

Fiona: *'Useful to do the subjective objective and then clinical reasoning it kind of gets that more in your head.'* (338)

They liked being able to visualise the patient, thought it was more useful than role play with their peers and more realistic than lectures and paper based PBL.

Leah: *'Especially having that video at the beginning as well because you really saw a patient with something wrong with them. Cos when we practice on each other we are just guessing so it was good to see someone who actually has a problem.'* (75)

They also appreciated the potential ability to use it at times and places of their choosing and at their own pace, as the following quotes show:

Leah: *'Nice to go through the whole thing using your own ideas as when we practice on each other it can stunt your thought process as they come in with their own thoughts and you can think maybe they are right and I'm wrong whereas with the program you can work through the whole thing yourself and you can see that you probably can do it its quite nice to reassure yourself that you can do it.'* (313)

Colin: *'It would be good for clinical reasoning. I suppose once it's made easier and you get the answers from your subjective. I think just cos you have time to think about what different moves are and have an anatomy book beside you and work out what could that possibly mean and you can sit there and work through what it rather than when you are with a patient, it could be useful at home with the computer, your books and figure it out.'* (291)

The general consensus at the end of the focus group was verbalised by one student as follows:

Thomas: *'It's got loads of potential and it's a really good idea just needs a bit of tweaking.'* (647)

3.20 Further VP development

The information collected from the Beta testing enabled further programming development of the VP. Specifically in the recognition of free-text questioning during the subjective assessment and management plan. The way students had worded questions as they tried to illicit subjective information allowed the programmer to increase the diversity of questions the software recognised. The collection of positive feedback from students did enable the researcher to gain permission for the VP to be housed on the university server for the subsequent exploratory research presented in the next chapters.

The use of the Diagnostic Thinking Inventory during Beta testing of the VP demonstrated that the DTI was not suitable for use by pre-clinical physiotherapy students. The wording was reliant on those completing it having had experience within practice and therefore it was discarded from further use as it was not able to measure any changes in clinical reasoning ability or learning within this context.

3.21 Conclusion

At the time this IFS was undertaken the political pressure on HEIs to adopt TEL was considerable, yet the ability to actually accomplish this successfully within Martias was more complex. A number of barriers were identified affecting TEL development and use within the physiotherapy programme. These included; a culture in which TEL remained low priority; illustrated by a lack of funding, time, and development support; low demand for TEL from academics and most crucially, a lack of the skills needed by academics to develop TEL and insufficient provision of staff development or

access to skilled learning technology support staff to remedy this. This limited availability of appropriate resources for TEL causes a 'project' approach to innovation to be adopted to create a bespoke VP. This approach was reported to adversely affect the long term sustainability of innovative practice within HEIs (Moule et al. 2008). However, the dichotomy of the situation lies in the need for robust evidence to demonstrate the value of VPs to obtain resources and funding for development, and the need for VPs to be developed to enable researchers to amass an evidence base to aid the procurement of resources.

The students involved in the development of the VP were positive about the concept and believed it had the potential to facilitate the learning of patient assessment and clinical reasoning. As discussed in the literature review, in order to demonstrate effective clinical reasoning skills a physiotherapist must possess certain key attributes; clinical skill, a sound knowledge base, and cognitive and metacognitive proficiency (Higgs and Jones, 2008). The VP was designed to facilitate these skills in physiotherapy students to enable them to engage with the complexity of practice, drawing on their prior learning to rehearse skills and make clinical decisions before venturing into real practice in their practice-based learning and their future professional careers. The research outlined in the following chapters attempts to ascertain whether this aim was achieved.

4.00 Chapter four: Methods

4.01 Research aim:

The study aimed to investigate the efficacy of using virtual patient simulation to facilitate the learning of patient assessment and clinical reasoning of pre-clinical physiotherapy students, by exploring the usability of a virtual patient simulation. Participants were recruited from a first-year cohort of MSc pre-registration physiotherapy students at one HEI. A case study approach was adopted which enabled various methods of data collection to be employed. The study generated mainly qualitative data, which was scrutinised using thematic analysis while the quantitative data aided the understanding of usage of the VPs. The study design was shaped by the literature review and further developed after undertaking the IFS which helped frame the research questions and identify the methods most suited to answering them.

4.02 Learning from the IFS

Studying the literature surrounding TEL and simulation for the IFS showed that students generally had positive attitudes towards learning with technology. Undertaking the IFS with input from physiotherapy students at Martias encouraged me to hone my research to specifically explore virtual patient simulation as the students were positive about it and thought that it would be a useful adjunct to their studies. However, the IFS had also illuminated the difficulties of being innovative with TEL within the higher education context. Evidence of effectiveness and benefit was required to gain support for the development of TEL. I recognised that ultimately support would only occur if VPs demonstrated improvements for academics and students and thus research with VPs needed to be undertaken.

As well as cementing the decision to undertake VP specific research the IFS identified several issues and factors that caused me to specifically develop and refine my research questions and study design.

Firstly, it established that quantitative data could not be collected on the measurement of change in clinical reasoning ability while using the VP. As the only tool I had located that was claimed to be a valid and reliable measure of clinical reasoning within musculo-skeletal physiotherapy, the modified Diagnostic Thinking Inventory (Jones, 1997), appendix 8.06, was not suitable for use in my study. It was designed for clinicians and therefore was neither applicable to, nor sensitive enough to measure changes in the clinical reasoning abilities of students in the pre-clinical phase of their education. The inability to measure clinical reasoning led to the research question focusing on how the VP could facilitate patient assessment and clinical reasoning, which in turn caused me to use the think-aloud method of data collection.

Secondly, the IFS caused the development of the study design to focus on the usability of VP simulation rather than just the students' usage of it. This was because the IFS highlighted issues related to the three components of usability: effectiveness, efficiency and user satisfaction. The question menus and the poor free-text recognition were dominant themes in terms of user satisfaction and effectiveness. However, the student involvement in highlighting these issues, in itself, showed how important student involvement in the development of simulation was from a usability perspective. This clarified that the study design should collect data on the student participants' perceptions of learning using VPs, from a technological development standpoint and that the data collected would be in-depth data that recorded the participant voice. This framed the research questions and confirmed the use of focus groups and think-aloud as the data collection methods.

Thirdly, the IFS cemented my decision on the educational mode of the intervention as a self-directed extracurricular approach as opposed to an intervention embedded in standard curricular delivery. The students' feedback showed appreciation of the potential ability to use VPs at times and places of their choosing and at their own pace, while the difficulties of

being innovative with TEL within the higher education context confirmed the need for the study intervention to be a self-directed.

Therefore, the IFS assisted in the development of the research questions. However it is acknowledged that the two questions are interlinked, in so far as, the factors affecting the usability of a virtual patient simulation were likely to affect its impact on facilitating the learning of patient assessment and clinical reasoning skills. Conversely, if the use of VPs was not effective in the facilitation of the learning of patient assessment and clinical reasoning this would inherently mean the usability was poor and the VPs at Martias would not facilitate the required learning need and help bridge the theory-practice gap. Thus although the case study was designed to explore both research questions, they were complexly interlinked.

4.03 Research questions:

- Which factors affect the usability of a physiotherapy virtual patient simulation?
- Can using a virtual patient simulation facilitate the learning of patient assessment and clinical reasoning skills to help bridge the theory-practice gap for pre-clinical physiotherapy students?

4.04 Research design:

Historically, there was a strong tradition for research to be guided by the dominant paradigm of positivism both within health (Plummer-D'Amato, 2008) and education (Mertens, 2005). However, contemporary research within both fields now ranges from the positivism of large quantitative studies to determine cause and effect, to those within the constructivist paradigm, that endeavour to explore and richly describe the distinctive experience of individuals within a specific setting (Denzin and Lincoln, 2005). The essence of the constructivist paradigm being that knowledge is socially constructed and a historical product (Miles and Huberman, 1994), as opposed to the single objective reality of positivism (Bowling, 1999). This diversity of research methodologies is unsurprising considering the

complexity that is inherent in both educational and healthcare practice. Understandably this complexity is also true within both the practice and research of healthcare education; with physiotherapy education being no exception.

As previously discussed the physiotherapy programme at Martias adhered to a constructivist learning approach which epistemologically allies with the constructivist research paradigm. That is, meaning is constructed by individuals as they interact with other individuals and/or objects in the world around them (Schwandt, 1997). I am in agreement with this view as my teaching experience has shown that individual students learn different things from the same content delivered in the same way. Therefore, when developing learning resources it is important that all students will learn from it what they need to learn, and thus it is essential to investigate how many different students interact with, and learn from a resource, and obtain their perspectives on that learning. The nature of the research questions reflected this stance as they aimed to explore how multiple students constructed knowledge, and to understand the complexity of their experiences when interacting with simulation technology. My theoretical perspective was interpretivism and this theoretical orientation had implications for the methodology and methods chosen (Mertens, 2005).

4.05 Theoretical framework

It has been claimed that interpretive research is the chosen approach when faced with any of the following situations: a study in a natural setting, the researcher acting as the key instrument, or a study when little is known about the topic and multiple and diverse perspectives need to be explored (Bassett, 2004; Bowling, 1999; Depoy and Gitlin, 1998; Miles and Humberman, 1994). As this study was set within a context encompassing all of the above, the research undertaken for this thesis was interpretive. Several authoritative authors in the area of healthcare education advocate the use of qualitative methods when researching areas that are previously under-researched (e.g. Bowling, 2002). Even advocates of positivism, such

as Cook (2005), suggest that qualitative methods can illuminate the complex pedagogical aspects of using technology within healthcare education. However, although tension between the epistemological positions often focuses on methods, methods are not uniformly linked to paradigms (Hammersley, 1992). This ongoing debate led to the emergence of the pragmatic paradigm which Tashakkori and Teddlie (1998) identify as the paradigm providing a framework for the use of mixed methods. They describe it as presenting a practical and applied research philosophy that eschews metaphysical concepts. However, this paradigm itself is the subject of much debate. Arguably, Mertens (2005) description of the pragmatic paradigm as one in which the methods are matched to the research question, actually should encompass all research.

Although the mixed methods were used in the study described in this thesis, I applied them within an interpretive framework; albeit that they were also pragmatic. My stance is that the division of research into quantitative and qualitative at the level of paradigm or methodology is fundamentally flawed as the distinction applies to the data itself (Yin, 1989) and should not be seen as conflicting but as different positions on a continuum of knowledge (Hammersley, 1992). This stance allows an open mind to the usefulness of various types of data in the building of a rich picture of the phenomenon being explored. This has resonance when exploring clinical reasoning as Edwards et al. (2004) argued that the act of clinical reasoning within physiotherapy is based in both constructionism, and the objectivity of positivism. The former is inherent in the collaborative reasoning patient-centred approach based on patient choices, values and beliefs (Higgs and Jones, 2008). The latter in the undertaking and measurement of objective tests on a patient, the results of which are aggregated and compared to a generalisation of the usual meaning of the findings; a diagnosis. As previously discussed clinical reasoning within physiotherapy involves these processes simultaneously and research into clinical reasoning within physiotherapy is typically interpretive (Patel and Arocha, 2000).

It was argued by several authors within the field of simulation that, specifically when researching its pedagogical possibilities, the choice of research methods can be assumptive and lead to misinterpretation of the real innovation of the approach (Maharg and Owen, 2007). Squire and Shaffer (2006), maintained that the research methodology chosen should not make assumptions about educational concept and context, as the role of such research is not to adapt simulation to existing practices but to explore the transformation of practice. Whitworth (2006) developed a critical methodology for studying TEL in which he argued that the introduction of TEL needed a holistic perspective and participation of students if the nature of the pedagogical effectiveness and the causes of variations in effectiveness, were to be understood. Other authors in this field concur, maintaining that the investigation of the impact of any technology introduced into students' learning experiences require methodologies that are sensitive to the complexities involved (Mandinach, 2005; McAndrew, Brasher and Hardy, 2004; Oliver and Harvey, 2002). Technology has the power to expand the limits of pedagogy, so according to Squire and Shaffer (2006) research should broadly explore the possible future rather than narrowly look at the present and, they argue, this can be achieved by systematic interpretive inquiry. Bearing this in mind, along with the paucity of research in the field of VP simulation within physiotherapy education, an exploratory research approach was deemed appropriate. It aligned with the directives on TEL from; HEFCE (2005) which aimed to promote learning research, innovation and development that began with a focus on student learning, the Department for Education and Skills (2003, p 25) which emphasised the importance of "intensive evaluation of learning experiences to balance large scale studies" and the focus of JISC (2007) which aimed to understand the experience of TEL from the students' perspective. Thus the research strategy chosen adhered to my ontological and epistemological position, the contemporary political drivers and the complexities of the research area. Within interpretivism a number of methodologies are available. In the complex educational context of this study action research or a case study approach were potentially appropriate, as both would involve in-depth investigation of the students' perspectives. However, action research

generally aims to be a catalyst for change, and as the effects of the use of simulation in this context were unknown, investigation was needed before considering whether change was indicated. Thus, the case study approach was chosen; the rationale underlying this decision was firmly based on its compatibility with the research context. As case study was described by Eisenhardt (2002, p 8) as 'a research strategy that focuses on understanding the dynamics present within single settings' and by Cresswell (1998, p 61), as 'an exploration of a "bounded system" or a case over time through detailed, in-depth data collection involving multiple sources of information rich in context'.

4.06 Methodology

The 'case', in case study research, is typically regarded as a specific and bounded, in time and place, instance of the phenomenon. The phenomenon of interest may be a person, process, group, or context (Schwandt, 1997). In the current study the case was; the use of a physiotherapy specific VP by pre-clinical physiotherapy students at Martias. The phenomenon was the potential to facilitate physiotherapy students' learning of musculo-skeletal patient assessment and clinical reasoning.

A case study approach was adopted because it best suited the aim of the study, as it enabled multiple sources of evidence to be used to investigate a phenomenon within a context in which the boundaries between the phenomenon and the context were not clearly defined (Yin, 1989). Stake (1995) emphasised that the foremost concern of case study research is to generate knowledge of the particular, to seek and determine understanding of issues intrinsic to the case itself. However, he also acknowledged that cases can be studied to further understand a particular issue or concept. Case study has many proponents within educational research (Stake, 1995; Yin, 1989) but has tended to be viewed as a poor relation, lacking credibility (Yin, 1993). While this may be partly due to the traditional dominance of positivism, the lack of clarity as to what a case study constitutes is also a factor. Indeed there appears to be a lack of clarity as to whether case study

is a methodology as suggested by Yin (1989) or a method as suggested by Crotty (1998).

Stake (1995) reported that proponents of case study agree that it is not a method *per se* but rather a set of methods that are neither inherently qualitative nor quantitative, he described case study as either intrinsic or instrumental. Undertaking the intrinsic case study the researcher is primarily interested in the case itself with no intention or desire to generalise beyond it. The study reported in this thesis adhered to the instrumental case study approach which, although still the study of a single case, it is driven by the phenomenon rather than the case itself, and it is undertaken with the intent of understanding what the case might infer about similar instances (Stake, 1995). A common criticism of case study research is the lack of representativeness of the case studied (Hamel, 1993), but at the initial exploratory stage of a phenomenon about which little is known choosing a case for its representativeness is paradoxical. The case was not chosen because it was typical within a wider population but in terms of its use to explore the phenomenon (Scott and Usher, 1999), which may then create understanding that can be inferred (Stake, 1995). This is not viewed as generalisation in the statistical sense but rather the desire for an enhanced understanding. An oft-touted criticism of case study research is its limited capacity to make generalisations to a larger population (Hammersley, 1992; Lincoln and Guba, 2000). However, the purpose of using the case study approach was not to generalise findings to a wider population but to explore the impact of VP simulation on physiotherapy students' learning experiences. However, Bassey (1999, p14) asserts that some degree of inference to similar contexts can be made and called these inferences 'fuzzy propositions'; statements of findings given without statistical details, which nevertheless can be applied in a more general sense than only to the specific cohort studied. It is a carefully worded statement of expectation, of how a finding from a specific setting can be transformed into an expectation for a more generalised setting. Bassey (2001) stresses that the exact findings from a case study should be clearly set out, and separated from any fuzzy propositions so that it is clear what has been found for the case

being explored, and what this could mean for other similar contexts. The understanding of the phenomenon from the current case study allowed for some degree of inference to similar contexts which are discussed in the final chapter. Bassey (2001, p 7) suggests that considering the application of the study findings in other practice settings is the 'best estimate of trustworthiness'.

4.07 Trustworthiness

Traditionally reliability and validity have served as benchmarks for rigour within research. 'Reliability is the extent to which a test or procedure produces similar results under constant conditions on all occasions' (Bell, 2005, p 117). Validity incorporates both internal validity; the extent to which a research tool measures what it is supposed to measure, and external validity; which refers to the generalisability of research findings to a wider population (Bowling, 1999). There is much debate concerning their use within interpretive research and when using qualitative methods; as reliability and validity are epistemic criteria (Schwandt, 1997). If it is argued that research findings are valid, it is argued that they are true or certain; thus they sit within the positivistic paradigm. Researchers committed to constructivism reject the concept of unmediated truth and they therefore reject this concept of validity. The debate has led to several different stances on the meaning of validity in interpretive research. Lincoln and Guba (2000) developed alternative criteria for judging interpretive inquiry. However, their initial criteria were criticised for implicitly assuming that research is capable of replication and represents reality; thus fundamentally positivistic (Scott and Usher, 1999). Silverman (1999) argued that accuracy of description is vitally important in qualitative research and Hammersley (1992) adhered to fallibilistic validity; in which validity is understood as a test of whether an account accurately represents the social phenomenon to which it refers, though no claim is made that a valid account is absolutely certain (Schwandt, 1997). Hammersley (1992) proposed that fallibilistic validity should be judged by checking whether an account was plausible and cited various means of establishing this including: triangulation,

member checking, providing fieldwork evidence, and theoretical candour. Again debate ensued.

Triangulation was defined by Cohen, Manion and Morrison (2000, p 112) as 'the use of two or more methods of data collection in the study of some aspect of human behaviour'. This definition fits with the multiple methods of data collection used in the case study reported within this thesis. However, claims that triangulation enables the aggregation of data from different sources to contribute to the reliability and validity of a study again caused epistemic argument (Schwandt, 1997). In fact the very uniqueness of qualitative data could be lost if triangulation was used in this way. Janesick (2000) recommends that triangulation is not used in case study research and Richardson (2000) recommends instead transparency of the many different aspects involved. Precisely stating the theoretical perspective, exactly how data are collected and analysed, the sample and tools used, and not only reporting the results but also explaining how those results were obtained increases the trustworthiness of a study (Bassegy, 1999). The current study is therefore described in detail to increase transparency, making it easier for readers to identify the way the study was undertaken, and to both understand analytical decisions and the study's limitations (Depoy and Gitlin, 1998).

The data collection was all undertaken via computer software records or video recording, thus creating raw data that minimises the influence of personal preconceptions that may occur when a researcher relies solely on field notes (Silverman, 1999). I endeavoured to be rigorous in the interpretation of the data and avoid the use of 'selective perceptions' (Bowling, 2002, p 404). Although it is acknowledged that all qualitative data display some bias as it is impossible, and indeed undesirable, to ensure that the researcher is completely detached from the research (Bassegy, 1999). Gillham (2000) recommends looking at all the data before any assumptions are made, looking for data that does not fit, and considering whether the researcher's preconceived ideas are biasing the data analysis. In the current study, these recommendations were adhered to in that there was

emphasis on not formally analysing the data until all the data was collected to allow exploration of all data sources simultaneously. However, I acknowledge that when I probed for participants to verbalise their thoughts or asked questions to gain more in-depth data on ideas already raised, I was in essence analysing the data in action which, within interpretive inquiry, is accepted practice (Depoy and Gitlin, 1998). However, I tried to avoid drawing conclusions to reduce my pre-conceptions influencing the data collected, although it is acknowledged that potential bias exists as the act of probing can change participants' responses and therefore influence the data collected (Silverman, 1999). I made a conscious effort to use a systematic process to analysis the data and to avoid being selective in the analysis of the data by incorporating reflexivity, as it was important that I acknowledge and subsequently clearly articulate any bias to improve the trustworthiness of the study (Depoy and Gitlin, 1998). It is the transparency of my judgements and reasoning that is important as this allows readers to decide whether the findings are appropriate to transfer to their own context (Scott and Usher, 1999).

The presented case study was procedurally sound, with congruence between the theoretical framework, methodology and methods chosen. There was an identifiable path of investigation that adopted multiple methods of data collection gathered over a period of engagement with the phenomenon followed by data analysis incorporating reflexivity that led to a faithful representation of the participants' views.

4.08 Reflexivity

Researchers using qualitative methods now place more importance on reflexivity which is the 'process of continually reflecting upon our interpretations of both our experience and the phenomena being studied so as to move beyond the partiality of our previous understandings' (Finlay, 2003, p108). It is self-examination by the researcher to determine how their perspective has influenced the research process as although researcher bias cannot be eliminated it can be identified and examined in terms of its

impact (Depoy and Gitlin, 1998). Previous to undertaking this thesis I had worked for sixteen years as a physiotherapist in a variety of clinical and managerial roles mainly within the musculo-skeletal setting. This work involved supervising and assessing many physiotherapy students from many HEIs in their practice-based learning placements both in the UK and abroad. Subsequently I began worked at Martias as a lecturer on the physiotherapy programme. As a clinician situated in the biomedical model of evidence-based practice there was a tendency to think in terms of cause and effect and best practice. Following best practice guidelines and evidence from systematic reviews as best practice, rather than the subtlety but importantly different, practice based on the best available evidence. However, over time, with post-graduate study I developed an enhanced understanding of the nature of evidence and the complexity of the biases involved in various methodologies. I came to understand that knowledge is related to meaning and context and that any situation may have multiple representations dependent on the perspectives of the individual's involved. This applies not only to the participants involved in a study, but to the researcher too. As a researcher I must not simply view the context of my research based on my own assumptions about it, but aim to understand the multiple perspectives of the participants (Silverman, 1999). Research cannot be independent of the researcher as their values and beliefs will shape the research question and methods used as these are dependent on the methodological considerations which are grounded in the researcher's values and beliefs (Mertens, 2005). Usher (1996, p 21) stated that "To know, one must be aware of one's pre-understandings even though one cannot transcend them". Therefore, my responsibility and aim as the researcher was to be transparent about areas of potential bias and this is addressed further within the discussion chapter of this thesis and within the ethical considerations.

4.09 Ethical considerations

Ethics were an integral part of the research planning process. Research must adhere to the principles of beneficence and non-maleficance, treating

participants fairly and with dignity, neither deceiving nor exploiting them (Walker, Holloway and Wheeler, 2005). During this study I was rigorous in the application of these ethical principles. The case study did not involve any aspects that could cause physical or emotional harm to participants and all participants were treated with respect. However, the principles of justice, veracity, confidentiality and consent needed careful consideration as the research participants were students undertaking the programme on which I taught, therefore ethical considerations related to power had to be addressed. Every effort was made to minimise these issues within the research design.

Students were not coerced to participate in the research, although it is acknowledged that they may have felt obliged due to the request coming from one of their lecturers. Doyle (2007) highlighted the socially powerful position teachers occupied in relation to their students, even adult students, and stressed that coercing students into participating in research is unethical. Therefore physiotherapy students may have had difficulty not participating in the current study as they may have considered they would be identifiable by their absence. To counter this it was made clear to the students that there was no obligation upon them to take part and there would be no penalty if they chose not to. An initial email was sent to each student outlining the study and stating that if a student did not wish to participate, or chose to withdraw at a later date, this was without prejudice and they were still free to use the VP involved in the study. In addition, when written consent was obtained students could choose their level of participation, as they separately consented for different data collection methods thus allowing students to participate in all, none, or only some of the forms of data collection (see appendix 8.07).

Participation in the study was confidential. However, anonymity was traded against the methodological decisions to use videoing, software data capture and focus groups as all data collection methods allowed me to identify the individual participants. True anonymity would mean that I would not be able to identify particular participant's responses (Bell, 2005), but, this level of

anonymity would have required that I did not personally undertake the data collection which was both undesirable and impractical within this case study research. My position of power was also considered when choosing the data collection methods. It was considered that focus groups, as opposed to individual interviews, were a way of gathering meeker participants' views as they had the presence of their peers for support (Silverman, 1999). Conversely, focus groups are a less confidential way of gathering participants' opinions but as the topic was not sensitive, confidentiality from peers was not seen as a major issue, although it is acknowledged it may have inhibited some from participating or vocalising their opinions. Within the transcripts, and subsequent data analysis the participants were all given a pseudonym which is used if they are throughout the thesis if they are quoted or represented in tables. Therefore no individual participant is identifiable through the information appearing in the current thesis. A pseudonym was also applied to the HEI, to reduce the likelihood of identifying where the study occurred as naming it could raise issues of anonymity and confidentiality as the number of participants was small enough to make identification of individuals theoretically possible. A formal application for approval was made to the Research Ethics Committee at both Martias, the location of the study and my institute of employment, and at Brunel University, the my place of study. Permission was granted by both committees (see appendix 8.08) and the study complied with all the requirements of the Data Protection Act of 1998.

4.10 Sampling

Sampling was purposive; that is participants were recruited because of their appropriateness for the research (Bowling, 1999), as opposed to the random sampling employed in experimental research. The population was a cohort of first-year physiotherapy students studying on a Masters level pre-registration programme at Martias. The cohort did not differ appreciably in terms of previous academic attainment, gender, ethnicity or age ratios from other physiotherapy cohorts at Martias. It consisted of twenty-seven students all with a previous degree at 2:2 or above; twelve male and fifteen

female. All were aged between twenty-one and twenty-four, bar one female who was thirty-six. One student's first language was not English, all other students were from the UK.

Purposive sampling is often the method used for qualitative data collection methods as it aims to select a sample typical of the population (Stringer, 2004). In this sense the selecting of the cohort was purposive, however, as the study was exploratory there was no basis on which to select typical participants from within the cohort (Judd, Smith and Kidder, 1991). As previously detailed in the ethical considerations the cohort was contacted via email requesting their participation (appendix 8.07) and informed consent was obtained from each participant prior to the intervention (appendix 8.09). Consent was separated by data collection method enabling participants to choose their level of participation. Twenty-six students consented to participate in the study; fifteen female and eleven male. The student who did not consent to participate was absent from the programme for health reasons and subsequently withdrew. The number of participants in the study was relatively small because of the depth of investigation (Bowling, 1999). All participants consented for data generated by using the VP to be used within the study, twenty-three consented to take part in a focus group and eighteen in the think-aloud videoing. Voluntary participation may have caused bias in the data generated as, for instance, students who were more confident may have been more likely to volunteer to undertake a think-aloud session. However, for ethical reasons participants are those who volunteer to participate so this is an acknowledged potential for bias within the interpretive paradigm (Bowling, 1999), but will be discussed in more detail in the discussion chapter. Eighteen students consented to participate in the think-aloud data collection method which meant it was necessary to use purposive sampling as only half this number of participants was required for think-aloud sessions. Having acknowledged that there was no basis to select typical participants, the criteria used were; gender, to create balance, previous academic assessments mark, to look at academic breadth, and propensity to

verbalise, which was imperative for the data collection method and will be discussed further within the think-aloud data collection section.

4.11 The intervention

The study intervention took place in the second term of the first year of the physiotherapy programme as this was when the curriculum taught musculo-skeletal objective assessment skills and linked them to the previously taught subjective assessment skills. That is, the two areas of assessment were combined to teach students how to undertake an effective patient assessment and use it to create a management plan. The study design used self-directed learning as the basis of the intervention, in that the use of the VP was not mandatory; participants were free to spend as much or as little time as they wished using it as an adjunct to usual programme delivery. It was envisaged that students would work independently using the VP enabling them to use it at times and locations of their choosing, as advocated by Kolb and Kolb (2005), Laurillard (2002) and Race (2005). For a three month period the entire first year physiotherapy cohort was given individual password access to the VP previously described in the IFS. The rationale for this intervention type was fivefold:

1. The first reason was pedagogical and built around the concepts of experiential and constructivist learning that the physiotherapy programme adhered to. Within a PBL based curriculum students are active agents of their own learning and the VP aimed to build on this capacity. Especially as one of the key attributes of TEL was cited as the ability for practise, at the time, place and pace of the student's choosing (Laurillard, 2002) and the task-performance-feedback cycle, inherent in the VP design, was reported to develop the self-directed learning skills needed to prepare for lifelong learning (Nicol and Macfarlane-Dick, 2006). This aligned with the both the HCPC (2012) and the CSP (2010) requirements that pre-registration physiotherapy curricular prepare students to be self-directed learners

to meet the professional requirement for maintaining mandatory professional registration with the HCPC.

2. The second related to the findings within the clinical reasoning literature that self-directed reflection is a chief component of improvement in clinical reasoning ability (Christensen et al. 2008) and that this require repeated practice both in and on action (Schon, 1987).
3. The third also related to the requirement of repeated practice within the literature on simulation (Cook et al. 2013; McGaghie et al. 2010; Issenberg et al. 2005). The literature on simulation specifically that based in physiotherapy but across health education as a whole was very unclear on the amount of simulation required. Studies cited represented a range of different settings, interventions and outcomes and were therefore not directly comparable as much appeared to depend on the learning context and the qualities of the particular.
4. The fourth related to the student ideas, collected during the IFS, of how the VP would assist their learning, they suggested it be used as an adjunct to usual study. They appreciated its potential to be used at times and places of their own choosing and at their own pace.
5. The fifth was based on the premise argued by Squire and Shaffer (2006) that research into the mechanisms by which technology affects learning, needs to take place outside of the set curriculum as the role of the research is not to adapt to existing practice but improve it. This concept was also easier to adopt as it bypassed the disinterest of other staff and some of the difficulties of being innovative with TEL within the higher education context. These difficulties have been previously discussed in the IFS.

4.12 Data collection methods

The study involved three methods of data collection which produced four types of data; three qualitative and one quantitative. The multiple methods of data collection enhanced access to the complex phenomenon under study as well as adding rigour to the research design (Denzin and Lincoln,

2005). Often when qualitative and quantitative approaches are combined, one approach is used as a preliminary or follow-up inquiry to complement the principle method of investigation (Silverman, 1999; Tashakkori and Teddlie, 1998). This was not so in this case study, as the quantitative and qualitative data were collected simultaneously.

4.13 Quantitative data

The VP software automatically collected data every time it was accessed and produced an individual participant activity log/feedback report for each episode of use, for an example see appendix 8.03. As previously discussed in the IFS, this captured an accurate record of usage by each participant as it logged the date and time a VP was accessed and for how long, as well as all interaction between the participant and the VP. The detail of the activity logs made it possible to tell the amount of time actually spent on the task of assessing a VP, not just the amount of time logged on to the software. This enabled the case study to capitalise on a source of evidence built into the VP software to gather data on usage. This was important as it gave an accurate record of usage by each participant and eliminated the need to rely on self-reporting. Thus eliminating inherent retrospective self-reporting inaccuracies and the potential bias of self-reporting usage either through inaccurate memory or in an effort to please me as the researcher, due to the power issue previously discussed. The numerical data collected was not intended to be used statistically and demonstrate cause and effect as in experimental study design, but to add to the understanding of the phenomenon under study.

4.14 Qualitative data

The qualitative data collection methods complemented one another, giving me insights into the thought processes of students as they used the VPs, via the think-aloud protocols, as well as retrospectively, via the focus groups which concentrated on the students' perceptions of their learning, thus, seeking understanding of their interaction with the VPs, the impact of them on their learning behaviours and identifying the issues which influenced

their use of them. The think-aloud sessions and the focus groups were video recorded, this created a raw data set that enabled repeated and detailed analysis, minimising the influence of personal preconceptions or analytical bias that may have occurred if I had relied on written field notes (Silverman, 1999).

4.15 Activity logs

As detailed in the IFS qualitative data was automatically collected by the VP software capturing the specific use of the resource by each participant. In chronological order it logged all questions asked and answers given and any notes that were made. The generated feedback report (see appendix 8.03) gave an accurate record of the way a VP was used by each participant. The way the data was collected and displayed in the reports was also useful in verifying and understanding topics that participants raised in the other qualitative data collection methods i.e. the issues around free-text that will be discussed later in the following chapters of this thesis.

4.16 Video: think-aloud

The complex nature of clinical reasoning makes it challenging to study as it involves judgement, experience and knowledge much of which is tacit and therefore not visible. It has been argued that clinical reasoning is only revealed in action, within context (Durning et al. 2011). Therefore data collection needed to take place during the process of clinical reasoning within the phenomenon of study. To meet this requirement I chose the think-aloud method.

The think-aloud method consists of asking participants to think-aloud while solving a problem and then analysing the resulting verbal protocols. It is used in both psychological and educational research on cognitive process and also in the development of computer software (van Someren, Barnard, and Sandberg, 1994). As the case study sought to explore cognitive processes while using a computer software within an educational context the data collection method was the best suited. The method has been used

in studies of clinical reasoning since the late 1970s (e.g. Boshuizen and Schmidt, 1992), and specifically within physiotherapy clinical reasoning research (e.g. Doody and McAteer, 2002). Think-aloud has been used to evaluate the usability of software (e.g. Oliver and Harvey, 2002), within nursing to evaluate TEL (e.g. Cotton and Gresty, 2006), and within medicine to evaluate the usability of a VP by Chesher (2004).

According to van Someren et al. (1994) the method first appeared, in Amsterdam, in the 1930s in the research of Otto Selz who used the think-aloud method to study creative reasoning processes. In the 1940s Groot used the method in his famous study of thought processes in chess and then in the 60s and 70s Elshout used the method in detailed process studies of cognitive skills that were related to general intelligence. The integrity of the think-aloud method is supported by information processing theory (Ericsson and Simon, 1993) which asserts that humans process information using two distinct memory systems; short and long-term memory (Miller, 1956). The content of short term memory is immediately accessible in the minds of individuals because the information is being processed at a conscious level during a specific task. Therefore by having participants verbalise as they problem solve their verbal record reveals the content of their short term memory. Thus the resulting verbal protocol gives direct data on the ongoing thinking process during the task and therefore is used within clinical reasoning research because it captures the taciturn applied knowledge at the time of actual reasoning (Ladyshevsky, 2004).

During the second month of the three month intervention period, nine participants were videoed while using a VP. The participant was free to choose which of the three patients to assess as I was interested in the process of interacting with a VP to carry out an assessment, not in comparing the assessment between VPs. The session took place in my private office on campus with just the participant and myself present. The think-aloud method used in this case study consisted of videoing individual participants as they undertook the specific task under study, in this case assessing a VP. The participant was asked to think-aloud while undertaking

the task, continually verbalising their thought processes. The pure think-aloud method does not involve the researcher probing for more information, as they are considered to be non-evaluative and unobtrusive, however, the use of probing is common if contentious. Probes can focus the participant on aspects of their thinking they may not otherwise have verbalised. This is viewed as a source of bias by some, but is considered by others to accurately access information that the participant was thinking but not reporting (Conrad and Blair, 2004). In the current study there was a need to balance collecting data that participants were thinking but not verbalising with the need to minimise researcher bias. However, a suggested reason for non-verbalisation of thinking is that the participant is finding the problem too difficult to solve and articulate concurrently (Ajjawi and Higgs, 2012; Conrad and Blair, 2004). As clinical reasoning is complex and students find it difficult, valuable data could have been lost without me using probes. Therefore probes around clarification of verbalisation and prompting for verbalisation when the participant seemed uncertain were used as suggested by Conrad and Blair (2004) and van Someren et al. (1994).

When the participant had finished using the VP the video was kept on and they were asked if there was anything else they wanted to say about their experience of using the VP or any other comments they wished to make. The purpose of this was to give the participants an opportunity to reflect on and evaluate the experience as a whole, to point out, for example, strengths and weaknesses or to suggest improvements. Some participants did not comment, some commented on the VP and others initiated a teaching session with me about some aspect of the patient assessment they had not understood. This is discussed further in the next two chapters.

In the context of this study the resulting protocol coupled with the information collected from the interactive resource gave information about the thought processes and clinical reasoning of the student participant that could not be obtained by simply looking at the end product of the patient assessment. It enabled me to see data about the lines of reasoning that were constructed then abandoned throughout the process. Therefore the

think-aloud method is one of the few techniques that gives direct data about the reasoning process capturing the participant's reasons for their actions and interpretations. The data collection time for each think-aloud videoing was dictated by the participant undertaking the VP assessment and varied from thirty-nine minutes to one hour and twenty-four minutes.

4.17 Focus groups

After all the think-aloud data had been collected and towards the end of the three month intervention period focus groups were facilitated. These explored the participants' opinions of the VPs, in particular participants' perspectives on its ability to facilitate their learning, in the assessment of patients, and clinical reasoning. I wanted to allow participants to share their ideas and experiences in their own words rather than answer pre-set questions. To capture this in-depth data, focus groups or unstructured one to one interviews could have been used, as they both seek to obtain detailed information (Stringer, 2004). However, in the context of this case study there were several advantages of using focus groups over individual interviews. Silverman (1999) suggests that the individual interview holds a power relationship that may inhibit participants from verbalising certain perspectives as the interviewer tends to control the flow of the interview. I also believed that focus groups, as opposed to individual interviews, had the potential to encourage less confident students to consent to take part and thereby facilitate the data collected being more representative of all participants. Thus, by using focus groups every participant who wished to have the opportunity to voice their opinions and ideas was able to do so and the data collected included multiple participants' experiences of VP use. The potential for achieving more in-depth data collection was possible via individual interviews, but undertaking twenty-four interviews would, not only have been more time consuming, but would not have tapped into the group interaction that generates ideas as participants respond and build on the ideas of others (Kitzinger, 1995). The two oft-cited negatives of focus groups, as compared to interviews, are acquaintanceship and lack of confidentiality; the former has been argued to disrupt the group dynamics,

while the latter is said to inhibit discussion (Bowling, 1999). However, the participants in this case study were accustomed to conversing in problem-based learning groups, so as the topic was neither sensitive nor contentious the participants' ability to work in discursive groups was useful. The focus groups aimed to elicit a range of views and ideas rather than consensus so the participants' previous experience with PBL helped to achieve this.

Three focus groups were facilitated. Although there is no specified optimum number, Kitzenger (1995) suggested four or five as adequate, but specified that sufficient are needed to reach data saturation, thus yielding sufficient data to give a depth of understanding of the phenomenon. The recommended size for a focus group is six to eight participants with over recruitment of two participants to account for drop-out (Stewart and Shamdasani, 1990). As twenty-four students had volunteered to participate, three groups of eight was chosen as it was felt that groups consisting of less than six participants would not stimulate enough discussion nor give the peer support Kitzenger (1995) believed encouraged less confident participants to verbalise their opinions. The homogeneity of a group also maximises the extent to which participants feel comfortable expressing themselves (Kitzenger, 1995). Within this study the groups were homogeneous in that the participants were all physiotherapy students at the same point in the curriculum. Morgan (1997) suggested that segmentation can be used; that is sorting participants into categories to create groups of participants who may, for instance, have differing knowledge levels. Segmentation was used in this study in so far as group B comprised of participants who had taken part in the think-aloud sessions whereas participants in groups A and C had not. This segmentation was chosen to avoid the potential for those participants who had taken part in the think-aloud appearing more knowledgeable than their peers who had not, and thus stifle the latter's ideas being verbalised. The gender balances in the groups was affected by participant availability: Group A had five males and three females, group B four males and four females, and group C two males and six females. Although it is unlikely this had much impact on these

participants as they were so used to working with each other in mixed groups.

Focus groups were conducted in a communications laboratory that allowed visual and audio data to be digitally recorded. A technician activated and checked the recording equipment and then withdrew. The nature of the room was such that the microphones and camera, although not covert, were unobtrusive, although as argued by Scott and Usher (1999) their presence changes the dynamic of the dialogue moving it from private conversation into the public domain and thus has an effect on the data collection process. What effect it had on the data collected is unknown but it did not prohibit participants from verbalising opinions. An informal atmosphere was created to set the participants at ease as suggested by Kitzenger (1995).

Participants were seated in armchairs around a coffee table with soft drinks, fruit and cakes being provided before each focus group commenced. All focus groups were preceded by a short explanation of the research topic, a confirmation that the video and transcript would be held securely, and assurance that the participants would not be identifiable even though some of what they said may be inserted into the thesis verbatim, this approach was recommended by Carter and Henderson (2005). It was reiterated that the participants could leave the group at any time, and withdraw from the research study at any time, without penalty. Participants were asked to take it in turns to speak because of the difficulties of transcribing simultaneous multiple speech but otherwise no ground rules were stipulated. The focus groups were loosely structured around the overarching research questions, and were designed to elicit participants' opinions and perceptions of the VPs and the ways in which they supported, or not, their learning. Identifying particular aspects of the implementation or the design that helped or hindered learning and finding ways to improve.

I facilitated each focus group in this case study. The facilitator by definition is a non-participant whose role is to facilitate group process and ensure the discussion covers the topic of interest (Plummer-D'Amato, 2008). There is debate in the literature as to whether focus groups should be facilitated by

the researcher or a facilitator unconnected to the study as researcher bias is a potential limitation of the focus group method (Plummer-D'Amato, 2008). Researcher bias can occur when the facilitator imposes a line of questioning or seeks support for a predetermined hypothesis (Walker et al. 2005). It was important to recognise this susceptibility and minimise its effect. However, in this case study my intimate knowledge of the VPs and understanding of clinical reasoning was an advantage as it meant participants' statements could be probed to add depth to the discussion. However, I recognise the disadvantages of this in terms of bias and the limitations of this are discussed further in the final chapter. Plummer-D'Amato (2008) advocates the use of introductory questions to get the discussion started, but as the participants all knew one another and the facilitator, introductions *per se* were not needed. Bearing in mind the issue of researcher bias and the fact the participants were used to working together discursively the focus group began with the topic for discussion being broadly introduced as follows:

Facilitator: *"Thank you for coming. What I would like you to do is just start off by telling me whether you have used the VP , what you thought, anything that you want to say about it and then if I need to get you to tell me about anything that you haven't already told me, I will ask you specific questions, is that OK?"*

Subsequently, I adopted a low-moderator role (Morgan, 1997) which involved using non-verbal prompting and repetition of participants' phrases rather than asking direct questions. Allowing the participants to say and discuss any aspects of the resource they wished, with the me only probing for more depth when necessary for clarity (Depoy and Gitlin, 1998).

One hour is advocated by Bowling (1999) as an appropriate length of time for a focus group but, in each focus group, after approximately forty-five minutes of discussion saturation appeared to have been reached as the participants were repeating previous views and new data was not forthcoming (Kitzenger, 1995). Once saturation was reached I assumed a high-moderator role (Morgan, 1997) and pursued some of the participants'

comments with some informal analysis and supplementary questions that tried to gain more in-depth data on some of the ideas already raised, which although more susceptible to researcher bias (Stewart and Shamdasani, 1990), gave further useful data. This adheres to Depoy and Gitlin's (1998) premise that within interpretive inquiry collecting data is closely linked with the analysis of the data, in that one action directly informs another, and that once immersed in the field the researcher evaluates the information obtained and acts upon it.

4.18 Data analysis

Although it is common in mixed methods research to transform qualitative data into quantitative data, this study used parallel data analysis methods in a complimentary fashion, thus providing a richer understanding of the phenomenon being explored. The study used thematic analysis to explore the qualitative data from both the focus groups and the think-aloud sessions. It also supported this with descriptive quantitative data analysis of data collected in the activity logs via the VP software. This type of parallel data analysis is often used in educational research and fits with the case study approach (Tashakkori and Teddlie, 1998).

4.19 Quantitative data analysis

The quantitative data collected by the VP software was used descriptively to report usage by each participant and thus support the qualitative data; as advocated by Bowling (1999), Silverman (1999) and Schwandt (1997). Statistical analysis was not intended nor undertaken.

4.20 Qualitative data analysis

Data analysis, like all aspects of the research process, was dependent upon the research questions originally posed and the intention to interpret the data to understand the participants' interactions with the VPs and their perspectives on those interactions. There was no standard method for the analysis of qualitative data within the case study approach, making the data analysis a key issue (Silverman, 1999). However, Miles and Huberman

(1994) argued that systematically following data collection and analysis methods helps ensure trustworthiness within a study. To this end data analysis methods used were developed from guidelines in the literature on systematic and suitable ways of interpreting data e.g. Schilling, (2006) and Silverman, (1999).

4.21 Thematic Analysis

The qualitative data collected was analysed using thematic analysis; a method for identifying, analysing, and reporting themes, the formulation of these themes is both an interpretation and representation of key findings from the data (Braun & Clarke, 2006). Two key approaches to thematic analysis have been identified; inductive and deductive (Braun & Clarke, 2006; Crabtree & Mill, 1999). An inductive approach involves the creation of themes which are strongly linked to and driven by the data, while a deductive approach is driven by pre-existing theories (Crabtree & Mill, 1999). I utilised an inductive approach creating themes without explicitly attempting to fit them into a pre-existing theory as there was little existing theory pertaining to the phenomenon under study. A systematic process based on the steps described by Schilling (2006) was adopted, these included; transcription of the data, condensing and structuring the data, building and applying a category system, displaying the data and results for concluding analysis and interpretation. Thematic analysis was used for both the transcripts from the think-aloud sessions and the transcripts from the focus groups. However, the two data collection methods produced different types of data and thus these were analysed as separate data sets. This allowed the study phenomenon to be more broadly explored and recognise differences in themes from the two data types. Nevertheless, inherently the same systematic thematic analysis process was followed and the following sections detail the process employed for both the think-aloud and focus group data sets. Although the two data types were analysed as separate entities they were undertaken synchronously to enable me to obtain a broad understanding of the phenomenon and to prevent the major themes from one data set biasing the inductive thematic analysis of the other data set.

Table 8: Stages of the inductive thematic analysis

Tasks completed
Video-recorded data collection, probing for increased depth of data
Transcription
Iterative reading of transcripts, preliminary interpretation
Identification of units of meaning from transcripts
Units of meaning are identified as descriptive codes
Pattern coding, developed from commonalities in descriptive codes
Emerging themes are identified from pattern codes
Major themes are developed from emerging themes
Linking of codes and themes to literature

4.22 Description of inductive thematic analysis process

Although Schilling (2006) began the process of data analysis at the transcription of data, in reality the first stage occurred while I was collecting the data, as during the focus groups and think-aloud sessions I prompted for more detail or asked for clarification of participants thinking, in essence analysing the data in action. However, I tried to avoid drawing conclusions during this data collection phase to reduce my pre-conceptions influencing the data collected. Although, as previously acknowledged, the potential for bias exists when prompting for more depth of information.

I elected to undertake the transcriptions of the think-aloud sessions and the focus groups myself to enable me to engage with the data in the early stages of analysis. This began once the data collection concluded and assisted me to develop a more thorough understanding of the data which added to a broad development of preliminary descriptive codes at an early stage (Silverman, 1999). Transcription included verbatim actual speech including non-specific verbalised sound i.e. 'erm' and laughter. It also included pauses in speech as these happened often mid-sentence and videos showed these appeared to be participants thinking mid-sentence. I did not tidy up or delete any verbalisations. All transcription followed the

same process as the standardisation of this contributes to the trustworthiness of the study (Silverman, 1999). As an example, the transcript of John's think-aloud session is in appendix 8.12. Having both audio and visual recording enabled me to attribute speech to a specific participant within the focus group data. Thereby, allowing ideas that emerged from the data to be attributed accurately by pseudonym and to understand how often units of meaning were repeated by whom in order to recognise their importance to individual participants and across the participants. The transcripts were read repeatedly to check for accuracy against the video recording and to become familiar with the extent and depth of the data. The understanding and interpretation of the phenomenon emerged in the process of reading and reflecting on the transcripts.

4.23 Generating initial units of meaning

The process of generating initial codes began once I was familiar with the transcripts and had generated an initial set of ideas about what was in the data and what was interesting about it. Codes were identified based on my evolving perception of their relevance and importance in the data. Initially all the transcripts were read and re-read in varying order giving equal attention to each data item. The coding process was carried out manually. Manual coding was employed both as a means to build my understanding of the collected data. using hardcopies of the transcripts (highlighting, note taking and post-it note commenting). A preliminary colour coding of the transcript data was undertaken to identify examples of units of meaning, as suggested by Stringer (2004), and thus emerging codes were identified across the transcripts. These were considered against the transcripts again for transparency and to ensure units of meaning covered all aspects of the transcripts. Schilling (2006) advocated using cross-transcript procedures for analysis, analysing each individual transcript in a chronological way. This may have had a bearing on the units of meaning selected, but was more systematic than dipping in and out of the texts and potentially missing important data. A unit of meaning was a segment of text that was comprehensive in itself and contained one idea, as described by Tesch

(1990). Each transcript was read multiple times to check units of meaning for accuracy and significance within the context of the researched phenomenon and guard against a tendency to select more evident data at the expense of the less obvious (Silverman, 1999).

4.24 Generating descriptive codes

The preliminary development of patterns and themes occurred subconsciously, during the units of meaning phase of analysing the data however once the initial process was completed, the sorting of relevant units of meaning into descriptive codes was formally carried out. The initial units of meaning that had commonality were amalgamated to form descriptive codes. All initial units of meaning were used in the first level reduction of the data. Schilling (2006) advocated being explicit, consistent and transparent when reducing the material. I adhered to this principle as the data was paraphrased and amalgamated to create descriptive codes while preserving its essential content. For this purpose tables were used during the process (see appendix 8.10 and 8.11) as these provided an efficient method to group and regroup data, helping me conceptualise the quality of each code, pattern and subsequent theme and how it related to the phenomenon. Emerging codes were identified and were considered against the transcripts again for transparency and to ensure they covered all aspects of the transcripts.

4.25 Searching for themes

A further reduction of the data was undertaken. The initial descriptive codes that had commonality were amalgamated to form pattern codes. All initial codes were used in the second level reduction of the data however the codes were amalgamated into more than one pattern code if deemed appropriate as suggested by Bowling (1999). The pattern codes were then further clustered and reduced to form themes, again pattern codes were allocated into multiple themes if relevant (Bowling, 1999). This phase had a broader focus directed toward theme generation, as I really began to consider how the coded extracts came together or stood in isolation.

4.26 Defining and naming major themes

The themes were then further clustered and reduced to form important findings for each data set, which created major themes for the study as a whole. These were then reviewed and refined in order to determine their overall coherency and meaning. This reviewing process involved reading the codes which pertained to each theme to determine whether they fit coherently within that theme and then checking the themes themselves to ensure they truthfully reflected the meanings found within the entire data set. Throughout the data analysis I returned to the research questions continually to ensure that the analysis adhered to the questions originally posed and that the emerging themes were embedded in the data. The data was rechecked to look for themes that had not been recognised during the first analysis. In this way the analysis involved a constant moving back and forward between the entire data set, the coded extracts of data and the themes that emerged from the literature. Applying this iterative and holistic approach prevented the development of themes in isolation or themes which pertained to my preconceptions.

4.27 Description of deductive thematic analysis process

The initial inductive thematic analysis of the think-aloud data identified certain codes pertaining to a priori themes identified in the literature review. The literature had highlighted specific core elements of clinical reasoning and clinical reasoning strategies and these were identified prolifically in the initial inductive thematic analysis of the think-aloud data across all transcripts. Therefore, for the think-aloud data a deductive thematic analysis was also undertaken using a frequency count of these a priori clinical reasoning codes. Silverman (1999) considered that counting the number of instances of established codes within the data was an accepted method which compliments other qualitative data analysis demonstrating that the qualitative analysis reasonably represents the data as a whole. The usage of each specific core element of clinical reasoning and clinical reasoning strategy by each participant was established by analysing each think-aloud

transcript several times to ensure the identification of each verbalisation of clinical reasoning was classified using these codes. Each verbalisation was categorised by aligning it with the accepted definitions within the clinical reasoning literature as described in the literature review, endeavouring to ensure the process was consistent in each case. In this way a pattern of clinical reasoning core components and strategies utilised by each participant was established and comparison across participants could be undertaken. Comparison could also be undertaken by specific VP assessed because, as previously explained in the IFS, the VPs were designed with different levels of complexity which the literature suggested affected the clinical reasoning strategy used.

4.28 Summary

To reiterate, the case study reported in this thesis adhered to Stake's (1995) instrumental case study approach, allowing for the use of mixed methods of data collection to capture the comprehensiveness of the case (Bassegy, 1999; Miles and Huberman, 1994). The study approach was selected to construct a multi-dimensional picture of the phenomenon of using VP simulation to facilitate the learning of patient assessment and clinical reasoning, with the objective of making inferences beyond the single case. The findings are presented and discussed in the following two chapters.

5.00 Chapter Five: Analysis and Results

The case study explored the concept of physiotherapy specific, virtual patient simulation as a means to facilitate physiotherapy students' learning of patient assessment and clinical reasoning during the pre-clinical phase of their pre-registration programme. The study design produced a wealth of detailed data to give an in-depth understanding of the study phenomenon; the potential to facilitate physiotherapy students' learning of musculo-skeletal patient assessment and clinical reasoning. As previously discussed the two research questions were interlinked, in so far as, the factors affecting the usability of a virtual patient simulation were likely to affect its impact on facilitating the learning of patient assessment and clinical reasoning skills. Conversely, if the use of VPs was not effective in the facilitation of the learning of patient assessment and clinical reasoning this would inherently mean the usability was poor and that VPs would not facilitate the required need to help bridge the theory-practice gap. Thus although the findings of the case study addressed both the research questions, they were complexly interlinked as they did so.

This chapter reports and explores the study's findings. A summary of the a priori themes from the literature review is followed by presentation of the major themes and important findings extrapolated from the data analysis. These are then discussed in relation to each of the research questions and linked to the existing literature. The findings of the study and discussion of those findings are presented together so that the data and its interpretation remain closely associated. This approach is recommended for case study methodology by both Bowling (2002) and Bassey (1999). The method of data analysis was explained in detail in the last chapter and this chapter does not repeat the analysis process but details of specific coding decisions are shown as the trustworthiness of the study is enhanced by reporting the rationale used to arrive at the major themes (Bassey, 1999). Analysis of the important findings from the data collection methods has been integrated to address the research questions and provide a synthesis of these findings, with supporting examples of participants' remarks and dialogue within the

text. All participants were given a pseudonym which is used consistently for the same participant throughout the presentation of the study findings as an identifier for quotes, along with the focus group (FG) or think-aloud (TA) identifier and transcription line number e.g. (FGB: 345) . The use of segments of conversation rather than isolated quotes was recommended by Kitzenger (1995) when displaying data, as it adds context. This was adhered to as appropriate throughout this chapter and in addition, where appropriate, some findings are presented in tables.

5.01 Key themes from the literature review

The literature review identified some key themes within both clinical reasoning and simulation pertaining to student learning. The key themes within the clinical reasoning literature were as follows:

1. Clinical reasoning is complex; involving the synthesis of knowledge, cognition and reflection. It is, therefore, both difficult to learn and problematic to measure.
2. Patient assessment involves the clinical reasoning strategies: hypothetico-deductive reasoning, pattern recognition and narrative reasoning. Students primarily use hypothetico-deductive reasoning, using less pattern recognition and narrative reasoning than experienced physiotherapists. Students also spend less time on the subjective assessment and more on the objective assessment than experienced physiotherapists.
3. Students struggle to bridge the theory-practice gap and apply the clinical reasoning taught at university during patient assessment within practice. They have trouble with differential diagnosis and have difficulty creating a reasoned management plan. However, students perceive they automatically use appropriate clinical reasoning and do not recognise their own errors.

The key themes within the health education simulation literature including that on virtual patients were:

1. Simulation which includes feedback and the ability to undertake repeated practice improves learning.
2. Students have a positive attitude to simulated patients, including VPs, as they give a realistic patient experience with less pressure than a real patient. Students feel assessing a simulated patient is more useful than other methods of teaching.
3. The use of free-text questioning of VPs is pedagogically superior to question menus but is problematic to program.
4. Using patient simulation improves student confidence in their own abilities irrespective of whether their actual performance improves.

5.02 Key themes from the IFS

The IFS explored simulation further and supported key themes one through three from the simulation literature. It did not explore theme four. However, it also identified:

1. The importance of user satisfaction with simulation as a component of effective learning, specifically around the use of free-text questioning.
2. The importance of the student perspective in the understanding of the usability of VPs.
3. The complexity of initiating the use of simulation within a programme of study.

5.03 Major themes from the case study

The key themes from the literature review and those from the IFS are integrated in the discussion of the study's findings within this chapter and the findings are presented interweaving the various data sources to build up a picture of the phenomenon under study. The findings that emerged from the thematic analysis of the two data sets were analogous, the two data types revealed different emphasises and aspects of the phenomenon. The

focus groups findings showed participants opinions, perceptions and ideas via self-reported data. The think-aloud findings, backed up by the activity logs, showed what the participants actually did and did not do when using the VPs, as well as their thought processes while doing it. However, the think-aloud method also revealed important findings pertaining to the facilitation of improved clinical reasoning and the bridging the theory-practice gap. The important findings from both data sets are detailed below but collectively they create the following major themes that emerged from the case study as whole:

1. Improving the learning and teaching of clinical reasoning in the patient assessment process.
2. Usability of virtual patients.
3. Use of cosmetic and response fidelity to bridge the theory-practice gap

As previously detailed in the methods chapter the transcripts from the think-aloud sessions and the focus groups were thematically analysed synchronously but separately so that differences in emerging themes from the two methods would be visible, the important findings from each data set are detailed separately below and tables detailing the coding process are shown in appendices 8.10 and 8.11.

5.04 Findings from the think-aloud coding

The inductive thematic analysis of the nine think-aloud transcripts, as described in the previous chapter, produced forty-eight initial descriptive codes. These descriptive codes were the amalgamations of units of meaning found in the transcripts. The occurrence of these varied, some were found in every participant's transcript e.g. 'issues with phraseology' while some only in a single transcript e.g. 'time pressure affected use'. The occurrence across the participant transcripts can be viewed in appendix 8.10. The descriptive codes were used in the second level reduction of the data as those with commonality were merged to form pattern codes, for

example, six descriptive codes were merged to form 'fidelity' as a pattern code. The merged codes were 'empathy', 'thinking as if patient is real', 'used VP in the way should assess a real patient', 'including VP wishes in management plan', 'asked VP social history' and 'verbalisation of lack of reality'. Six codes were merged drawing together participants' problems and ideas on the easiness of the VP software to form the pattern code 'ease of use'. The amalgamated codes can be seen in appendix 8.10.

Descriptive codes were amalgamated into more than one pattern code if deemed appropriate as suggested by both Stringer (2004) and Bowling (1999). For example the descriptive code 'Integration of propositional knowledge' was amalgamated into various pattern codes pertaining to the various assessment and clinical reasoning processes as it was considered to be relevant to each. At this stage all descriptive codes were retained. The pattern codes showed that the findings supported a priori themes on clinical reasoning from the literature review and therefore deductive thematic analysis was undertaken. This analysis, as described in the previous chapter, did not in itself produce further themes but did produce important findings on participants' use of the component parts of clinical reasoning and clinical reasoning strategies as identified in the literature review by Jones and Rivett (2004) and Higgs (2003). In the inductive analysis six codes were merged on the use of hypothetico-deductive reasoning, four on the use of narrative reasoning and three on the use of pattern recognition. Thereby, informing the findings on facilitating clinical reasoning in the patient assessment process. This will be discussed in more depth and linked to the literature when addressing clinical reasoning under the second research question later in this chapter.

The pattern codes were further reduced to produce emerging themes and ascertain the important findings, see appendix 8.10. The important findings from the think-aloud were:

1. Usability of virtual patients.

2. Facilitating clinical reasoning in the patient assessment process.
3. Supervised verbalising of patient assessment detects errors in clinical reasoning.
4. Response fidelity bridging the theory-practice gap

5.05 Findings from the focus group coding

The inductive thematic analysis of the three focus group transcripts produced forty-nine initial codes, some of which appeared frequently and across all transcripts i.e. 'lack of recognition of free-text questions', while others appeared less frequently and only in one transcript i.e. 'can make mistakes without hurting a patient'. Thirty-six of the initial codes were apparent in focus group A, twenty-nine in B and twenty-four in C. these are displayed in a table in appendix 8.11. The initial descriptive codes that had commonality were amalgamated to form pattern codes for example; thirteen codes were merged that showed the participants referring directly or indirectly to clinical reasoning into a pattern code, 'VP facilitated clinical reasoning'. 'Better than role play' became a pattern code from the amalgamation of the three codes 'less pressure than role play, not being judged', 'better than each other because gives real information to think about' and 'better than each other because makes you think about pathology'. All codes were used in the second level reduction of the data to create the pattern codes even if only mentioned once by one participant in one focus group i.e. 'can make mistakes without hurting a patient' stood alone in the pattern code of patient safety. Again descriptive codes were amalgamated into more than one pattern code if deemed appropriate as suggested by Stringer (2004) and Bowling (1999). For instance the descriptive code 'Interpreting the video' was amalgamated into the pattern codes 'caused clinical reasoning' and 'the video was useful' as it was considered to pertain to both pattern codes see appendix 8.11 for further detail.

Patient safety was dropped as a code at this stage. Although the literature considered that the use of simulation as a pre-patient experience increased the safety of patients (DH, 2011; Ziv et al. 2005) it was only mentioned once by one participant in one focus group. Suggesting this was either not something the participants had thought of, or not something they thought of as important within the context of the study. Again pattern codes were allocated into multiple themes if relevant i.e. the video was perceived as helpful for clinical reasoning and because of this participants suggested more visual images would improve the VP design, see appendix 8.11. The theme of 'usability' came from the merging of pattern codes, 'issues with free-text questions', 'fidelity', 'issues with technology', 'feedback' and 'the video was useful' then the theme of 'usage' was merged with this to create the important finding 'usability of virtual patients'. The important findings that emerged from the focus groups were:

1. Usability of virtual patients.
2. Facilitating the learning of the patient assessment process.
3. Using virtual patients to improve usual learning and teaching methods.

5.06 Important findings

The first important finding that emerged from both the think-aloud and the focus group data was the usability of VPs. The second important finding from each data set focused on using the VP to learn patient assessment, however they differed in emphasis. The participants' perceptions from the focus groups concentrated more on the patient assessment process while the think-aloud data demonstrated clinical reasoning within the assessment process. The other important findings focused on improving the teaching and learning of patient assessment and clinical reasoning but again, there was a difference in emphasis. The participants' emphasis in the focus groups was on using the VP concept to improve usual teaching and learning methods whereas the important findings from the think-aloud were emergent knowledge within the teaching of clinical reasoning in pre-

registration physiotherapy education. The major themes and important findings are discussed in the following sections addressing the research questions and linking with key themes from the literature review and IFS.

5.07 Usability

Findings from both the focus group and think-aloud data sets, supported by the activity logs, assisted in addressing the first research question: Which factors affect the usability of physiotherapy virtual patient simulation? As previously outlined in the IFS, usability is considered to consist of three components: effectiveness, efficiency and user satisfaction (International Organisation for Standardisation, 1998). The three components are interlinked but inherently, effectiveness refers to the accuracy with which the goals of use are achieved, efficiency is the ratio of resources expended versus achievements gained, and satisfaction reflects users' attitudes to the object of study. In the context of this case study:

- Effectiveness was understood to be the extent to which using the VPs facilitated the learning of clinically reasoned patient assessment.
- Efficiency was the ratio of resources expended and achievements gained. Though it is acknowledged that the study design did not incorporate this beyond perception of achievement gained, as the VP software development itself was not captured within the study design and this would be necessary in ascertaining the resources expended.
- Satisfaction reflected the participants' opinions of the VPs and the VP concept in the learning of patient assessment and clinical reasoning.

Although usability was not specifically referred to by participants, its component parts were and it emerged as an important finding within both the focus group data and the think-aloud data, and thus was a major theme from the study. An understanding of the effectiveness and, and to a lesser

extent the efficiency, of using VPs was essentially addressed by the second research question. Although aspects of effectiveness and efficiency are inextricably intertwined with user satisfaction, many of the findings that led to a better understanding of them are discussed later in the chapter when addressing the second research question. Within the major theme of VP usability, user satisfaction was the most persistently voiced theme.

5.08 User satisfaction

In areas pertaining to user satisfaction the participants expressed their opinions prolifically so there was a considerable amount of data collected on this topic particularly from the focus groups, though to a lesser extent from the think-aloud sessions. Much of it was repetitious but inherently this showed the strength of feeling participants had on this issue, and how they perceived it affected their usage of the VPs and therefore their potential learning from them. Participants' satisfaction was important because research with healthcare students had shown a strong positive relationship between the perceived ease of initial use and the ongoing usage of TEL resources (Wharrad et al. 2005; Lee et al. 2002) and thus ease of use was an important factor if VPs were to facilitate learning. In terms of the case study at Martias the findings showed that participants had a positive attitude to the VP concept as a learning tool. They were positive about the realism in the concept of using VPs and liked the videos and images. They were dissatisfied with the software's ability to recognise free-text and to give them individualised feedback. They made suggestions for improving the aspects they were dissatisfied with to improve the future potential for learning using VPs.

5.09 Recognition of free-text

A key theme pertaining to VPs from the literature was the use of free-text questioning which was believed to be pedagogically superior to question menus but was problematic to program. Lack of recognition of free-text was an issue that had been encountered in the literature, as although few studies exploring free-text VPs existed, within the ones that did, it was an oft

reported cause of user dissatisfaction (Chesher, 2004; Schitteck-Janda et al. 2004). Within the case study exploring VPs at Martias the most prominent cause of dissatisfaction from the participants' perspective was the lack of recognition of their free-text inputting of questions, this concurred with the findings of Chesher, (2004), Schitteck-Janda et al. (2004) and of the beta testing from the IFS. All three focus groups involved much discussion of this issue. Participants voiced their frustration with the lack of recognition of their questions which they perceived caused them to abandon using the VPs. They also felt it adversely affected their learning of patient assessment and clinical reasoning as the following three dialogues demonstrate:

Focus group A:

Gary: The wording is annoying, the way you have to ask certain things, you have to be really specific in what you are asking or else there is no answer to it so you have to be really specific in the way you are asking things and be clear. Like ..., I was trying today as well, and it doesn't give you an answer (FGA: 24)

Facilitator: It doesn't respond at all? (FGA: 29)

Peter: You have to be specific (FGA: 31)

Gary: I mean on a limb, like a knee, I muddled through it, I realised how specific you needed to be and I was able to sort of go through it, but then the back, I asked it for a number of different ways to do a ... and I got frustrated and turned it off in the end. So yeah, the specificness that you had to do was the thing that annoyed me the most (FGA: 33)

Focus group B:

Ann: A couple of questions, it did throw random answers up. I can't remember what [inaudible] and asked it something and got an answer, the

answer was really useful, but it wasn't what I asked it. Oh, that's a good bit of information but I still don't know the thing I wanted to (FGB: 120)

Mark: I had trouble with the ... pattern, it just didn't understand what I was asking (FGB: 125)

Georgina: I did ask about eight times and in the end I gave up (FGB: 127)

Focus group C:

Laura: I was the same. I found the clinical reasoning hard because it didn't understand what I was saying. I would end up getting annoyed and changing onto a total different ... and I didn't get a lot of the objective questions so there was no, that is not how I would normally do it so, I don't know. It's a good idea, it's just that it didn't understand a lot of the time apart from the flexion, extension, you could get, I got it to do that, but a lot of the other things, past medical history, I don't think I got anything on because it just didn't recognise, and that could be been me typing it wrong. (FGC: 19)

Elaine: I agree that it was really good but if you didn't get a question answered the way you wanted it, or if it didn't recognise it and you had tried a couple of times to write that question, you'd just lose patience with it and go off on a tangent and fine something else, which was slightly frustrating but other than that, it worked pretty well as a tool. (FGC: 28)

So participants thought the free-text concept was good but the VPs at Martias did not recognise the free-text well enough and this meant participants' patient assessments, and therefore their clinical reasoning, was less organised and more random than they intended. This affected usability not only from a user satisfaction point of view but also decreased the effectiveness of the VPs as the goal of using the VPs was to facilitate the learning of clinically reasoned patient assessment. Participants'

comments on the free-text recognition suggested it was adversely affecting this goal. The lack of free-text recognition was by far the biggest satisfaction issue for participants that negatively affected usability. However the feedback given by the VP also caused dissatisfaction.

5.10 Feedback from VPs

Participants valued getting feedback on their performance but they wanted the VP software to be able to give them individualised performance feedback on each patient assessment undertaken and their clinical reasoning within it. Participants found the feedback from the VP software unhelpful and wanting more specific detail on their performance. This mirrored the findings of the VP evaluation undertaken in the IFS. The demand for feedback was unsurprising as it had been consistently identified as a prominent theme by the national student survey and its presence in effective simulation learning was a key theme from the literature review. For, as John explains, without feedback learning is not facilitated:

John: Because the programme might make you clinically reason but obviously unless you get some kind of feedback, you don't know if your reasoning is wrong. (FGB: 340)

Participants liked the concept of performance feedback, it was the way the feedback was set up within the VPs at Martias, as explained in the IFS, that participants found unhelpful and disillusioning.

Georgina: Yeah, any feedback is useful There's no point in doing it if, it's pointless doing it if you don't know whether you have done it right but as John said, it wasn't constructive at all, it just made me think oh I have done a really bad job, it was a complete waste of an hour and a half (FGB: 233)

Participants wanting more specific detail on their performance.

Gary: *The feedback's good because you see how much you don't know or how much you didn't ask or should ask (FGA: 238)*

Gary: *It's not as specific as 'you didn't ask this' but it says how many questions in a table (FGA: 243)*

Peter: *not specific enough, I don't think. (FGA: 246)*

Gary: *It just shows that you missed parts (FGA: 247)*

Jim: *But I think it would need to be a lot more specific, maybe you didn't ask this, a really good breakdown of what you didn't ask and what you did ask to take the most from it (FGA: 249)*

Wayne: *Maybe prioritise it as well, you missed a really key question, a must question (FGA: 253)*

Within the design of the bespoke VP software at Martias, part of the problem with giving specific performance feedback was the issue with free-text recognition, especially in the management planning as the participants had to use free-text to create their management plan. The specific detail participants were requesting had been aimed for in the VP programming but had not been achieved due to its complexity. So this lack of feedback adversely affected usability; it not only gave poor user satisfaction but it decreased the effectiveness and efficiency of the VPs as learning tools, as feedback is considered a prerequisite within simulation (Cook et al. 2013; McGaghie et al. 2010; Issenberg et al. 2005) and indeed for any effective learning (Nicol and Macfarlane-Dick, 2006).

5.11 Spelling error

Interestingly analysis of the activity logs revealed that part of the free-text recognition problem could be attributed to poor spelling by participants. The VP software did not incorporate a spell check facility and multiple activity

logs showed repeated spelling errors by participants that lead to a lack of question recognition, for example table 9 below shows an extract of the activity log from Katy’s think-aloud session, in this extract all questions that are not answered by the VP are due to spelling errors by Katy:

Table 9: Activity log for Katy

13:27:38	where is the ap	Sorry, I do not know how to answer that.
13:27:50	were is the pain excatly	Sorry, I do not know how to answer that.
13:28:19	is the pain constant	The pain is constantly there but not too bad unless I lift something
13:29:12	What other things aggrevate the pain	Sorry, I do not know how to answer that.
13:44:13	resited right wrist extension	Sorry, I do not know how to answer that.
13:44:40	resisted right wrist extension	Oxford Scale - 5 Pain free
13:45:05	resisted unlar devation on the right wrist	Sorry, I do not know how to answer that.
13:45:34	resisted right wrist ulnar deviation	Oxford Scale - 5 Pain free
13:46:02	resisited radial deviation on the right wrist	Sorry, I do not know how to answer that.
13:46:19	resisted right wrist radial deviation	Oxford Scale - 5 Pain free
13:47:06	reisisted left wrist ulnar devation	Sorry, I do not know how to answer that.

Poor spelling was not mentioned at all by participants in the focus groups as this did not appear to be recognised as a reason for recognition issues. A few participants verbalised it in their think-aloud sessions i.e. Georgina verbalised corrected herself on a few occasions:

Georgina: OK, erm, “Is the wrist causing you pain?” Don’t understand. Erm, “Does your wrist hurt?” Yep, it hurts a bit now. A bit sore

now. OK, erm, "What type of pain is it?" (Indistinct) "What type of pain, where's it gone, in your wrist?" I keep making spelling mistakes (TA Georgina: 66)

Georgina: Erm, "Do you have any hobbies?" "Do you have (indistinct)" Oh, that's not how you spell hobbies (TA Georgina: 113)

Although Georgina noticed that her spelling was causing her questions not to be recognised by the VP during her think-aloud session, she did not mention this when discussing recognition issues in focus group B. In general participants did not question their own clarity but assumed that any difficulty with recognition was solely due to the VP software. This contrasted with the findings of Schitteck-Janda et al. (2004) who reported that dental students using free-text inputting perceived that it caused them to reflect on how they posed questions to patients. There was undoubtedly an issue in the Martias software with free-text recognition, but the programmed questions for the VPs had been created by an expert musculo-skeletal physiotherapist and had been devised taking into consideration both best-practice subjective assessment questions and each VPs response fidelity. Learning to ask questions in an appropriate way using language that is understood by the specific patient being assessed is part of learning patient assessment and VPs had been used successfully in medicine to teach communication skills (Bearman et al. 2001). However, the issues with questioning the VPs lead to some participants perceiving that the way the questions needed to be asked was unrealistic. Mark for example appeared not to have considered his phraseology may be lacking in some way:

Mark: I am having to phrase things in a way that the computer will understand so it's not really allowing me to practice how I talk to a patient. It is not particularly realistic to life, how you are wording the questions, you have got to word them in a manner that the computer understands rather than wording it how you would to a patient so they understand. (TA Mark: 240)

Mark's focus was on how he wanted to talk to a patient; a clinician centred approach. This concurs with the findings of Wessel et al. (2006), less than half the students they studied used narrative or collaborative reasoning during their first practice-based learning experience. It is therefore possible that for some students, like Mark, interacting with VPs would help their communication skills. If students could be encouraged to reflect on how they communicate and adapt their communication in differing contexts, they could be encouraged to adopt the desired collaborative approach to patient assessment. Learning to ask questions in an appropriate way using language that is understood by the specific patient being assessed could be construed as bridging the theory-practice gap. However, it is acknowledged that this was masked at Martias by the problem with free-text recognition as that was repeatedly referred to by participants and had a substantial negative affect on their satisfaction with the VPs. It did however also lead to various ideas of how to improve VPs to improve learning, and to a few participants reflecting on their performance. These concepts will be discussed later in the chapter.

5.12 Other technology issues

Beyond the free-text issue other topics that caused dissatisfaction specific to using technology were not directly reported by participants except Mary who reported that computer issues had caused problems with her accessing the VPs.

Mary: 'I couldn't get the patient to appear on the screen and I tried it on different computers and that put me off going back to it. (FGC: 70)

Mary: 'I just got the screen and that was it and I tried to unblock it on the computer but it just didn't work and I gave up. Which is really bad, I should have tried but I didn't.' (FGC: 76)

Facilitator: Did you not get to ask any questions? (FGC: 79)

Mary: *I didn't, no.* (FGC: 81)

The initial difficulties Mary encountered caused her to abandon attempts to use the VPs. This concurs with the findings of Wharrad et al. (2005) and Lee et al. (2002) who reported a negative correlation between perceived ease of initial use and further usage of technology in student learning. Usage is obviously an important component of usability as if students do not use VPs they cannot learn from them. The think-aloud sessions exposed a lack of familiarity with the bespoke software. This was unsurprising but had not been addressed in the study design, which was an oversight. During the sessions I had to clarify for all participants at least on one occasion how to interact with the VP for example with Robert and Mark:

Robert: *Err, do I need to run through like THREAD and all that stuff?*
(TA Robert: 59)

Facilitator: *You should do it as you would do it with a patient* (TA Robert: 61)

Mark: *Does it understand a VAS score, it's not even a VAS score it's a numerical rating score. Will it understand a numerical rating score?* (TA Mark: 76)

Facilitator: *No, because the patient wouldn't.* (TA Mark: 79)

Mark: *That's true. Good point.* (TA Mark: 81)

Generally, even though participants were positive about the VPs, they reported finding it challenging to navigate when initially using them. Comments in the focus groups often pertained to text recognition issues but intertwined with this was a lack of understanding that the subjective assessment involved questioning the VPs as a patient in everyday language using sentences as opposed to key word search type inputting. While the objective assessment involved precise commands in medical

terminology. Peter's and Georgina's comments below suggested they felt they learnt how to interact with the VPs relatively quickly. Participants did however suggest improvements which are discussed later in the chapter.

Georgina: Definitely applicable, definitely had positive benefits. I mean there were quite a few teething problems at the start. (FGB: 8)

Peter: I thought the more you practiced on it, the easier it was, you knew what questions you need to ask to get the more points, to get the criteria. The first time it wasn't the best, the second time it got better and the third time, I think I asked more questions and I found that in the subjective, I got more out of it and the objective as well, you know more questions that you need to ask (FGA: 65)

The lack of familiarity with the VP software would have been diminished if an introductory session had been undertaken in a computer lab with all participants present. Contemporary best practice guidance for using simulation in healthcare education advocates pre-simulation preparation of learners in which rules and expectations are explained (Motola et al. 2013). Future usage of VPs should incorporate this.

5.13 Fidelity

The literature on simulation suggested that the level of fidelity needed to simulate a patient interaction should be real enough to enable the students using it to feel involved in practice, with the level of psychological fidelity necessary to promote the learning required (Kneebone, 2003). In general participants at Martias treated the VPs as real patients suggesting their fidelity was appropriate for the learning of patient assessment and clinical reasoning. However, from the point of view of efficiency, the case study findings cannot compare the fidelity of the VPs at Martias to other physiotherapy VPs so it is unknown whether VPs with less fidelity would have been equally effective as a learning tool. Nevertheless, participants expressed satisfaction with the use of videos, they felt the cosmetic fidelity

enhanced the reality of their experience. This aligns with the suggestion in the literature that the use of patient images was important for psychological fidelity in a VP simulation (Maharg and Owen, 2007) and that people tend to respond within virtual settings as they would respond to real people with similar characteristics (Dotsch and Wigboldus, 2008). During the think-aloud participants verbalised empathy for the VP as though real and left objective testing they assumed would be painful until the end of the assessment as should be done in practice, for example David assessing Charlie's knee:

David: So, I'll probably go flexion medial lateral and then do extension last on his affected knee. Poor chap, looks like he's in a lot of pain. (TA David: 574)

The realism of the patients especially due to the videos was mentioned in both focus group A and B.

Peter: yeah that patient is real, you still want to find out the problems. That was my view (FGA: 192)

Facilitator: So you felt like it was a real patient? (FGA: 195)

Peter: Yeah, it's good because it is responding to the questions that you are making so you might expect an answer but it might be another answer, it is good (FGA: 197)

David: I thought the videos were a nice touch....., it's nice to have a bit of an image to go with it (FGB: 194)

However, focus groups A and C revealed that some participants had not seen the patient videos, as the settings of some computers blocked pop-ups which meant the initial patient videos did not play.

Laura: I didn't have a video. I had a picture and text (FGC: 85)

Facilitator: *There is a video. When you go into each patient there is a video at the beginning. But if you have got pop-ups blocked on your PC then you won't get it because it is a pop-up. Did you see the video?* (FGC: 87)

Elaine: *No, I think I had it blocked on mine as well. Because it says you will see a video* (FGC: 91)

This was a usability issue as the participants who had watched the videos thought the VPs were more realistic and more effective in the facilitation of learning to clinically reason because they contained the videos. This mirrored the findings from the IFS, in which, having videos of the VPs was in the participants' list of attributes for a VP resource. In fact the use of the video clip at the start of each VP assessment was an idea that came from the students during a focus group in the IFS. The literature also suggested videos may increase the effectiveness of VPs as within the physiotherapy literature on TEL both Preston et al. (2012) and Davies et al. (2005) reported that students perceived watching videos of real patients increased their confidence for patient interaction once they were in a practice-based learning setting.

Overall participants perceived that the issues with the software decreased the usability of the VPs at Martias but that the VP concept was effective for learning so the technical issues should be worked on.

Georgina: *I think it is definitely worth progressing with it, it is definitely worth trying to get it to that point because it will be beneficial, it is now, we wouldn't say to you give up because it is definitely worth it* (FGB : 598)

Naomi: *I think it helped me* (FGB: 602)

Georgina: *Continue with it and fine tune it* (FGB: 604)

5.14 Usage

However, although participants reported thinking the VP was useful to enhance their learning, actual usage, on the other hand, was low. The activity logs from the VP software showed that its use by many participants appeared to be triggered by the study's data collection episodes, which meant that they accessed it towards the end of the intervention period. Therefore, as the issue with free-text recognition would have only become apparent once they logged on and used the VPs other factors must have contributed to the low overall usage. The detail of the activity logs showed that once logged in the participants spent time on the task of assessing the VP but that many of their free-text questions were not being recognised. Activity logs showed that some assessment attempts were not long enough to actually fully assess a VP and the frustration of free-text not being recognised probably contributed to the termination of the assessment attempts and the lack of subsequent use. The activity logs highlighted that a lack of familiarity with how to formulate both subjective and objective questions to interact with the bespoke VP software was an issue. This stemmed from a combination of factors. It was partly due to the VP programming not being able to understand follow up questions or probes as a human would i.e. 'tell me more about that', but it was also due to participants inputting words as they would in a search engine rather than in a format used when talking i.e. Gary's input of the single word 'work' in table 10 below. As previously stated an introduction session on using the VPs would have potentially diminished this issue.

Table 10: Activity log for Gary assessing Joanne

12:45:10	what is the problem	My low back has been hurting for about 6 months
12:45:26	any past injuries?	Special 'Pronoun Clarification' Response...
12:45:44	pins and needles?	Special 'Pronoun Clarification' Response...
12:46:00	Any pins and needles	No

12:46:10	work	Sorry, I do not know how to answer that.
12:46:35	are you working?	Sorry, I do not know how to answer that.
12:47:04	how did it happen?	Special 'Pronoun Clarification' Response...
12:47:12	what happened?	I haven't been to hospital my GP sent me
12:47:36	why you think you have been referred?	Sorry, I do not know how to answer that.
12:48:03	ppivm	Sorry, I do not know how to answer that.
12:48:24	flexion of lumbar spine	Sorry, I do not know how to answer that.
12:48:35	ap	Sorry, I do not know how to answer that.
12:49:36	paivm for L1	Sorry, I do not know how to answer that.

Gary's comments in focus group A confirmed his frustration.

Gary: I mean on a limb, like a knee, I muddled through it, I realised how specific you needed to be and I was able to sort of go through it, but then the back, I asked it for a number of different ways to do a ... and I got frustrated and turned it off in the end. (FGA: 33)

Usage was an important factor in the question of usability as low usage affects the efficiency and effectiveness of any learning resource. One of the key educational principles identified as leading to effective learning with simulation is deliberate practice, which involves the repeated performance of the skill being learned coupled with corrective feedback and increasing complexity of the learning task (Motola et al. 2013). Thus repeated usage would be necessary. Development of a VP involves the same capital outlay whatever the subsequent usage, thus factors that participants perceived affected their usage were highly relevant.

5.15 Self-directed learning

Activity logs showed that the maximum number of self-directed interactions with the VPs by any student was three, while nine participants did not login

and assess a VP at all, although two of the male participants who did not undertake a self-directed VP assessment were involved in a think-aloud session so did use it. Table 11 illustrates the number of self-directed logins per participant but excludes the think-aloud assessment as this was not a self-directed VP interaction. In the case of Mary, one of the females who undertook no self-directed VP assessment, the focus group data clarified that she tried to log in but was defeated by the technology.

Table 11: Number of self-directed VP assessments attempted

Number of VP assessments	0	1	2	3
Male participants (n11)	4	3	2	2
Female participants (n15)	5	8	0	2

As detailed in the methods chapter when this case study was initiated there was a tendency within higher education, to take for granted students abilities to undertake self-directed learning especially when developing TEL (Stefani, n.d.). The premise at the time was that technology was used to facilitate self-directed learning, offering students the option of time, place, and pace, to maximise learning (Race, 2005; Laurillard, 2002). The theory being that if interactive TEL was supplied students would use it. Participants were MSc students undertaking a programme involving a lot of self-directed study, there was, therefore, an assumption on my part that they would use the VPs. This was both because it would potentially benefit their learning and because they had agreed to be part of the study. However, no participants used the VPs across the three month intervention period. All participants' assessments of VPs were clustered on or around the same date. Three participants Peter, Gary and Julie used the VPs soon after they were given access but then did not continue to do so. Outside of their early usage the patterns of use showed that the majority of participants who used it did so just prior to their focus group or think-aloud session, suggesting that the study's data collection episodes triggered their interaction. Only one participant, Ann, used it after the data collection session she was involved in, even though all participants had access to the VPs for some time post

data collection. This pattern of usage did not adhere to the suggestion in the literature review that students would use available TEL resources for self-directed learning (Race, 2005; Laurillard, 2002) as although some participants reported liking the ability to use the VPs alone at their own pace they did not actually do so. Despite the quote below David undertook no self-directed VP assessments and Eliza used one VP once.

David: *It is really convenient as well, you can literally sit at your computer at 11 o'clock at night and so it is quite nice in that sense (FGB: 610)*

Eliza: *I definitely think that as well as being a good revision aid to use in your own time (FGA: 585)*

5.16 Time

Time pressure was mentioned by participants in the focus groups as a factor for their lack of use. Gary was one of the participants who used the VPs early in the intervention period but then did not use them again. He explained his reasons for not continuing to use them:

Gary: *I definitely didn't learn everything that I could have learnt from it. Using it a few times would have definitely highlighted some things I was missing. The frustration was part of it, but time, I didn't really have the time, doing a lot of coursework (FGA: 147)*

John reported during his think-aloud session that he had not used the VPs very much due to the pressure of other mandatory work within the programme, but that having used one he thought the VPs would help with the relevant mandatory learning. This suggested he perceived the VPs did facilitate the learning of the patient assessment skills he would need for his viva.

John: *'I think it certainly helps 'cos it, by doing it all kind of long hand, and having to think, it does make it sink in a bit more and stuff like that and it helps. And, I am really struggling just with all the VIVA's and stuff at the moment. I am, I feel like I'm struggling quite a lot worrying about different patients and I do think this, if I can use this more, it will help.'* (TA John: 363)

5.17 Improving learning and teaching with VPs

The various satisfaction issues led participants to suggest improvements to the VP design to increase usability. These suggested improvements also sit within the major theme of improving the learning and teaching of patient assessment and clinical reasoning that emerged from both data sets. The findings from the focus groups showed that the participants liked the VP concept and wanted the VPs at Martias improved to increase their ability to facilitate learning. They were generally in agreement that improved free-text recognition would enhance the usability of the VPs.

Naomi: *But if the programme was improved so that it would recognise your answers, makes asking the questions easier, rather than, it took about five attempts to get the answer out of it, but if the programme changed and you could ask it a few ways and it would pick up keywords, having a more complex situation you will still get the answers out of it if it was just developed a bit more* (FGB: 477)

Participants wanted to be in control of how they assessed the VPs. To this end some participants suggested a menu of questions could be used instead of free-text:

Julie: *It might be useful if there was an option you could select, saying, instead of typing in something, you could select a pre-phrased question, so say like you click on treatments and it comes up with a list of back treatments and you can select* (FGA: 39)

Charlotte: *When you are doing the objective thing, there could be buttons that say rather than having to type out, which could speed up the process of doing it (FGC: 9)*

The menu suggestion reflected the literature's reports of VPs in medicine that had tried to incorporate only free-text questions to minimise student prompting but due to recognition issues had resorted to incorporating list-based questions e.g. Chesher, (2004). Chesher noted during his observation of participants in think-aloud sessions that most started by trying to use the free-text method of asking questions but resorted to the question lists in frustration. The students from Martias who evaluated question-menu based VPs for the IFS had adamantly disliked the question menus. They perceived that as an assessment method question-menus did not allow the user to control the VP assessment. Bearman (2003) also reported that medical students found picking from a pre-set list of questions artificial and frustrating.

Participants wanted improved feedback on their performance. Again, as already stated, part of the problem with the feedback was the issue with free-text recognition especially in the management planning. The participants liked the general concept of performance feedback, but like the students from Martias who evaluated different VPs for the IFS, it was the lack of specific detail they took issue with.

Gary: *It is good that it gives you an obvious way to do a treatment, so it has the goal setting, the treatment plan, but it would be good to know whether that is good or not (FGA: 57)*

Ann: *It would be good to highlight the bits you had not done enough in, rather than just give us, vague areas, show us which areas our strengths are in, what we can focus on more (FGB: 238)*

Although participants wanted improved feedback on their performance there was no general consensus on how to achieve this. However, during focus

group B the participants who had been involved in the think-aloud sessions discussed the usefulness of verbalising their thought processes and being questioned on them. Several participants initiated a teaching session at the end of their think-aloud, questioning me on answers gleaned from the VP they had not totally understood or areas of propositional knowledge they were unsure about. They liked the immediacy of the individualised feedback they received from doing this. Thus the think-aloud sessions led to suggestions that the VP interact with the student user in a similar way, to increase learning, in that the software would probe clinical reasoning to increase reflection in action as well as giving individual performance feedback. The programming difficulties of this were not discussed.

Naomi: It did make you think about what you were doing and what you needed to do next, when you did the video, you were asking me why are you doing that, so maybe if the computer could somehow, like the discussion stage at the end of your exam, why did you ... range of movement, and you have to say I did that because, just highlighting it a bit more rather than in your own head, right I'm doing this because I need to make sure what they can do on their good side, maybe sometimes the computer can ask you (FGB: 306)

As previously discussed participants found the initial videos of the VPs useful and suggested using more videos and images within the objective assessment to show pertinent information such as posture or range of movement. The think-aloud had captured the participants using the video as part of their clinical reasoning of the patient assessment, these examples show Robert assessing Charlie, and Naomi assessing Amy:

Robert: Err, on the video it looked like his crutches weren't the right height. (I'll check it again actually) and obviously not weight bearing on his left leg. (TA Robert: 8)

Naomi: *So, I am just watching the DVD as she has let us into the house and I could see that she was supporting her wrist and tripped over a dog.* (TA Naomi: 5)

Therefore the participants' wanted more aspects of the patient encounter to be captured visually to enable them to clinically reason via observation of the VPs ability to move and function.

David: *I thought the videos were a nice touch. I thought the pictures, you type in 45° flexion, you see his arm do that, it's nice to have a bit of an image to go with it* (FGB: 194)

Georgina: *The way they are doing it as well, if there are doing it tentatively or if they are, it depends, that kind of stuff* (FGB: 197)

Ann: *Do it that way, you may not need to ask it as many or as specific questions, if you have a little video rather than having to find a way to say how was the quality of the movement* (FGB: 200)

An improvement suggested by the participants that had not been discussed in the literature was incorporating the documentation of patient assessment into the VP learning experience. The VPs had a way for the participants to type in notes as an aid memoir, which was used but found wanting:

David: *The notes on the side, it would be nice if like the whole box was there. I keep having to scroll up and down to see what I've asked.* (TA David: 392)

Participants found making notes useful but they wanted to be able to document their assessment in a more structured way.

Peter: *Also, I thought it was good how you could save your notes, that was good, it could be a bit more structured, the notes section, you*

could do a bit more in terms of getting it like you have subjective or objective. (FGA: 44)

There were three aspects to this:

1. Some wanted it to aid their memory of the questions they had already asked and had answered to support their ongoing assessment structure.
2. Some participants felt a form that prompted their assessment process would be helpful.
3. It was also acknowledged that incorporating the writing of accurate patient documentation as a medico-legal record would be useful.

As this discussion from focus group B demonstrates:

Robert: The only thing I found difficult was remembering which questions to ask in the subjective, so when we got to after the objective, there were columns to put in your treatments goals, so perhaps a set up for the subjective assessment so that, social history, you have got to ask all those questions, a box to write all the answers in there, just like what we get in the viva, just like a blank sheet of paper with the different headings to remind you or what you get on placement (FGB: 250)

Naomi: So you mean having a form on there so you can write on there that is a good (FGB: 257)

John: That's not necessarily real, that's why a lot of the time we don't get it in class, and didn't they say that you might go on placement and they say right, go and do a subjective assessment and they don't necessarily have a form (FGB: 259)

Naomi: *But you still have to ask all those questions. You'd have to do past medical history, social history, your investigations, so at least having something as a reminder* (FGB: 263)

Robert: *I find it hard doing it on a computer screen, if I could write something down then it makes it a lot easier* (FGB: 268)

John also indirectly acknowledged that incorporating the writing of accurate patient documentation as a medico-legal record would be useful in bridging the theory-practice gap. Ann had improvised and handwritten her patient documentation as would usually happen in practice. Including this as part of a VP interaction would be useful in helping to bridge the theory-practice gap in the skill of completing accurate patient documentation as a medico-legal record.

Ann: *I did that when I was with Tracey being videoed but when I have done it again at home, you know the sheets we were given in the exam, I used that, I practiced that, then I didn't forget what I had done.* (FGB: 82)

Naomi: *I think that was the difficult bit, writing it down is a good idea* (FGB: 87)

Ann: *It made me practice that as well* (FGB: 89)

5.18 Summary of findings pertaining to usability

The findings showed that the VP concept was appreciated by the participants but the VP software used at Martias had both shortcomings and attributes which affected its usability. The findings that negatively affected user satisfaction and effectiveness, and therefore usability were:

1. The interaction difficulties, specifically with the free-text recognition but also a lack of spell check and lack of familiarity with the software.

2. Inadequate individualised performance feedback.
3. Inadequate embedding of the facility to practise patient documentation.
4. Participants reported a lack of time to undertake VP assessments as they were non-mandatory learning.

The finding that positively affected user satisfaction and effectiveness, and therefore usability was the realism of the VPs, especially their cosmetic fidelity, via the videos, and their response fidelity.

5.19 Research question two

The second research question addressed was: Can using a virtual patient simulation facilitate the learning of patient assessment and clinical reasoning skills to help bridge the theory-practice gap for pre-clinical physiotherapy students? Despite the low usage of the VPs the data collection methods enabled the second research question to be answered as findings showed that using a VP could facilitate the learning of patient assessment and clinical reasoning to help bridge the theory-practice gap. The focus group findings showed that participants perceived that the VPs facilitated the learning of patient assessment and clinical reasoning while the think-aloud data demonstrated that it did. In all three focus groups participants verbalised that the VPs facilitated clinical reasoning and helped to cement the patient assessment process, the caveat to this being that this facilitation would be vastly improved by improvements in the free-text recognition of the VP software they were using. However, all participants who voiced an opinion were generally positive about the concept of VPs as a learning tool and important findings from the think-aloud and the focus group data analysis both pertained to facilitating the learning of patient assessment and clinical reasoning. Findings from the think-aloud data showed that assessing the VPs facilitated participants clinical reasoning and bridging the theory-practice gap in several ways and the focus group findings showed the participants were somewhat cognisant of this.

5.20 The assessment process

An important finding from the focus group data showed that the participants saw using the VPs as a way to practise their assessment process to improve their assessment skill, especially for summative assessment vivas and for assessing real patients in practice, for example:

Naomi: I did think it was useful towards helping for the viva and stuff, just making you think, but also the process (FGB: 129)

Eliza: It is good in that it pulls everything together in one. When we have done our vivas and stuff, mostly so far we have just done certain areas, this area and then that area but it is good for pulling everything together and just refreshing your mind and revising the whole situation (FGA: 210)

Participants discussed patient assessment using the terminology associated with its component parts i.e. subjective and objective, and frequently referred to practising the assessment process. The concept of using patient simulation for repeated practise to improve skills tallied with a key theme from the simulation literature (Cook et al. 2013). The findings also revealed that the participants thought there was value in doing a patient assessment with a VP over and above the usual teaching methods of lectures, role play and paper-based PBL. This finding concurred with a previous study undertaking with physiotherapy students using a high fidelity mannequin (Prybylo and Conner-Kerr, 2012) which showed that students preferred the mannequin over role play and lectures, as they felt it was more realistic and facilitated better learning. It also concurred with the findings of the IFS in which students saw the benefits of VPs over roleplay.

Jim: I think you learn more when you go through and do it anyway, so doing it on the online, actually going through and doing it rather than just talking about it in class or something like that, you're going through it, you are doing it step-by-step, you are going to take more from it (FGA: 566)

The concepts of patient assessment and clinical reasoning are interrelated, however they are not mutually interchangeable. Patient assessment is possible, though not desirable, without incorporating clinical reasoning. However, the focus group findings suggested that participants assumed they automatically used appropriate clinical reasoning during patient assessment. This concurred with a key theme from the literature (Wessel et al. 2006).

5.21 Facilitating clinical reasoning

An important finding from the focus group data showed participants perceived assessing a VP helped them practise their clinical reasoning while the think-aloud findings revealed that using a VP did facilitate participants' clinical reasoning. To a greater or lesser extent all observed participants demonstrated clinical reasoning while using a VP. The think-aloud findings also illuminated how they were using clinical reasoning, while the focus group data showed that they were cognisant of using it in a practical if not theoretical sense. During the focus groups participants did not mention clinical reasoning strategies i.e. pattern recognition or hypothetico-deductive reasoning, and in fact talked about clinical reasoning itself rarely. However, without using the theoretical terminology they discussed their use of clinical reasoning repeatedly within each focus group. For example, without naming it, Steve talked about his use of hypothetico-deductive reasoning:

Steve: Yeah, you sort of have like a list of things in your head that it could be and you go through what one of those it is, I think that is how I look at it, you think OK, it could be think, this or this, so you pursue one route, right, that has not happened, come back, right what is the next one on my list, that is how I would tend to do it. (FGC: 125)

In the following quote Ann refers to clinical reasoning directly and its importance in carrying out an effective assessment.

Ann: I think one of the ones I viewed, it was the wrist fracture one ... it was definitely making me think a lot more, well why is it that, because if I know that, then I know to ask that question, I think it would be, so I want to ask that question, just to compare if that backs up by what I think already. I think if you don't clinically reason, you can't decide where to go to next, it's a bit haphazard. (FGB: 300)

5.22 Clinical reasoning strategies

So the focus group findings showed that participants recognised they were using clinical reasoning while assessing a VP but the think-aloud data was fundamental in understanding how interacting with the VPs facilitated clinical reasoning, and the nature of the clinical reasoning it facilitated. Findings showed that all three types of reasoning suggested by Jones et al. (2008) as present in the assessment of a patient; hypothetico-deductive reasoning, pattern recognition, and narrative reasoning were used by participants. There was however, variance across participants in the types used and frequency of use. All participants predominantly used hypothetico-deductive reasoning. The much higher use of this reasoning strategy adheres to the literature on novice clinical reasoning which consistently reported that students tend to use hypothetico-deductive reasoning rather than the pattern recognition approach of experts (Patel and Arocha, 2000; Jensen et al. 1990). Findings reported in the literature review also highlighted that students focused on a clinician centred hypothetico-deductive reasoning process rather than a patient centred narrative reasoning process (Cruz, Moore and Cross, 2012; Wessel et al. 2006; Doody and McAteer, 2002). Although the data from the current study supported this, of the nine participants, eight did include narrative reasoning within their assessment, and two used pattern recognition. Table 12 shows the use of the three clinical reasoning strategies by frequency for each participant. It also shows which VP was assessed by the participant.

Table 12: Clinical reasoning strategies by frequency

Participant	Patient	Hypothetico-deductive reasoning hypothesis verbalised	Pattern recognition verbalised	Narrative reasoning verbalised
Robert	Charlie	1	1	2
David	Charlie	1	1	4
John	Charlie	4	0	2
Katy	Amy	7	0	0
Naomi	Amy	6	0	2
Georgina	Amy	11	0	3
Carol	Amy	10	0	1
Ann	Joanne	9	0	7
Mark	Joanne	11	0	4

5.23 Hypothetico-deductive reasoning

All participants used hypothetico-deductive reasoning and verbalised hypotheses, though the frequency varied. The two participants who verbalised pattern recognition verbalised less hypotheses than those who did not verbalise pattern recognition. In order to create a hypothesis participants needed to integrate their propositional knowledge with the information they were eliciting from the VP they were assessing. All participants verbalised doing this however they also all demonstrated that their propositional knowledge was insufficient on occasions to evaluate the responses given by the VP. Therefore, they could not always confirm or refute their hypothesis. The occurrences of this varied across participants but the finding mirrored those of studies undertaken by Wessel et al. (2006), Doody and McAteer (2002) and James (2001) which all reported that physiotherapy students struggled to clinically reason during patient assessment and could not interpret all the information gathered so disregarded hypotheses without confirming or refuting them. This in turn meant students had difficulty creating a reasoned management plan and tended to guess at treatment strategies. The data collection at Martias supported this finding as all participants had difficulty creating a totally reasoned management plan and guessed at some treatment strategies or goals. Six of the participants verbalised this lack of knowledge when creating a management plan for their assessed VP. This use of reflection on

their own performance is discussed later in the chapter. The difficulty with creating the management plan from the data gleaned without sufficient propositional knowledge caused several participants to initiate a teaching session with me at the end of their think-aloud session. Again this will be discussed in more detail later, but the dialogue below from the end of John's session typified the guessing of treatment strategy reported by Wessel et al. (2006), Doody and McAteer (2002) and James (2001) as John's treatment plan for Charlie was not completely clinically reasoned and based on a full understanding of Charlie's problems.

Facilitator: *and that was the other thing, when you said you were going to do strengthening exercises* (TA John: 402)

John: *Yeh* (TA John: 404)

Facilitator: *but you haven't got any weakness on your problem list.* (TA John: 405)

John: *Oh, right, yeh* (TA John: 406)

Facilitator: *So, why do you need to strengthen something, if you don't know it's weak, because you didn't do any muscle testing?* (TA John: 411)

5.24 Pattern recognition

As pattern recognition is associated with expertise (Patel and Arocha, 2000) its use by two participants was interesting. Both assessed the same patient, Charlie Fern, who was the least complex patient and reported his football injury in a way that was likely to cause an experienced physiotherapist to use pattern recognition, as he had a common injury sustained in a formulaic way. Both participants, Robert and David, reasoned that the injury was to the medial collateral ligament early on in their assessments when Charlie recounted the mechanism of injury. This diagnosis was, in fact, correct but they failed to use differential diagnosis techniques sufficiently to exclude

fully other structures which could well have been involved. Jones et al. (2008) reported that a common cause of error in clinical reasoning was caused by overemphasis of findings that adhere to a preferred hypothesis based on pattern recognition. Interestingly pattern recognition was discussed at length by participants, who also assessed Charlie, in focus group A, so not those who had participated in the think-aloud sessions. Ivan does allude to his adherence to a preferred hypothesis and even suggests it is not an ideal method of reasoning. However, the discussion centred on their assumption that their use of pattern recognition for Charlie was an appropriate clinical reasoning strategy, without error, they did not verbalise their lack of differential diagnosis and all believe they reasoned appropriately. As Gary says below they perceived Charlie's diagnosis as obvious. This concurs with Wessel et al. (2006) who found during their first practice-based learning experience physiotherapy students believed they had clinically reasoned automatically and appropriately throughout, and did not recognise their own errors.

Ivan: With me, I get an impression very early on, the bad thing is that it, even if something else comes up, I find it very hard to get rid of that impression. And so with this, as soon as it told me you had pain on the medial side, you are thinking medial collateral ligament, so I left that test to the end and I did it and it came up painful, so I mean (FGA: 309)

Gary: I am doing the same, I am having an idea from the beginning, some tests with that idea (FGA: 315)

Ivan: So I don't think it changed the way I clinically reasoned (FGA: 318)

Gary: Because at the beginning it was an obvious problem. I don't know if that was the problem but if you had a patient like that, with ..., it is not easy to test, it is not easy to find, and then maybe you could ask more questions (FGA: 320)

Later in the discussion Gary also identified that adhering to a preferred hypothesis was not necessarily an effective clinical reasoning strategy but that he felt he persisted with it despite this. He then indicated, albeit without the terminology, that although he had used pattern recognition for Charlie, the least complex patient, when he assessed Joanne, the most complex patient, he reverted to hypothetico-deductive reasoning:

Gary: Depending in the mechanism and where the pain was, I get this one thing stuck in my head and I don't seem to go away from it unless something else sort of very obvious comes up, which is a bad thing but, in the case of the back, there could be more things going on so I would go through the motions and stuff like that, wait to make a decision on it until the end, until I have done everything I think (FGA: 359)

Gary: There are more stuff to clear maybe? Possibly we are more familiar with the knee, anatomy and pain (FGA: 374)

Gary: I definitely thought that, I instantly think that the pain is coming from the back and not anywhere else but to determine what specifically it is, it takes a little bit more digging around (FGA: 380)

Again this finding of using hypothetico-deductive reasoning in a more complex situation corresponded with the literature which stated that hypothetico-deductive reasoning is reverted to even by experts when faced with problems they cannot use pattern recognition for (Kempainen et al. 2003).

5.25 Narrative reasoning

Although the literature (Cruz, et al. 2012; Wessel et al. 2006; Doody and McAteer, 2002; James, 2001) suggested that students tend to be focused on a clinician led model of clinical reasoning rather than a patient centred collaborative reasoning process, the think-aloud data showed that all bar one participant, Katy, incorporated asking the patient about their view of

their problems and about their lifestyle as normal process within the subjective assessment. Thus, participants verbalised narrative reasoning during the patient assessment process for example:

John: *'So, it can't stop him from playing football, which is the main thing.'* (TA John: 56)

Participants also verbalised narrative reasoning during management planning as shown in this illustration of a conversation with Mark below. In this conversation I only used 'uha' as a prompt to initiate further verbalisation, this depicts the pauses for Mark's thinking time as he tried to incorporate the patient as a person into the management plan. During his assessment Mark had asked Joanne about her hobbies. Table 13 below shows an extract from the activity log showing Mark's questions and Joanne's replies. It shows that Mark tried to find out more about the relevance of the patient's swimming but his question was not recognised. Thus he struggles to include the patient's viewpoint in the management planning even though he tries to do so.

Table 13: Extract from the activity log of Mark's think-aloud

15:07:41	do you have any hobbies	I like to swim but I only get to go about once a week now.
15:08:05	does swimming help you pain	Sorry, I do not know how to answer that.

Mark: *'That are going to be sort of motivating factors for her.'* (TA Mark: 702)

Facilitator: *'Uha,'* (TA Mark: 704)

Mark: *'Like, if she has any problems with caring for her child or whether she loves swimming and she can't go swimming because of it, or she can only go once a week because she is in pain for the rest of the week following it.....'* (TA Mark: 706)

Mark then verbalised other thought processes but subsequently returned to trying to include the patient's perspective into the management plan.

Mark: *'My long term goal I would like to be something again for the patient that's actually important to her, erm, rather than just a, erm, measurement of some sort, erm, but I presume that she can't go swimming because of her back, 'cos she only goes once a week.'* (TA Mark: 770)

Facilitator: *'Uha,'* (TA Mark: 775)

Mark: *'Although it could just be that she doesn't have time to go more than, more than once a week so I don't really know what to put for the long-term goals at the moment.'* (TA Mark: 777)

Ann also incorporated Joanne's social history into her management plan:

Ann: *Long-term goal, to.....be able to pick up her son and hold him pain free, 'cos leaning down and lifting hurts her and she wants to give him a cuddle, she told me that earlier. So to lift up and hold him pain free in well* (TA Ann: 507)

Although the think-aloud findings showed that most participants used narrative reasoning it was not discussed as a concept in the focus groups, except in the sense of the VPs being real patients and therefore participants asked them about their problems. The participants were actually discussing the fidelity of the VPs and their merits over role play but Peter's comment shows his intent to use narrative reasoning within patient assessment generally.

Peter: *I still wanted to find out what a ... yeah that patient is real, you still want to find out their problems.* (FGA: 188)

This finding shows that a VP with the level of fidelity of the VPs at Martias can facilitate narrative reasoning. As it was perceived as realistic enough by participants for them to interact with it, in many ways, as they would a real patient.

So findings showed that all three clinical reasoning strategies were used when assessing the VPs and the use of these strategies aligned with the literature on novice clinical reasoning although the incorporation of narrative reasoning appeared to be higher. To clinically reason using each strategy participants needed to integrate the core elements of knowledge, cognition and reflection identified in the literature (Jones and Rivett, 2004; Higgs, 2003). Findings from the think-aloud sessions showed participants incorporating these elements to varying extents.

5.26 Propositional knowledge

All participants verbalised the integration of propositional knowledge i.e. pathology, anatomy or specific tests for differential diagnosis. Table 14 shows the number of verbalisations per participant for propositional knowledge. The frequency of verbalisation varied across participants but it is acknowledged that the actual integration of propositional knowledge was higher than the verbalisations of it. The use of non-propositional knowledge was unlikely as participants had not undertaken any practice-based learning previous to using the VPs. It was not verbalised by any participants.

Examples of the integration of propositional knowledge are:

Mark: Well, if she has got any pins and needles and numbness in her legs then it's a possible sign of some sort of cord compression, particularly numbness but, it doesn't look like she has cord equinus, which is good, or cord compression. (TA Mark: 262)

Carol: She's got a mild Dinner Fork Deformity present which indicates a fracture of end of radius, erm, Colle's fracture. (TA Carol: 338)

Table 14: Integration of knowledge

Participant	Number of verbalised integrations of propositional knowledge
Robert	11
Ann	12
David	24
Katy	5
Naomi	20
John	5
Georgina	8
Carol	9
Mark	15

5.27 Cognition

All participants used cognition as they processed and evaluated information given by the VP they were assessing. The findings of the think-aloud showed participants processing information given by the VP and synthesising it with their propositional knowledge to decide on their next action within the patient assessment. The frequency of cognition was not analysed as it was an ongoing inherent process as the following examples demonstrate:

Katy: I am going to ask the patient what their main problem is. My request has not been understood. Where is, where is the pain? Pain is in the left wrist, sort of deep in the joint. OK, so it sounds like it could be a mechanical problem. OK, I am going to ask what, erm, causes the pain to increase. She doesn't understand what I am asking. Erm, what aggravates the pain? The pain gets worse if I try to type or sew for a long time. I can't grip anything very well either. Erm, it sounds like it could be, maybe, a medial nerve compression either. OK, I am going to ask what eases the pain. The pain is better with the splint on resting it. OK, so, I'm thinking it's aggravated by any movement and pain is eased with not moving it. So, it could be muscular or, erm, jointy problem, could be OA either. I am going to ask her how long she has had the pain. OK, she fell about 2 months ago. Right, I am going to ask her, erm, how, what does the pain feel like? How would you describe the pain? My request has not been understood. Erm,

erm, so, I'm thinking maybe she may have a bone in her hand or wrist maybe fractured. (TA Katy: 4)

David: Erm, he said he was playing football 2 weeks ago, someone tackled him, twisted his left knee really badly. Erm, because of the twist I immediately think some kind of ligament. (TA David: 29)

Carol: Erm, she has got restricted range of movement in her left wrist in both extension and flexion. Erm, at the moment I am kind of, like with regards to generally what's going on; I think it just could be quite stiff from being in the plaster cast for 6 weeks. There could be some damage to her structures maybe from the fall, maybe. I am not quite sure yet. (TA Carol: 118)

5.28 Reflection

The think-aloud findings show the use of reflection as part of the clinical reasoning process demonstrating reflection both in and on action (Schon, 1987). Much of the verbalised reflection involved the lack of information gleaned from the VPs due to the non-recognition of questions, for example Ann reflects in action on the fact that the recognition issue is causing her to undertake her assessment in a more random order than she would like:

Ann: OK, I'm just going to, her some, more about social, just while we are on it. I'm going to ask her who she lives with. Her son, OK. "Do you have/live in a house or a flat?" A house. "Do you have stairs?" I can do stairs, fine, OK. Erm, right, I am going to go into "aggs" and "eases", now, 'cos I can try and work out what's going on. I know that's this is the wrong order, just for the sake of the tape (TA Ann: 116)

Ann also demonstrates reflection in action as she clinical reasons Joanne's back pain and David reflects on his assessment so far and his omissions while deciding what information to obtain next:

Ann: *Because it's a stretching rather than a compressing of the right side. It's stretching the left side, which is causing the left side pain. It hasn't said the right side is sore, so the restriction obviously isn't in the, sort of, compression here but it's in the stretching of this side. I would think. I would expect it to be the same on the other side to be honest, because she's not said, well, I don't know if one side's worse because I don't think I got that far, which was probably something I should have asked. Erm, right, so she hasn't got a full range of movement, so range of movement limited by pain* (TA Ann: 309)

David: *Erm, I should have asked him how old he is at the start and stuff, completely forgot about that. OK, his left knee.* (TA David: 234)

Facilitator: *Keep telling me what you're thinking.* (TA David: 237)

David: *I've just gone back and asked him how old he was.* (TA David: 239)

David: *So, I've put in 13 year old male....* (TA David: 243)

David: *Pain in left knee. I'm just checking over my notes really to make sure I've got everything that I would normally ask.* (TA David: 247)

Facilitator: *That's fine. It's just that I want you to do it out loud instead* (TA David: 250)

David: *Sorry, I was literally looking over, looking back over what I've asked him and I forgot to ask him how old he was, which is strange...* (TA David: 252)

David: *'cos it's one of the first things I'd do. Erm, so I put down 13 year old male, 6 out of 10 and his 'aggs' and 'eases' he has told me and then I put his sleeping, THREAD questions, past medical history, including*

X-rays and surgery. I blatantly missed a load of other stuff out but... (TA David: 257)

David: I can't remember what it is. Erm, he wouldn't be working 'cos he's 13. He's still at school and he's currently going to school on crutches. (TA David: 264)

Reflection on action was evident during the process of creating the management plan, in so far as participants realised they had not asked all the necessary questions in their subjective assessment or gleaned enough objective results to create an effective management plan and rectified this by seeking the information they needed from their VP at that point.

John: Erm, so, I've done past medical history, current problem, social problems, erm (laugh). I've just realised that I have forgotten some of the main things that I'm.....(TA John: 77)

Facilitator: *Like what?* (TA John: 80)

John: name, age, date of birth (laugh). (TA John: 81)

Interestingly the lack of a VPs understanding of their questions caused some participants to reflect on their phraseology as had been reported in the literature by Schitteck-Janda et al (2004) with dental students using a VP. The following dialogue was initiated by John at the end of his think-aloud session:

John: Erm, yeh, I asked, it didn't recognise respiratory. (TA John: 338)

Facilitator: *No* (TA John: 339)

John: "Do you have any respiratory problems", so, I had to ask, "Do you have asthma?" (TA John: 340)

Facilitator: *Yes, but that's because it doesn't recognise jargon. It does in the objective but not in the subjective...* (TA John: 342)

John: *Oh, right.* (TA John: 344)

Facilitator: *It's because it's a patient.* (TA John: 345)

John: *Yeh* (TA John: 346)

Facilitator: *so you can't use medical terminology with it because it doesn't understand.* (TA John: 347)

John: *Oh, right, OK Do you reckon it would have recognised it if I said breathing problems?* (TA John: 349)

Facilitator: *Yes* (TA John: 351)

John: *Oh, right, OK. I thought, shall I ask breathing or asthma. Oh, I'll do asthma, but...* (TA John: 352)

Facilitator: *Yes, it will recognise either or those.* (TA John: 354)

John: *Probably should have asked both really.* (TA John: 355)

The findings from the think-aloud supported the a priori themes pertaining to clinical reasoning from the literature review in so far as the participants all verbalised using the component parts of clinical reasoning: knowledge, cognition and reflection (Jones and Rivett, 2004; Higgs, 2003), while using the VPs. Participants mainly used hypothetico-deductive reasoning, though could not always evaluate the information received and struggled to create a clinically reasoned management plan (Wessel et al. 2006; Doody and McAteer, 2002; James, 2001). However, the findings also showed that some participants used pattern recognition even in the pre-clinical stage of

physiotherapy education, when presented with a formulaic injury. The participants believed they had clinically reasoned automatically and appropriately however, the data showed that they did not differentially diagnose, concurring with the findings of Wessel et al. (2006). Participants also adhered to a preferred hypothesis based on pattern recognition, a common error reported by Jones et al. (2008). Narrative reasoning appeared to be used by more participants than the literature suggested as Wessel et al. (2006) found less than fifty percent of their student participants used it. Bearing in mind the difficulties experienced questioning the VPs this use of narrative reasoning bodes well for the participants using it with real patients in practice especially as they reported using it because they perceived the VPs as realistic.

5.29 Using VPs to improve learning

With regard to facilitating the learning of clinical reasoning the findings from this study moved beyond the themes from the literature review to address the improvement of the teaching methods of patient assessment and clinical reasoning in university-based physiotherapy education. The major theme that emerged from the study was; improving the learning and teaching of clinical reasoning in the patient assessment process, however the important findings from the two data sets addressed different aspects of this theme. The emphasis of the two differed, in that, the focus groups showed the participants saw VPs as a way to improve their learning and enhance usual teaching methods. Their emphasis was on using VPs to improve current methods of teaching and learning within their programme. While the think-aloud process showed how the concept of using VPs or other types of simulated patient could be used as a catalyst for learning. The think-aloud method itself was fundamental in demonstrating how valuable verbalising the clinical reasoning process could be in terms of learning and improving clinical reasoning. Although little empirical evidence was found in the literature on the effective teaching of clinical reasoning in pre-registration physiotherapy education, this finding is somewhat supported by contemporary literature within clinical reasoning with experienced Australian

physiotherapists. Two recent studies reported that the retrospective verbalisation of clinical reasoning within their communities of practice aided reflective learning and clarified the reasoning process (Delany and Golding, 2014; Ajjawi and Higgs, 2012). Within the case study based at Martias the think-aloud method highlighted the value of verbalising while assessing a VP not only to me as the researcher but also to the participants who took part in a think-aloud session. This was articulated in focus group B and it shaped participants ideas on improving usual teaching.

Carol: I think that is one of the biggest things in the viva, the discussion but, when somebody says so why did you do that, that is the bit that you are least practiced on in the run up to the viva. You get all this practice on how to do an objective test or whatever you can practice that as much as you want, but I think to get into the habit of someone actually asking why are you doing that test or whatever, the more practice you could give at that would help your clinical reasoning and stuff (FGB: 349)

Facilitator: So even the computer asking you that or working together in groups (FGB: 356)

Georgina: So you say just do the ... so you do it and they give you the result and you are like great, yeah, but then, it made me think why didn't I do that. You said to me, why do you think that? I stumbled, it just made me think I don't know why I am saying it, but I know what I am saying. So yeah, we do need to be questioned more. Because we do know it. I think a lot of us are just lacking the confidence to do it, but to be asked it there and then and to answer it is good (FGB: 358)

These were important findings creating emergent knowledge in the teaching and learning of clinical reasoning and will be discussed in further detail in the following chapter.

5.30 The theory-practice gap

A central concept within the case study was the facilitation of learning to bridge the theory-practice gap and the findings showed that assessing a VP could facilitate learning in this area. The think-aloud data revealed that participants had gaps in their knowledge base in a way that exemplified the theory-practice gap but it also showed that using the VPs helped participants clarify concepts around this. The VPs helped participants to bridge the theory-practice gap as they gave genuine results within both the subjective and objective assessment, which facilitated clinical reasoning as participants reflected on the results obtained. Participants recognised the value of this, as discussed by participants in focus group C:

Steve: Yeah, as Charlotte said, when on this course, you don't get a chance to clinically reason really because nine times out of ten we're all healthy individuals and you can sit and do a pretend subjective assessment but it is never like the real think but as you say, it is good to get the process of what questions you would ask (FGC: 55)

Tony: Objective as well, for getting actual numbers for range of movement, we measure each other and we are all relatively normal so it is actually quite nice to get different ranges of movement like you would get in a patient. (FGC: 60)

The participants are, without necessarily realising it, discussing the response fidelity of the VPs. The realistic way the VPs were programmed to respond to participants interactions (Seropian et al. 2004) which increased their psychological fidelity; how realistic the participants found the VPs and therefore how they responded to them (Neary, 1994).

5.31 Response fidelity

As detailed in the IFS the three VPs were programmed to respond during the subjective assessment in the style of a real patient fitting their demographic. The think-aloud data showed that this response fidelity

facilitated learning that bridged the theory-practice gap, by initiating learning related to the practice of interacting with patients. For example, Amy was an elderly lady and was taking aspirin as instructed by her doctor. However, as with many patients, Amy did not entirely understand why she was taking aspirin. Georgina carried out a thorough patient assessment of Amy asking both 'do you have any heart problems?' and 'Are you on any medication for your heart?' to which Amy replied 'no' in both cases. However, 'Are you on any other medication?' received the reply 'Aspirin for blood'. The following is Georgina's verbalisation of this:

Georgina: 'Are you on any medication for your heart? No. Does she have any heart problems, no, on any other medication? Aspirin for blood. I thought she said she had no heart problems'. (TA Georgina: 97)

This demonstrates the theory-practice gap. Students are taught the cardiovascular system and think of it in a connected way. However, patients do not always think of the heart and blood as interrelated so subjective assessment questioning needs to be precise and in terminology understood by the patient. As previously explained in the IFS, the VP was programmed using realistic terminology. Findings from the think-aloud data showed participants using medical jargon in their questioning of the VPs. As previously indicated when discussing reflection, if participants reflected on their use of language the realistic terminology could facilitate bridging of the theory-practice gap in this respect. This type of realism bridged the theory-practice gap in a way that did not happen in role play and practical skills sessions, as students do not give genuine results when practising on each other. They do not realistically interact as patient and physiotherapist because students all understand the terminology used and they lack the necessary practical and pathological knowledge to portray a patient with a particular pathology, from a specific demographic, accurately. Participants appreciated getting appropriate objective results from the VPs.

Ann: you get more information, especially when it comes to the objective side because specific, they only have 60° ... but practicing on

each other, it might not be very realistic at all. On the objective side it really helps, a lot better than when we practice on each other (TA Ann: 113)

The previous examples demonstrated that the fidelity of the VPs facilitated bridging the theory-practice gap. The use of the think-aloud process was fundamental in exposing an important finding relevant to the theory-practice gap and usual teaching. Think-aloud sessions with different participants but the same VP, Amy, highlighted a common misconception which indicated that usual teaching was compounding the theory-practice gap. When assessing Amy, who had recently had the cast removed post Colle's fracture, participants expected to find one tissue structure, either muscle (myogenic) or joint (arthrogenic), as causal of Amy's residual problems with her left wrist. Here Naomi verbalises her 'either-or' type thinking:

Naomi: 'my initial thought was that it would probably be when I first heard it was a fracture, my initial thought was probably be arthrogenic and be stiffness, but she hasn't reported any stiffness, mainly pain, and it's mainly on activity, so I mean it could still be arthrogenic but I am still probably heading more towards it being myogenic now Myogenic because is only really hurts when she has been using it constantly all day and she has weakened with her grip and it has been specifically worse when she is trying to lift something.' (TA Naomi: 220)

During usual teaching participants had learned that they should differentiate between joint and muscle problems using passive and resisted movements. However, in reality, due to joint immobilisation, typically post-fracture patients have problems with muscles, which are contractile so shorten and weaken, and joints which stiffen. Both types of structure can therefore cause pain and stiffness simultaneously. This was not a concept the participants who assessed Amy were cognisant of, as Carol's verbalisation demonstrates:

Carol: 'I am going to do passive now, erm, just to see, take like the contractile element out of the equation.' (TA Carol: 179)

Carol: *'Passive, that's painful as well; erm.'* (TA Carol: 188)

Facilitator: *'What are you thinking?'* (TA Carol: 190)

Carol: *'Erm, that put a spanner in the works, erm. That it's something to do with the joint then if it's still painful on passive it's not muscle. I don't know.'* (TA Carol: 192)

In this way supervising participants verbalising their thought processes while assessing a VP facilitated the ability to recognise a misconception from usual teaching. This general misconception would not have been picked up if participants had purely used the VPs in self-directed learning. The implications of this are discussed in more detail in the next chapter.

5.32 Peer learning

As previously mentioned when discussing assessment practice, some of the participants' supported the premise within the literature of VPs being used for self-directed learning. However an important finding from the focus group data showed the participants' were interested in how VPs could be used to improve their learning and enhance usual teaching methods. They had ideas around using VPs within PBL sessions as a group learning tool. This was discussed at length in focus group B and to a lesser extent in group C. At the time of the data collection this concept had not been addressed in the literature, although subsequently some studies that touch on this have been undertaken. Participants thought the interactive VPs were more valuable than the paper-based scenarios used in PBL and they appreciated peer learning and its ability to enhance the learning of clinical reasoning, as described by Robert.

Robert: *'I didn't know the answer to some of the things so I think the VP would be good in a group situation as well, it can spark discussion, if you had two or three of you going through the patient together, then discuss*

it, it can bring up discussion points, why did you do this? I wasn't sure if I was going right so if I had someone else to give me advice.' (FGB: 343)

The literature has not addressed the specific use of VPs within PBL, although peer learning had been suggested as useful to enhance clinical reasoning (Ajjawi and Higgs, 2008; Ladyshevsky, 2004). Participants felt that working with the interactivity of the VPs gave a realism that paper-based scenarios could not achieve. As discussed in focus group B:

Robert: I would find that to enter that as a PBL scenario in our groups on a Tuesday morning, one person at the computer and you all sitting round talking, working through a scenario like that a lot more beneficial I think, I don't know if it just me but I tend to switch off in PBL (FGB: 579)

Facilitator: When you say more beneficial, more beneficial than doing it by yourself or more beneficial than the PBLs you do at the moment? (FGB: 584)

Robert: PBLs, and then at the end, if you still come up with your learning outcomes, go research and come back next week, and then you start a new scenario with the subjective, one every week (FGB: 587)

Ann: Still have to come up with what we had done, still have to go away and find it but a much more interactive way of figuring out what is wrong (FGB: 591)

This finding was unexpected as at the time of data collection and was emergent in nature. It is discussed further in the next chapter.

5.33 Conclusion

Prior to the case study undertaken at Martias there was no evidence in the literature of VPs facilitating learning within physiotherapy education.

The case study explored the use of VPs to answer the research questions:

1. Which factors affect the usability of physiotherapy virtual patient simulation?
2. Can using virtual patient simulation facilitate the learning of patient assessment and clinical reasoning skills to help bridge the theory-practice gap for pre-clinical physiotherapy students?

The data collected gave in-depth answers to these questions and insights into how the use of VPs could improve the learning of clinical reasoning skills and help to bridge the theory-practice gap in this area. The major themes and important findings are now summarised. The following chapter will further discuss the emergent knowledge.

The major themes that emerged from the case study were:

1. Improving the learning and teaching of clinical reasoning in the patient assessment process.
2. Usability of virtual patients.
3. Use of response fidelity to bridge the theory-practice gap

To explore the research questions and the concept of VP use a specific VP software had to be incorporated into the study design. It is acknowledged that a different VP software would potentially have given different findings. Nevertheless the findings of the case study using the VPs at Martias showed that the VP concept was effective as a tool for facilitating patient assessment and clinical reasoning. The VPs did facilitate patient assessment and clinical reasoning skills; there was clear evidence of participants verbalising the use of the component parts of clinical reasoning, as well as different clinical reasoning strategies in the think-aloud data. This was supported by the participants reporting, during the focus groups, that using the VPs facilitated their learning of patient assessment and clinical reasoning. They saw the value of the VP concept as a realistic interactive simulation. However, findings also showed the particular VP software used at Martias had both shortcomings and attributes which affected its usability.

The findings that negatively affected user satisfaction and effectiveness, and therefore usability were:

- The interaction difficulties.
- Inadequate individualised performance feedback.
- Inadequate embedding of the facility to practise patient documentation.
- Not embedding the VPs in the usual curriculum.

The finding that positively affected user satisfaction and effectiveness, and therefore usability was:

- The realism of the VPs, especially their cosmetic fidelity, via the videos, and their response fidelity.

The findings suggested further work needs to be done in a number of areas if VPs are to be used within physiotherapy education. In terms of using VPs to facilitate the learning of patient assessment and clinical reasoning an improved system of interacting with the VPs would need to be established. Specifically, either free-text recognition needs improving or VPs with another form of interaction need developing. If free-text inputting is used, a spell check should be incorporated. The feedback given needs to be individualised performance feedback, it should be focused on the user's performance to specifically facilitate improving patient assessment and clinical reasoning. The use of further videos and images would enhance cosmetic fidelity and response fidelity and realistic medico-legal patient documentation should be included in the learning experience. The recommendations for improving the overall VP experience for students would be to incorporate them into usual teaching. To embed them in the programme of study with the additional facility for students to use them for self-directed learning. To begin with a supervised introductory session to familiarise students with the VP software and then use them in supervised group learning sessions incorporating VPs that cover various contexts and have varying complexities.

6.00 Chapter Six: Discussion

This chapter further explores the emergent findings of the case study and clarifies the key messages in relation to emerging new knowledge. The implications of this knowledge on the learning and teaching of clinical reasoning within physiotherapy education are discussed. The chapter also provides a critique of the limitations and strengths of the research methods used and the resultant trustworthiness of the research as a whole. Suggestions for further study are also addressed.

As previously discussed findings from the case study supported the key themes from the literature review as well as adding knowledge on the usability of VPs within physiotherapy. However, the use of the think-aloud data collection method was fundamental in highlighting important emergent knowledge within the teaching of patient assessment and clinical reasoning. The literature provided little empirical evidence on the teaching and learning of clinical reasoning in pre-registration physiotherapy education and the findings of this exploratory case study add knowledge within the area. Nevertheless the findings should be considered emergent and are not necessarily applicable to other contexts. They would benefit from wider investigation.

6.01 Emergent findings

In some respects all the findings of this case study could be considered emergent due to the dearth of evidence on VP use in physiotherapy. However, many findings concurred with the findings of previous studies on VPs in medicine, simulation in health education or clinical reasoning within physiotherapy. The emergent findings discussed in this chapter are those not previously addressed by the literature.

6.02 Emergent findings: usability

The emergent findings pertaining to the usability of virtual patients to facilitate the learning of clinically reasoned patient assessment by pre-clinical physiotherapy students were:

1. The inadequate interactive programming of a VP is likely to have a detrimental effect on students learning effective clinically reasoned patient assessment.
2. Students perceive that using VPs instead of paper-based patient cases in PBL will improve their learning

There was some evidence within the focus group findings that the difficulty with the free-text recognition in the VP software had an effect that could lead to the development of poor patient assessment and clinical reasoning habits. As previously discussed participants felt free-text issues caused a randomness to their patient questioning which they found frustrating and uncondusive to learning effective clinically reasoned patient assessment. In addition, because the medical terminology used in the objective assessment made the language less diverse and therefore the programming easier, the free-text recognition issue was more prominent in the subjective assessment. Participants reported concentrating more on the objective assessment to decrease frustration and maximise learning. However this style of usage did not facilitate good assessment practice and clinical reasoning, in fact the converse, as experienced physiotherapists spend more time on the subjective assessment where they generate the majority of their hypotheses, while students spend much longer on the objective examination (Doody and McAteer, 2002). Thus VPs should be encouraging more emphasis on the subjective assessment to facilitate the learning of effective clinically reasoned patient assessment. This suggests that the interaction of a VP needs to be effective enough to facilitate an appropriate patient assessment process and that the use of VPs not able to achieve this may actually have a negative effect on the goal of use. However, the mode of interaction needed to achieve effectiveness would need further study as using question menus was adamantly disliked by students in both the IFS evaluation and within the literature (Bearman, 2003). While free-text recognition had proved problematic in studies within medicine and dentistry (Chesher, 2004; Schitteck-Janda et al. 2004). Speech recognition has been

used successfully in high fidelity VP interactions within medicine (Raij et al. 2006) but there are cost implications with this.

6.03 Using VPs for PBL

An important emergent finding of the study was the strong participant support for the use of VPs as a tool in problem-based learning. Participants envisaged VPs as the scenarios for PBL sessions, enabling them to work as a group within a realistic patient and physiotherapist interaction to help link theory to practice. They felt that working with VPs mimicked the reality of practice, giving a realism that paper-based scenarios could not achieve. This finding was unexpected, as at the time of the data collection the focus of TEL was still on self-directed solo learning (Race, 2005). However, the focus of TEL and specifically simulation within health education has shifted from solo self-directed learning to a model of autonomous learning that involves group learning and requires educators to be involved in the learning process along with their students (Motola et al. 2013). Recent best evidence within medicine, though not VP specific, reported that integration within the curriculum is critical to the success and effectiveness of simulation-based education (Motola et al. 2013; McGaghie et al. 2010). Although this was not evident in the literature at the time of the study intervention, the findings of the case study at Martias showed clear evidence of participants' perceptions that VPs could be of more benefit if integrated into the physiotherapy programme. In many respects using VPs within PBL takes the PBL process one step further towards the practice situation as well as increasing the possibilities for Schön's (1987) concept of reflection-in-action and Kolb's (1984) experiential learning cycle. It would facilitate students practising complex clinical reasoning skills and obtaining performance feedback to bridge the theory-practice gap. The literature on group working and clinical reasoning within physiotherapy is equivocal, Ladyshevsky (2004) explored the advantages of peer-coaching for pre-clinical students on clinical reasoning during musculo-skeletal patient assessment. The findings showed that working with a peer increased students' confidence and peer feedback was considered helpful by

students, but clinical reasoning ability during patient assessment was not appreciably different. However, peer learning within communities of practice to enhance clinical reasoning had been suggested as useful for qualified physiotherapists (Ajjawi and Higgs, 2012; Ajjawi and Higgs, 2008). The literature on group working using simulation was also equivocal. Cook, Brydges, Hamstra et al. (2012), in a systematic review of technology enhanced simulation reported improved outcomes from group working though conversely, Cook et al. (2013) in a further systematic review of simulation reported inconsistent findings for group working and recommended further studies were undertaken. Interestingly contemporary research investigating medical students using interactive VPs to diagnose cranial nerve palsy via either group learning or independent learning showed that using a VP as part of a group significantly improved differential diagnosis (Johnson, Lyons, Kopper et al. 2014). A further recent comparative study within medicine, although with branching-logic style VPs, reported that students, who worked with a partner as opposed to individually, answered significantly more questions about the patient case correctly when tested as an individual directly afterwards (Jäger, Riemer, Abendroth et al. 2014). Contemporary literature within physiotherapy also suggested that PBL did not sufficiently develop students' clinical reasoning skills (Gunn et al. 2012) and that students still viewed learning to clinically reason as a component of practice-based learning rather than university-based learning (Christensen et al. 2013). Gunn et al. (2012) suggested that PBL fostered high levels of motivation and self-direction in the majority of physiotherapy students, but their ability to transfer problem-solving skills from PBL to practice was very variable. Therefore, although PBL had been conceived specifically to help bridge the theory-practice gap and facilitate clinical reasoning by working on paper-based patient problems (Barrows and Tamblyn, 1980) it was not necessarily achieving this. The participants in the study at Martias perceived this was because of the lack of interaction with paper-based scenarios. They felt the ability to interact with a VP and extract information mimicked reality and this was a key attribute of a VP. They also perceived undertaking this as a team with peers and an educator present would enhance the learning experience. The findings of Wessel et

al. (2006) concurred with this, showing that students believed that group working reinforced their learning, but they needed staff facilitation as they lacked confidence in their ability to learn correctly without it. The think-aloud findings endorsed this viewpoint as they showed the value of an educator being present to correct errors that students did not recognise themselves making.

6.04 Emergent findings: clinical reasoning

The supervised verbalisation of clinical reasoning used in the think-aloud data collection method revealed important findings that were not previously addressed in the literature or exposed by the other data collection methods. These emergent findings were not specifically related to the use of VPs but directly related to the teaching and learning of clinical reasoning and bridging the theory-practice gap. Thus the findings were not directly related to the research questions, but unexpected findings in exploratory research are not infrequent and often these findings are only loosely related to the initial research questions posed (Silverman, 1999). These emergent findings pertaining to the teaching and learning of clinical reasoning were:

1. The supervised verbalisation of the clinical reasoning process by physiotherapy students while undertaking patient assessment identifies errors in knowledge and reasoning that would be unlikely to be identified by retrospective discussion of the process or viewing of patient management plans.
2. Realistic patient simulation that includes response fidelity, helps bridge the theory-practice gap in clinical reasoning within physiotherapy.

6.05 Errors in clinical reasoning

An important finding from the case study was that the expert supervision of students' verbalisation of their clinical reasoning process while undertaking patient assessment identified errors in knowledge and clinical reasoning that were unlikely to have been identified by retrospective discussion of the

process or looking at the created management plans. Supervised verbalisation identified that participants used inaccurate propositional knowledge and flawed clinical reasoning strategies but were unaware of their lack of an effective clinical reasoning process. This was an important finding not only because its use could lead to improved teaching and learning, but specifically because it showed that the unsupervised assessment of real patients by student physiotherapists within practice-based learning has the potential to lead to ineffective patient management and therefore be detrimental to patients. The finding showed that the reported end result of a patient assessment may be insufficient to highlight faulty clinical reasoning and lack of differential diagnosis and therefore, concurrent issues may be missed. Findings in the case study showed that participants relied on pattern recognition for Charlie's formulaic injury presentation and were unaware of their potential for misdiagnosis because of their omissions. In the case of Charlie, participants' preferred hypothesis was a medial collateral ligament injury, they did not go on to rule out O'Donoghue's triad, by excluding injury to the anterior collateral ligament and medial meniscus. Furthermore, none of the participants seemed aware of their omission even retrospectively during focus group discussions with their peers. This mirrored the findings of Wessel et al. (2006) who reported physiotherapy students' lack of insight into their poor assessment and clinical reasoning skills, and those of Doody and McAteer (2002) and James (2001) who showed that students struggled to clinically reason during patient assessment and therefore had difficulty devising a reasoned patient management plan. The later was also true of the participants at Martias as management plans were not always clinically reasoned i.e. strengthening exercises were put into management plans without muscle strength having been tested in the assessment.

6.06 Teaching clinical reasoning

Standard approaches to teaching clinical reasoning tend to focus on gathering patient data, hypothesising a diagnosis, stating the signs and symptoms and subsequently devising a management plan. However this

teaches little about how to interpret and evaluate patient data, and the nuances of clinical reasoning often remain hidden from students (Delany and Golding, 2014). The literature on clinical reasoning suggested that experts have difficulty predicting the errors that novices will make (Eva, 2004) and that experienced clinicians find it difficult to explain and teach clinical reasoning because it has become ingrained in their own way of thinking (Delany and Golding, 2014). Therefore supervising the verbalisation of students' clinical reasoning to focus teaching efforts on students' misunderstandings is likely to be beneficial. This approach would also give students the individualised performance feedback that both the participants in the IFS and the case study at Martias requested and would circumvent the issues with feedback directly from the VPs. The supervision of students verbalising their clinical reasoning is indisputably time consuming for educators, however it would be possible to use a webcam to record a student's verbalisation while using a VP and then replay it later to discuss with peers and an educator. It would also be possible to capture performance feedback this way to enable later viewing and discussion. It could help to identify knowledge students are struggling to learn via usual teaching methods and give students insight into their lack of ability in certain areas. Motola et al. (2013) advised that best practice when teaching with simulation is for an educator to give feedback in a debriefing session that is focused specifically on the student's current performance and the specific improvements needed to meet the expected level of performance. The findings of the case study suggested students would value this as several participants initiated a teaching session with me at the end of their think-aloud session in an effort to understand the data gleaned from the VP when they lacked sufficient propositional knowledge. However, the debriefing session alone for clinical reasoning is unlikely to optimise learning without students verbalising their thought processes, as, unlike hands on skill practise, clinical reasoning is not visible to an observer. The study at Martias showed that for clinical reasoning verbalisation of thinking is needed to show errors in knowledge and identify guesswork. Clinical reasoning is not a separate skill but acquired hand in hand with knowledge. A consistent finding in the literature was that the accuracy of clinical reasoning was

dependent on the clinician's knowledge base (Norman, 2005; Elstein et al. 1990; Groen and Patel, 1985). The identification of errors in a student's knowledge, or a lack of knowledge in a certain area, enables the student to gain the accurate knowledge necessary and thus facilitates improvements in their clinical reasoning. Blackford et al. (2015) reported that students valued having their performance observed and formatively critiqued during simulation, as within university based learning students are often only closely observed during examinations. The supervised use of verbalisation of clinical reasoning while assessing VPs and the resultant performance feedback is inherently a formative assessment process. This process could also be used for summative assessment as unlike the common viva style assessment this would highlight errors in the reasoning process rather than just the end result and identify whether students were guessing, even if correctly.

As previously discussed participants who took part in think-aloud sessions identified that the process of articulation of their clinical reasoning facilitated their learning and that this was enhanced by being questioned as to why they were asking their VP for particular information. The literature on clinical reasoning reports reflection being enhanced when practice is articulated and discussed with others (Ajjawi and Higgs, 2012). However, the potential of reflection to improve clinical reasoning is unlikely to be fully realised by students without facilitation by staff, as the findings of this study, and those within the literature, show students do not recognise their own errors. The findings of the study at Martias showed that greater attention needs to be given to the errors in understanding and knowledge that students are unaware they have. Recent investigation into feedback characteristics that stimulate medical student reflection (Dekker, Snoek, van der Molen et al. 2013) found that positively phrased questions that focused on the individual student's ability to reflect on their performance were most beneficial. This is particularly important because recent literature has shown that student confidence increases when using simulation without a corresponding increase in ability or learning.

6.07 Simulation and student confidence

In common with the simulation literature as a whole many of the contemporary studies within the physiotherapy simulation literature showed student increases in confidence in their own ability to treat patients after using simulation. Many studies reported this increase in confidence as a positive reason for using simulation. However, they had not measured students' learning gains with the simulation intervention but relied on self-reported confidence levels (Mandrusiak et al. 2014; Ohtake et al. 2013; Silberman et al. 2013; Smith et al. 2012; Shoemaker et al. 2009). Jones and Sheppard (2011a) did however investigate improvements in clinical ability and reported that it was not improved by the simulation intervention more than usual teaching. Worryingly, however, the students who used the simulation were more confident in their abilities and overestimated their ability to treat patients throughout their subsequent practice-based learning placement. This study highlighted that that the assumption of learning effect from simulation may be misplaced, as is the temptation to jump to the conclusion that increasing students' confidence in their own abilities is inevitably positive.

Robust studies that moved beyond student self-reported data were few. However, robust randomised controlled trials were undertaken by Blackford et al. (2015), Blackstock et al. (2013) and Watson et al. (2012). Again findings showed simulation, using standardised patients, increased students self-reported confidence levels, but there was no significant differences in student competency between the simulation and control groups. In these studies the control groups undertook traditional practice-based learning but as they were not comparably asked about their confidence levels it is not possible to say whether simulation and traditional practice-based learning increased confidence in the same way. Although the focus for the authors was the replacement of practice-based learning with simulation, which they concluded their findings supported, the use of simulation did not improve students' performance beyond that of normal practice. Blackford et al. (2015) also explored students' thoughts on the simulation experience via

focus groups. Findings showed students felt the simulation increased their confidence and that the interaction during the simulation week with staff and peers improved their learning experience. This finding supported the concept of supervised simulation and group work.

6.08 Bridging the theory-practice gap

Observing participants verbalising their clinical reasoning while using a VP identified misunderstandings common to multiple participants. This commonality suggested that the usual teaching of some topics at Martias needed improvement. It was unlikely this need for improvement would have been identified without the think-aloud method being used in the case study as the verbalisation of clinical reasoning was not supervised within university-based teaching, although it may have taken place in practice-based learning. However, it is common practice within practice-based learning for each student to be supervised by a different educator in a different clinical setting and therefore although the error may well have been corrected at an individual level it is unlikely this would have been linked as common across multiple students. In the main, the flaws in usual teaching were exposed because I, as an educator, listened to several students clinically reasoning through the same VP assessment however, the response fidelity of the VPs was also a factor and findings showed that realistic patient simulation helped bridge the theory-practice gap in clinical reasoning. It was the response fidelity of the VP that highlighted the fact that various participants were struggling with the same concept. Neither the focus groups nor the activity logs would have highlighted this issue without the think-aloud method being part of the study. Although the issue was discussed in focus group B this was because verbalising their clinical reasoning and interacting with me had made the participants cognisant of the errors in their knowledge base. They identified that the process of articulation and discussion of their clinical reasoning facilitated their learning. Therefore, interacting with the VPs helped the participants bridge the theory-practice gap within the musculoskeletal patient assessment process because the VPs gave the participants realistic patients to assess

and their learning was enhanced by having an educator present to notice errors they did not know they had made and correct them. Conversely without the response fidelity of the VPs the errors in knowledge and reasoning would not have been visible to me as the observing educator. This was not only to do with the realism of each VPs pathology and personality but also to do with the realism of the process of eliciting information rather than having it presented as a *fait accompli*, as in textbooks or paper-based cases. Due to this realism, participants unanimously thought worked with the VPs was more useful than student role play and paper-based scenarios, and, in line with the literature and the IFS findings, participants in the case study at Martias requested more VPs of varying complexity and in other clinical specialties. This suggestion would appear to have value as within medicine contextual factors such as a patient's low proficiency in English or emotional volatility, have been shown to influence clinical reasoning performance and cause expert clinicians to overlook key information resulting in inaccurate diagnosis (Durning et al. 2011). Coupled with this, best practice teaching with simulation includes feedback combined with deliberate practice and the important feature of deliberate practice is continually practising a skill at more challenging levels (Motola, et al. 2013). Therefore a range of VPs with increasing complexity should be advantageous.

However, for VPs to be used in this manor the recognition of free-text inputting would need to be improved or an equivalent amount of realism would need to be achieved in a different way. As previously discussed, in the literature review, standardised patients are an option, but they are costly. Recently, because of the cost factor, Mandrusiak et al. (2014) explored training senior physiotherapy students as standardised patients for junior students and Murphy et al. (2015) explored using volunteer real patients. Both studies reported that the training could be achieved within one hour, with costs being significantly less than for usual standardised patients. Both studies reported student satisfaction with their learning but neither study collected data other than student self-reporting so other factors were not investigated. However, it would be possible to use the

supervised verbalisation of physiotherapy students clinically reasoning while assessing another type of simulated patient i.e. standardised patients or volunteer patients, as opposed to VPs if the response fidelity needed to bridge the theory-practice gap could be achieved.

The main goal of supervising students while verbalising their clinical reasoning would be to stimulate and improve their clinical reasoning skills to enhance their clinical ability with patients in practice. This has the potential to improve student learning and thus potentially improve patient management. It is aligning with the recommendation from the Department of Health that healthcare professionals learn skills via simulation before undertaking them in practice to improve patient safety and care (DH, 2011). It would appear that supervision is necessary to ensure students' understand what they do not know, to try to ensure that students' confidence in their own abilities does not exceed their actual abilities.

6.09 Recommendations for facilitating learning

Based on the findings of this study, the following recommendations can be made for facilitating the learning of patient assessment and clinical reasoning in pre-registration physiotherapy education:

1. Supervised practise of students undertaking patient assessment while verbalising their clinical reasoning would help identify errors in knowledge and enable correction. Retrospective discussion of the end product is unlikely to identify all the errors made in clinical reasoning that supervised practise would identify. The errors in student knowledge while clinical reasoning need to be highlighted by educators so that these can be the focus of reflection and improvement.
2. The supervised practise of multiple students assessing the same patient can highlight flaws in students' understanding

that expose areas in which usual teaching needs improvement.

3. Realistic patient interactions with accurate patient information and response fidelity should be undertaken to provide authentic learning activities that can help to bridge the theory-practice gap.

6.10 Currency of the findings

Although this case study was initiated some time ago the findings are still pertinent. The issues discussed in chapter one around the difficulties of sourcing practice-based learning remain and may worsen if the current government's proposed changes to the funding of physiotherapy pre-registration education within England are adopted. There is still no new evidence on the use of VPs within physiotherapy and the simulation evidence within physiotherapy education remains equivocal. Due to this lack of evidence the CSP does not currently support the use of simulated learning to replace practice-based learning but it does recognise the potential for simulated learning to enable students to be more prepared and confident to enter practice (CSP, 2014). However, much of the literature on simulation within physiotherapy pre-registration education reports increases in student confidence without a corresponding increase in ability. Therefore, the willingness to adopt simulation exceeds the evidence of its effectiveness, especially in the facilitation of clinical reasoning. Indeed, there is still a lack of clarity generally on best practice for the teaching and learning of clinical reasoning in pre-registration physiotherapy education. Therefore, the emergent findings from the case study at Martias add knowledge in these areas.

6.11 Limitations and strengths of the study

This exploratory case study has several acknowledged limitations as well as a number of strengths. The study aimed to explore the concept of VP use with pre-clinical physiotherapy students to facilitate the learning of patient assessment and clinical reasoning. However to do so it focused on the

experiences of using a specific VP software, with a specific cohort of students from one MSc pre-registration physiotherapy programme, within one UK HEI. It also used mainly qualitative data. Therefore, as previously discussed in the methods chapter, there is a lack of agreement on the ability to generalise the findings to other contexts. Lincoln and Guba (2000) argue that generalisation is impossible as there is no guarantee that findings are valid in other settings, at other times, while other authors hold the view that some generalisation is possible from case study research. Both Stake (1995) and Yin (1994) argue that case studies can be used for analytical generalisation, that is, they can be used to support, contest, or enhance a theory or concept (Schwandt, 1997). Eisenhardt (2002) also suggested that case study research could be used to generate theory where little background knowledge exists for a particular phenomenon. Therefore, as there was a dearth of literature, the exploratory case study approach was a strength in this context, as it was open to the collection of both a breadth and depth of data from various sources and via various methods to explore the phenomenon and include the participant voice. In this type of exploratory case study, data collection, data analysis and theory-building are interwoven (Silverman, 1999). Therefore, although the methodology used limits the generalisability of the findings, the lack of theory concerning the educational benefits of VP simulation within a physiotherapy context and the teaching and learning of clinical reasoning, suggests that the findings may have transferability to similar settings, though further research would enhance this.

My intimate involvement in the design and development of the VPs prior to the exploratory research could be considered to be a limitation of this study. Although it was not the specific VP software under investigation, but the concept of VP use, I recognise that my involvement had the potential to create bias in the data. However, by acknowledging my involvement and by thoroughly detailing the methods used and data analysis undertaken the trustworthiness of the study is upheld. I believed, after reviewing the literature and undertaking the IFS, that a VP simulation had enough merit to investigate its ability to facilitate clinical reasoning. When the necessity of

designing and developing a bespoke VP became apparent the design was based on best practice pedagogical principles and the current available evidence on VPs and simulation. Thus, I was not a disinterested observer. However, although researchers may perceive they have an impersonal view of the problem the very act of identifying a problem to investigate implies a viewpoint. A researcher cannot set aside their pre-understanding for it is the interaction between the researcher's understanding and the phenomenon they are investigating that develops knowledge (Usher, 1996). Therefore, the desire to investigate a context and a pre-understanding of that context is not bias but part of the process of interpreting data and developing understanding. The findings of the study did not adhere to my preconceived ideas as the data collected highlighted issues and concepts I had not previously contemplated, thus demonstrating I did not adhere to biased subjectivity and only take notice of statements to support my opinions, ignoring counter-evidence (Sandberg, 1997). However, I acknowledge that the process of coding the data, though helpful in creating understanding of themes has the potential to deflect attention away from themes less obvious to me because of my viewpoint on the context. To counteract this I returned to the original data throughout the analysis process paying attention to divergent views from individual participants as advocated by Silverman (1999).

Although advocates of positivism may consider the use of qualitative data, as opposed to quantitative data, a limitation, the strength of these data collection methods was their capacity to reveal different perspectives of the complex phenomenon. The study was strengthened by the triangulation of these different perspectives. The participant voice was represented strongly via the self-reported data from the focus groups and to a lesser extent the think-aloud sessions. However, unlike much of the previous literature in this area, the study did not rely solely on self-reported data which is open to subjectivity in its reporting. The case study also automatically collected usage data via the VP software and used data collected by an observer knowledgeable in both MSK physiotherapy and pedagogy who interpreted participants' actions, and the verbalisations of their thinking. This allowed

the study phenomenon to be more broadly explored and recognise differences in themes from the two data types, gaining insight into aspects of the phenomenon that self-reporting data alone would not have exposed. Thus, although improvements in participants learning could not be quantified, the VPs impact on participants' clinical reasoning could be observed and recorded. It is acknowledged that because I collected and interpreted the data bias may exist, but the use of multiple data collection methods reduces bias and adds rigour to this interpretive research (Denzin and Lincoln, 2005).

I undertook this case study in my place of employment with participants from the programme of study I taught on. This could be deemed a limitation for, as a familiar member of staff an issue of power could have arisen and participants could have felt obliged to participate. The process of obtaining consent detailed in the methods section aimed to mitigate this and the subsequent lack of use of the VPs would suggest it was not an issue. I facilitated each data collection session and it is acknowledged that this may have skewed the data. However, participants verbalised negativity as well as positivity about the VPs, so participants appeared to verbalise what they thought rather than what they thought I wanted to hear. In this case study my intimate knowledge of the VP could also be deemed a strength as it enabled participants' statements to be probed to add depth to the data collected.

My status as a lone researcher may also be considered a limitation as Schilling (2006) suggested that a control check should be undertaken by another researcher during data analysis to enhance trustworthiness. However, from an epistemological standpoint Sandberg (1997) argued that although traditionally inter-judge reliability is used to show validity through replicability, this is based on a positivist epistemology and therefore is theoretically inconsistent. I agree with this standpoint. Since researchers cannot escape from interpreting the data, the trustworthiness of the study is based on my interpretive awareness and the transparency of this process. I used this principle in the thematic analysis of the data.

In retrospect a limitation of the study was its use of a self-directed intervention without a timetabled introductory session, as this probably contributed to the low usage of the VPs. An introduction to the VP software would have potentially strengthened the data collection in so far as it may have decreased the frustration around question recognition and thus increased usage. However, conversely this intervention type was also a strength, as the literature was equivocal on effective methods of delivery of learning via VPs. The use of a three month self-directed extracurricular intervention enhanced knowledge in this area.

It could be considered a limitation that the case study did not include the VP resource efficiency ratio in its design which, in terms of investigating the usability of a specific VP resource, needs to be ascertained from the ratio of resources expended versus the achievements gained. For although there was no actual financial cost for the development of the VP at Martias, the capital outlay in time was considerable. However, the case study was not investigating the VP software at Martias per se but the concept of VPs so the capital outlay for the VPs development was not captured within the study design.

6.12 Conclusion

The research undertaken at Martias was a case study of a cohort. The extent to which the findings are generalisable to similar contexts is an area for further research. The findings were based clearly in the evidence and related to previous literature on both clinical reasoning and patient simulation. Findings showed that the VP concept was effective as a tool for facilitating patient assessment and clinical reasoning. As prior to the case study there was no evidence in the literature of VPs facilitating learning within physiotherapy education, the study gave an increased understanding of the usability of VPs and the potential benefits and drawbacks of using VPs with physiotherapy students. It also revealed emergent knowledge pertaining to the teaching and learning of clinical reasoning and bridging the

theory-practice gap. It is acknowledged that the results of this study are based within the local context and therefore may not be transferable to other contexts. However, an advantage of undertaking the case study within this context was that it yielded findings that could be used to make a difference within the physiotherapy programme under study. Issues within university-based teaching were addressed and study findings were taken into account when revalidating the programme with the HCPC. Therefore the findings of the study had an effect on the teaching of patient assessment and clinical reasoning within the MSc pre-registration physiotherapy programme at Martias.

6.13 How this study supports the literature

This study supported the literature on clinical reasoning within pre-registration physiotherapy education in that:

1. It showed student participants using the clinical reasoning strategies: hypothetico-deductive reasoning, pattern recognition and narrative reasoning during patient assessment.
2. It showed they primarily used hypothetico-deductive reasoning but struggled with differential diagnosis and had difficulty creating reasoned management plans. However, they perceived they used appropriate clinical reasoning and did not recognise their own errors.

The health education simulation literature stated that learning with simulation is effective if it is embedded in the curriculum, undertaken in a group learning environment, includes performance feedback and facilitates deliberate practice. The participants in the case study supported this premise. They were also in agreement with the medical literature on VPs, in that:

1. They had a positive attitude to the VP concept perceiving them as more useful than other methods of teaching because they give a realistic patient experience.
2. Found the difficulties with free-text recognition frustrating.
3. They wanted to incorporate VPs within their learning that covered various contexts and had varying complexities.

6.14 What this study adds to the literature

The emergent findings pertaining to the teaching and learning of clinical reasoning were that:

1. The supervised verbalisation of the clinical reasoning process while undertaking patient assessment identifies students' errors in knowledge and reasoning that would be unlikely to be identified by retrospective discussion of the process or viewing of patient management plans.
2. The supervised practise of multiple students assessing the same patient can highlight flaws in students' understanding that expose areas in which usual teaching needs improvement.
3. Realistic patient simulation that includes response fidelity, helps bridge the theory-practice gap in clinical reasoning within physiotherapy.

The emergent knowledge pertaining to the use of VPs within pre-registration physiotherapy education were that:

1. Participants perceived their learning would be enhanced by using VPs instead of paper-based patient cases in PBL.
2. They wanted the facility to practise documenting accurate medico-legal records.
3. Findings showed the inadequate interactive programming of a VP is likely to have a detrimental effect on students learning effective clinically reasoned patient assessment.

6.15 Suggestions for future research

This exploratory case study involved a detailed investigation of twenty-six pre-clinical physiotherapy students who were studying on one programme, at one UK HEI. It provided a wealth of data about the participants' interactions with the VPs, yielding insights into both how they used them and how they would like to use them. It also revealed important findings within the teaching and learning of clinical reasoning. However it raised many questions that need further investigation within pre-registration physiotherapy education to clarify and expand the findings of this study as there is a lack of published literature addressing any of the following three areas:

1. The usability of VP designs.
2. Using VPs to facilitate clinical reasoning.
3. The teaching and learning of clinical reasoning.

Further investigation is required to strengthen the understanding of the usability of VP designs. Specifically the strengths and weaknesses of specific VP designs and their implications for facilitating learning. Comparative research of modes of student interaction i.e. the use of free-text versus question menus or speech recognition, as the difficulties of programming the free-text recognition would become void if other methods showed more effective learning. In terms of the usability of VPs within physiotherapy further work needs to be done in a number of areas including:

- The circumstances under which VPs are introduced into the curriculum.
- The usability of other VP software.
- The design of VPs to optimise learning within a required context i.e. clinical reasoning.
- The efficiency ratio of cost versus learning gains.

- Using VPs in PBL.

Further investigation is also required in the teaching and learning of clinical reasoning. Bearing in mind the time consuming nature of educators listening to students verbalise their clinical reasoning during patient interactions, the supervised verbalisation of clinical reasoning versus usual teaching needs further investigation. There is a temptation to conclude that noticing students' errors and correcting them during the verbalisation of clinical reasoning will improve clinical reasoning in practice-based learning, however, although that may be so, this study cannot conclude this. A comparative study of verbalisation of clinical reasoning versus usual teaching would clarify learning gains but the difficulties of measuring clinical reasoning remain. However, further studies are needed to measure learning gains as contemporary literature showed that simulation can increase confidence without increasing competence. This is potentially worrying for practice-based learning where students work with real patients whose safe and effective treatment is paramount and so further research in this area is a priority. Based on the findings of this case study the think-aloud method may be useful in ascertaining students' ability levels rather than just their confidence levels.

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8.00 Appendices

8.01 Email to recruit physiotherapy students IFS

Dear all

As a pilot study for my doctorate I want to investigate your opinions on the usability of a virtual family that has been created to help student health professionals improve their subjective interviewing technique. My proposal is for 8 to 10 participants from your cohort to individually use the virtual family for 1 hour in a computer lab. Then to follow this up with a 45 minute focus group to discuss all the participants opinions on the usability of the family and its effectiveness as an aid to subjective assessment. The lab session will start at 12.00 on Wednesday 12th of April 2006 directly followed by the focus group which will finish at 2pm. If you would like to participate in this study (you are under no obligation to do so) please can you reply to this email as soon as possible. Ethical approval has been sought and granted from the University Ethics Committee.

Thanks
Tracey

8.02 Participant information and consent form IFS

Participant Information and Consent Form

Physiotherapy students' opinions on the usability of a virtual patient interviewing software.

The purpose of this research is to investigate 1st year physiotherapy students' opinions on the usability of a virtual family which has been created to help student health professionals improve their subjective interviewing technique. Each participant will use the virtual family for 1 hour in a computer lab and directly following this will take part in a 45 minute focus group with the other participants to discuss their opinions on the usability of the virtual family and its effectiveness as an aid to subjective assessment. The lab session will start at 12.00 on Wednesday 12th of April 2006 directly followed by the focus group which will finish at 2pm. If you agree to participate in this study you are free to withdraw at any time without prejudice.

Involvement in this research project is entirely voluntary and if you do agree to participate in this study you are free to withdraw at any time without prejudice.

Your participation in this study is entirely confidential. At no time will you be identified within the published results of this study. The researcher is not receiving any funding or personal payment for

this study. Ethical approval has been sought and granted from the University Ethics Committee.

Please complete the consent form on the reverse of this information sheet. Thank you for your time.

The participant should complete the whole of this sheet him/herself

Please tick the appropriate box

	YES	NO
Have you read the Research Participant Information Sheet?		
Have you had an opportunity to ask questions and discuss this study?		
Have you received satisfactory answers to all your questions?		
Do you understand that you will not be referred to by name in any report concerning the study?		
Do you understand that you are free to withdraw from the study:		
➤ at any time		
➤ without having to give a reason for withdrawing?		
➤ without affecting your future education?		
Do you agree to take part in the focus group data collection phase of this study?		

I, _____ *(participant's full name) agree to take part in the above named project / investigation, the details of which have been fully explained to me and described in writing.

Signed
(Participant)

Date

I, Tracey Burge certify that the details of this project / investigation have been fully explained and described in writing to the subject named above and have been understood by him / her.

Signed
(Investigator)

Date

Please feel free to contact me in the future if you have any questions.

8.03 Virtual patient feedback report

User: David Jones

Date: 14/03/2008 09:12:33

Patient: Charlie Fern - Knee Injury

Session Name: observation14/3/08

Duration: 01:04:53 (As a Junior Physiotherapist, you would normally have 30

minutes to assess this patient)

Session Summary: You asked for the same information 4 times. Repeating requests can be frustrating to patients and harm your credibility. You requested 40 items that were not understood and 57 that were understood. Whilst some misunderstood requests are due to the limitations of the computer program one should try to use clear unambiguous language whenever possible.

Standard Protocol Compliance: You did not ask the patient for their consent to be assessed. You did not confirm the patient's name. You did confirm the patient's date of birth. You did not verify the patient's identity by asking them to confirm their address. This can also be helpful information to keep the patient's records up to date. You did not confirm the patient's current physician. Contacting the patient's physician may be required and this information can also be helpful to keep the patient's records up to date.

Timing of Assessment Requests: The sequence in which your Subjective requests were made is consistent with the sequence deemed appropriate by an expert panel. The sequence in which your Objective requests were made is consistent with the sequence deemed appropriate by an expert panel.

Relevance of Assessment Requests: The table below shows the relevance and quantity of questions/tasks you requested and the total possible questions/tasks deemed appropriate by an expert panel.

...	Subjective			Objective		
	Possible	Requested	Remaining	Possible	Requested	Remaining
Very Important	51	8	43	33	18	15
Important	65	15	50	16	4	12
Possibly Relevant	31	1	30	11	4	7

In addition, you requested 7 items that probably have no relevance for this patient/condition. Requesting information that is not relevant wastes time and resources and can be frustrating to the patient. Make every attempt to only ask for information you think will add value to your assessment.

Topic Areas of Assessment Requests: The table below shows the general topic areas and quantity of questions/tasks you requested and the total possible questions/tasks deemed appropriate by an expert panel.

Subjective		
Topic	Possible	Requested
Present Medical	0	0
Problem Specific	1	1
Causes	8	0
Effects	19	4
Clinical Events	10	1
General	0	0
Medications	3	3
Existing Conditions	13	5
Lifestyles	0	0
Hobbies/Leisure	2	0
Occupation	0	0
Work Locations	2	0
Work Descriptions	1	0
Living Arrangements	0	0
Co-Habitation	4	2
Habits	0	0
Drinking	1	0
Smoking	1	0
Drugs	1	0
Exercise	3	0
Social	1	0
Family	1	0
Permissions/Consent	5	0
Preferences	2	0
Demographics	10	1
Past Medical	0	0
Problem Specific	0	0

Causes	1	0
Effects	2	0
Clinical Events	4	1
General	0	0
Medications	2	0
Previous Conditions	11	1
Other	7	0
Other 2	18	7
Other 3	20	2
Objective		
Topic	Possible	Requested
Diagnostics	0	0
Muscle-Skeletal	4	2
Range of Movement	30	11
Special Tests	20	8
Observations	3	0
Muscle Tests	7	7

Problem List: You included 0 out of 9 possible items in your list that were deemed as good practice by an expert panel.

1	pain 4/10 - 7/10 on movement (twisting LR and F)	
2	Can't play sport at present (football and rugby)	

Treatment Plan: You included 0 out of 7 possible items in your list that were deemed as good practice by an expert panel.

muscle strengthening	1
thereaband, ligament strength	2

Short-Term Goals: You included 0 out of 0 possible items in your list that were deemed as good practice by an expert panel.

reduce pain from 4-7/10 to 2-4/10	10 days
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off crutches	14 days
participating in training in (light) with support	21 days

Long-Term Goals: You included 0 out of 0 possible items in your list that were de practice by an expert panel.

Return to competeive sport	30 days
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Scenario Specific Items: None.

Assessment Log :

Time	Request	Type	Response	Note
09:13:16	what is your main problem	Sub	Sorry, I do not know how to answer that.	
09:13:41	how are you feeling	Sub	Sorry, I do not know how to answer that.	
09:13:59	what is your problem	Sub	I hurt my left leg playing football 2 weeks ago. I had the ball and I was going to score for sure, this guy tackled me, but it was a foul tackle, he put his foot out to trip me and I went down. I twisted my left knee really badly.	
09:14:56	what is your pain	Sub	It's like a stabbing pain in my knee when I bend it too far or twist it.	
09:15:29	on a scale of 1-10 how painful is you knee	Obj	Sorry, I do not know how to answer that.	
09:15:41	how painful is your knee	Sub	On a scale of 1 to 10, it hurts about 6 at its worst and 2 at its best.	
09:16:18	do you have other injuries	Sub	No	
09:16:52	is it stopping you	Sub	Special 'Pronoun	

	from playing sports		Clarification' Response...	
09:17:12	is the injury stopping you from playing sports	Sub	Sorry, I do not know how to answer that.	
09:17:36	are you currently	Sub	Sorry, I do not know how to answer that.	
09:17:48	are you currently at school?	Sub	yes	
09:18:42	what aggravates your knee	Sub	Sorry, I do not know how to answer that.	
09:18:57	are there any aggravating factors	Sub	no	
09:19:11	are there any easing factors	Sub	no	
09:19:40	are there any movements that make the pain worse	Sub	Sorry, I do not know how to answer that.	
09:19:52	are there any movements that increase your pain	Sub	Sorry, I do not know how to answer that.	
09:20:10	are there any movements ease your pain	Obj	Sorry, I do not know how to answer that.	
09:20:24	are there any movements reduce your pain	Obj	Sorry, I do not know how to answer that.	
09:20:45	when does your pain get worse	Sub	Sorry, I do not know how to answer that.	
09:20:59	when does your pain begin	Sub	Sorry, I do not know how to answer that.	
09:21:30	what makes your pain worse	Sub	It is worse if I twist, especially when I get in and out of the car.	
09:22:42	which direction does the pain get worse	Sub	No	

09:23:10	what makes your pain better	Sub	It's better if I rest it by watching television or playing PlayStation with it up on the sofa.	
09:23:38	can you sleep at night?	Sub	I sleep OK sometimes my knee hurts if I twist it	
09:24:20	do you have any thyroid problems	Sub	no	
09:24:50	do you have any heart problems	Sub	No	
09:25:11	do you have any rheumatoid arthritis	Sub	No	
09:25:28	do you have any epilepsy?	Sub	No	
09:25:47	do you suffer from asthma	Sub	no	
09:26:12	Do you have diabetes ?	Sub	No	
09:26:38	have had any previous injuries	Obj	Sorry, I do not know how to answer that.	
09:26:52	have you been injured before	Sub	Sorry, I do not know how to answer that.	
09:27:30	have you had any previous problems?	Sub	Sorry, I do not know how to answer that.	
09:27:47	have you had any knee injuries before	Sub	Sorry, I do not know how to answer that.	
09:28:51	have you had an x-ray?	Sub	No, no X-Rays	
09:29:15	have you had any surgery	Obj	Sorry, I do not know how to answer that.	
09:29:29	have you had surgery before?	Sub	No	
09:30:05	how old are you?	Sub	13	
09:31:46	who referred you to physiotherapy	Sub	Sorry, I do not know how to answer that.	

09:31:58	did you see your doctor first?	Sub	Sorry, I do not know how to answer that.	
09:32:15	did you see your gp first?	Sub	Sorry, I do not know how to answer that.	
09:33:22	do you play any sports	Sub	I play football and rugby.	
09:33:51	any other social activities?	Sub	Sorry, I do not know how to answer that.	
09:34:10	is this injury preventing you from participating in sport?	Sub	Sorry, I do not know how to answer that.	
09:34:52	do you live with your parents?	Sub	My Mum and Dad and my little sister	
09:35:29	are you currently attending school?	Sub	yes	
09:36:46	are you currently on any medication	Sub	Sorry, I do not know how to answer that.	
09:37:00	are you currently taking any medication?	Sub	I don't know what they are	
09:38:06	are you taking any medication	Sub	I'm on paracetamol for pain if i need it but I don't take it much.	
09:39:03		NOTE		13 y/o male, pain L knee 6/10 stii at school and attending. lives at home with mum dad, and little sister. aggs: twisting movements, (soft tissue) eases: rest, sleeps ok T O H O R O E O A O D O PMH: no x-rays- no surgery: no medication: yes

				paracentamol, SH: plays footabll and rugby, is not playing at the moment due to injury.
09:40:15	are taking any anticoagulants?	Obj	Sorry, I do not know how to answer that.	
09:40:25	are you taking any steroids	Sub	I don't think I am on any steroids just painkillers	
09:40:39		NOTE		steroids, 0
09:41:26	observation of gait	Obj	Sorry, I do not know how to answer that.	
09:41:58	observation of left knee	Obj	mild effusion present	
09:42:23	is there inflamation?	Sub	Sorry, I do not know how to answer that.	
09:42:41	measurements of effusion	Obj	Sorry, I do not know how to answer that.	
09:43:17	observation of right knee	Obj	Normal	
09:44:12	active right knee flexion	Obj	Right Knee Active Flexion - :Full Range of Movement painfree	
09:44:55	active extension right knee	Obj	Right Knee Active Extension - :Full Range of Movement painfree	
09:45:19	active medial rotation right knee	Obj	Right Knee Active Medial Rotation - :Full Range of Movement painfree	
09:45:39	active lateral rotation right knee	Obj	Right Knee Active Lateral Rotation - :Full Range of Movement painfree	
09:46:18	active flexion left knee	Obj	Left Knee Active Flexion - :110	

			degrees of movement pain end of range over medial aspect of knee VAS 4	
09:48:05	active exstension left knee	Obj	Sorry, I do not know how to answer that.	
09:48:16	active medial rotation left knee	Obj	Left Knee Active Medial Rotation - :Full Range of Movement painfree	
09:49:11	active lateral rotation left knee	Obj	Left Knee Active Lateral Rotation -:10 degrees of movement pain medial aspect of knee VAS 7	
09:50:12	active extension left knee	Obj	Left Knee Active Extension - :Full Range of Movement Painfree	
09:51:40	passive flexion right knee	Obj	Right Knee Passive Flexion - :Full Range of Movement Painfree	
09:52:34	passive extension right knee	Obj	Right Knee Passive Extension - :Full Range of Movement Painfree	
09:52:50	passive medial rotation right knee	Obj	Right Knee passive medial rotation - :Full Range of Movement Painfree	
09:54:15	passive lateral rotation right knee	Obj	Right Knee passive lateral rotation - :Full Range of Movement Painfree	
09:54:49	passive flexion left knee	Obj	Left Knee Passive Flexion - :110 degrees of movement pain over medial aspect of knee limiting range VAS 4	
09:55:23	passive medial	Obj	Left Knee passive	

	rotation left knee		medial rotation - :Full Range of Movement Painfree	
09:55:41	passive extension left knee	Obj	Left Knee Passive Extension - :Full Range of Movement Painfree	
09:56:42	passive lateral rotation left knee	Obj	Left Knee passive lateral rotation - :10 degrees of movement limited by pain VAS 7	
09:57:29	how irritable is you knee?	Obj	Sorry, I do not know how to answer that.	
09:57:40	how irritable is you left knee	Obj	Sorry, I do not know how to answer that.	
09:58:00	how long does it take for your pain to go away?	Sub	Special 'Pronoun Clarification' Response...	
09:58:16	how long does your pain last for?	Sub	It hurts all the time but if I twist it, it hurts really bad but then it goes off again quite fast. It probably takes about 5 minutes.	
09:59:33	Resisted felxion right knee	Obj	Sorry, I do not know how to answer that.	
10:00:02	Resisted flexion right knee	Obj	Oxford Scale - 5 Painfree	
10:00:27	resisted extension right knee	Obj	Oxford Scale - 5 Painfree	
10:00:39	resisted medial rotation right knee	Obj	Oxford Scale - 5 Painfree	
10:00:47	resisted lateral rotation rightj knee	Obj	Sorry, I do not know how to answer that.	
10:01:25	RESISTED FLEXION LEFT KNEE	Obj	Oxford Scale - 4 slight discomfort medial aspect of	

			knee VAS 1	
10:02:11	resisted extension left knee	Obj	Oxford Scale - 4 slight pain medial aspect of knee VAS 2	
10:02:21	resisted extension left knee	Obj	Oxford Scale - 4 slight pain medial aspect of knee VAS 2	
10:02:45	resisted medial rotation left knee	Obj	Oxford Scale - 4 Painfree	
10:03:13	resisted lateral rotation left knee	Obj	Oxford Scale - 4 slight pain medial aspect of knee VAS 2	
10:03:52	apleys test	Obj	Sorry, I do not know how to answer that.	
10:04:02	apleys test right knee	Obj	Sorry, I do not know how to answer that.	
10:04:24	Apley's right knee	Obj	Sorry, I do not know how to answer that.	
10:04:37	Apley's test right knee	Obj	Sorry, I do not know how to answer that.	
10:04:48	Apley right knee	Obj	Sorry, I do not know how to answer that.	
10:05:10	valgus right knee	Obj	Sorry, I do not know how to answer that.	
10:05:27	valgus stress test right knee	Obj	Negative	
10:05:59	varus stress test right knee	Obj	Negative	
10:06:25	valgus stress test left knee	Obj	Pain medial aspect of knee VAS 4 no instability detected	
10:07:18	varus stress test left knee	Obj	Negative	
10:07:38	varus stress test left knee	Obj	Negative	
10:08:23		NOTE		Objective

				Assessment. L knee mild effusion, R knee normal AROM R knee: F full E full MR full LR full AROM L knee: F 110 pain 4/10 E full MR full LR 10 pain 7/10 clear hip and ankle...no problems PROM R knee F full E full MR full LR full PROM L knee F 110 4/10 E full MR full LR 10 7/10 RROM right knee F 5 E 5 MR 5 LR 5 RROM left knee F 4 1/10 E 4 2/10 MR 4 LR 4 2/10 special tests; valgus R knee: 0 Varus R knee: 0 Valgus L knee: pain 4/10 Varus L knee: 0
10:09:10	sag test left knee	Obj	Negative	
10:10:01	lachmans test left knee	Obj	Negative	
10:10:48	posterior draw test left knee	Obj	Negative	
10:10:56		NOTE		sag test L knee: 0 Lachmans test: 0 PCL draw test: 0

8.04 Email to recruit students beta testing

Dear all
I am undertaking a study for my doctorate entitled: Exploring the use of virtual patients to support the learning of patient assessment and clinical reasoning in physiotherapy.

The purpose of this research is to explore the effectiveness of a specific computer based musculoskeletal patient simulation resource in enhancing pre-clinical physiotherapy students' clinical reasoning processes. It aims to investigate the factors that influence the effectiveness, or the ineffectiveness, of the simulation.

The study involves you initially completing a pre-test Diagnostic Thinking Inventory, on Monday the 6th of August, which takes about 10 minutes. At 9.00 am on Tuesday 7th of August, in Lab F, you will be given access to the virtual patient resource for a three hour period to use as you wish. After the three hour period your access will be terminated and you will complete a post-test Diagnostic Thinking Inventory. Data will also be collected by the computer on your use of the resource.

On Wednesday the 8th of August a focus group will be used as a data collection method to explore your opinions of the virtual patient resource especially with regard to its ability to facilitate clinical reasoning. This focus group will be facilitated by the researcher.

The research will involve approximately four hours of your time plus 1 hour-1 hour 30 minutes if you agree to participate in the focus group. However, please note even if you do not wish to participate in the study you are still able to use the resource for the three hour period in lab F.

Involvement in this research project is entirely voluntary and if you do agree to participate in this study you are free to withdraw at any time without prejudice.

Your participation in this study is entirely confidential. At no time will you be identified within the published results of this study. Ethical approval has been sought and granted from the University Ethics Committee.

On Monday the 6th of August I will be available to answer any questions and I will have consent forms for you to sign if you are willing to participate.

Thank you
Tracey

8.05 Participant information and consent form beta testing

Participant information and consent form

Exploring the use of virtual patients to support the learning of

patient assessment and clinical reasoning in physiotherapy.

The purpose of this research is to explore the effectiveness of a computer-based musculoskeletal patient simulation in enhancing pre-clinical physiotherapy students' clinical reasoning processes. It aims to investigate the factors that influence the effectiveness, or the ineffectiveness, of the simulation.

The study involves you initially completing a pre-test Diagnostic Thinking Inventory, on Monday the 6th of August, which takes about 10 minutes. At 9.00 am on Tuesday 7th of August, in Lab F, you will be given access to the virtual patient resource for a three hour period to use as you wish. After the three hour period your access will be terminated and you will complete a post-test Diagnostic Thinking Inventory. Data will also be collected by the computer on your use of the resource.

On Wednesday the 8th of August a focus group will be used as a data collection method to explore your opinions of the virtual patient resource especially with regard to its ability to facilitate clinical reasoning. This focus group will be facilitated by the researcher.

The research will involve approximately four hours of your time plus 1 hour-1 hour 30 minutes if you agree to participate in the focus group. However, please note even if you do not wish to participate in the study you are still able to use the resource for the three hour period in lab F.

Involvement in this research project is entirely voluntary and if you do agree to participate in this study you are free to withdraw at any time without prejudice.

Your participation in this study is entirely confidential. At no time will you be identified within the published results of this study.

The researcher is not receiving any funding or personal payment for this study. Ethical approval has been sought and granted from the University Ethics Committee.

Please complete the consent form on the reverse of this information sheet. Thank you for your time.

The participant should complete the whole of this sheet him/herself

Please tick the appropriate box

	YES	NO
Have you read the Research Participant Information Sheet?		
Have you had an opportunity to ask questions and		

discuss this study?		
Have you received satisfactory answers to all your questions?		
Do you understand that you will not be referred to by name in any report concerning the study?		
Do you understand that you are free to withdraw from the study:		
➤ at any time		
➤ without having to give a reason for withdrawing?		
➤ without affecting your future education?		
Do you agree to take part in the quantitative data collection phase of this study? (diagnostic thinking inventory and virtual patient tracking)		
Do you agree to take part in the focus group data collection phase of this study?		

I, _____ *(participant's full name)
 agree to take part in the above named project / investigation, the details of which have been fully explained to me and described in writing.

Signed
 (Participant)

Date

I, Tracey Burge certify that the details of this project / investigation have been fully explained and described in writing to the subject named above and have been understood by him / her.

Signed
 (Investigator)

Date

Please feel free to contact me in the future if you have any questions.

8.06 Diagnostic Thinking Inventory

Diagnostic Thinking Inventory

(Adapted from Bordage, Grant, and Marsden, Med. Ed. 1990, 24:413-425)

Instructions

This inventory contains 40 items concerning your diagnostic thinking. Each item contains a stem, two accompanying statements and a rating scale. The scale refers to a continuum between the two statements. Please put a cross (X) in the box which best describes your position on the continuum.

Do not try to work out any underlying meaning to each item; there is no right or wrong answer. Only the sum of the items will have significance. Simply respond as spontaneously as you can by indicating how you actually diagnose and not how you think you should. You often find that you actually do things associated with both statements for a given item; the position of your cross on the scale will indicate which one you do most often.

Do not put your mark on a line; if you hesitate between two statements, please decide which one reflects what you do most often. You may think that there are other alternatives beside the two statements given (and there can be more than two in many instances), please make a choice on the basis of the two statements provided.

The word 'diagnosis' relates to your assessment findings, not necessarily the doctor's/referral diagnosis.

It will take you about 10 to 15 minutes to complete the inventory

Name:

Date:

1.	<i>When the patient presents his/her symptoms,</i>	I think of the symptoms in the precise words used by the patient								I think of the symptoms in more abstract terms than the expressions actually used (e.g. acute / bilateral)
2.	<i>In considering each possible diagnosis,</i>	I try to evaluate their relative importance								I try to give them equal importance or weighting
3.	<i>In thinking of diagnostic possibilities,</i>	I think of diagnostic possibilities early on in the case								First I collect the clinical information and then I think about it
4.	<i>When I am assessing a patient,</i>	I often get one idea stuck in my mind about what might be wrong								I usually find it easy to explore various possible diagnoses
5.	<i>Throughout the assessment,</i>	If I follow the patient's line of thought, I tend to lose my own thread								I can still keep my own ideas clear even if I follow the patient's line of thought
6.	<i>When it comes to making up my mind about the diagnosis,</i>	I do not mind postponing my decision about the case								I feel obliged to go for one diagnosis or another even if I am not very certain
7.	<i>Once the patient has clearly presented his/her signs and symptoms,</i>	I think about them in my mind in the patient's own words								I translate them in my mind into medical terms (e.g. numbness becomes Paresthesia)
8.	<i>In relation to the routine history,</i>	I often feel that I did not sufficiently cover the routine history								I usually cover the routine history to my satisfaction
9.	<i>As the patient tells his/her story and the</i>	I often find it difficult to remember what has been said								I can usually keep track in my mind of what has been said

	<i>case unfolds,</i>									
10.	<i>During the course of an interview, I find that:</i>	Some key pieces of information seem to leap out at me								It is often difficult to know which items of information to latch onto
11.	<i>When I cannot make sense of the patient's symptoms,</i>	I move on and gather new information to trigger new ideas								I ask the patient to define these symptoms more clearly
12.	<i>In considering diagnostic possibilities,</i>	I often come up with unlikely diagnoses								I am usually in the right area
13.	<i>While I am collecting information about a patient,</i>	The various items of information usually seem to group themselves together in my mind								I often have difficulty seeing how the pieces of information relate to each other
14.	<i>When the diagnosis becomes known and I realise that I've missed it initially</i>	It is often because I knew the disease/injury/condition but failed to think about it								It is often because I do not know enough about the disease/injury/condition
15.	<i>During the clinical interview,</i>	I cannot bring myself to dismiss some information as irrelevant								I'm quite happy to dismiss some information as irrelevant

8.07 Email to recruit physiotherapy students case study

Dear all

I am undertaking a study for my doctorate entitled: Exploring the use of virtual patients to support the learning of patient assessment and clinical reasoning in physiotherapy.

The purpose of this research is to explore the effectiveness of a specific computer based musculoskeletal patient simulation resource in enhancing pre-clinical physiotherapy students' clinical reasoning processes. It aims to investigate the factors that influence the effectiveness, or the ineffectiveness, of the simulation.

The study involves you being given access to the virtual patient resource for a three month period to use as you wish. After this period your access will be terminated. Data will also be collected by the computer on your use of the resource.

In April focus groups will be used as a data collection method to explore your opinions of the virtual patient simulation especially with regard to its ability to facilitate clinical reasoning. These focus groups will be facilitated by the researcher.

The research will involve approximately 1 hour-1 hour 30 minutes if you agree to participate in the focus group. Beyond this the time you spend using the resource is entirely up to you.

Involvement in this research project is entirely voluntary if you do not wish to participate in the study you are still able to use the resource for the three month period.

If you do agree to participate in this study you are free to withdraw at any time without prejudice.

Your participation in this study is entirely confidential. At no time will you be identified within the published results of this study. Ethical approval has been sought and granted from the University Ethics Committee.

On Tuesday the 8th of January at 9.00 am in the skills lab I will be available to answer any questions and I will have consent forms for you to sign if you are willing to participate.

Thank you
Tracey

8.08 Ethical approval

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Memorandum

To: Heads of School/Research Ethics Officers

From: David Anderson-Ford, Chair, University Research Ethics Committee

Phone: 68731

Subject: Statement of approval Date: 17 May 2006

I would like to remind you that for any research involving human participants which is conducted under Brunel University sponsorship, a statement indicating that the research project has been approved by either a School Research Ethics Committee, or the University Research Ethics Committee, must be included on all information sheets, advertisements (such as e-mails requesting participants) and posters.

This applies equally to research conducted by students or staff members at this University.

Head of School of Sport & Education
Professor Ian Rivers

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Tracey Burge
Doctor of Education (EdD) Research Student
School of Sport and Education
Brunel University

DUPLICATE LETTER

16th June 2014

Dear Tracey

RE33-07 Does a computer based free-text "virtual patient" simulation resource help facilitate the clinical reasoning of pre-clinical physiotherapy students?

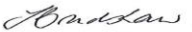
I am writing to confirm the Research Ethics Committee of the School of Sport and Education received your application connected to the above mentioned research study. Your application has been independently reviewed to ensure it complies with the University/School Research Ethics requirements and guidelines.

The Chair, acting under delegated authority, is satisfied with the decision reached by the independent reviewers and is pleased to confirm there is no objection on ethical grounds to grant ethics approval to the proposed study.

Any changes to the protocol contained within your application and any unforeseen ethical issues which arise during the conduct of your study must be notified to the Research Ethics Committee for review.

On behalf of the Research Ethics Committee for the School of Sport and Education, I wish you every success with your study.

Yours sincerely


pp Dr Richard J Godfrey
Chair of Research Ethics Committee
School Of Sport and Education



8.09 Participant information and consent form case study

Participant Information and Consent Form

Exploring the use of virtual patients to support the learning of patient assessment and clinical reasoning in physiotherapy.

The purpose of this research is to explore the effectiveness of a computer-based musculoskeletal patient simulation in enhancing pre-clinical physiotherapy students' clinical reasoning processes. It aims to investigate the factors that influence the effectiveness, or the ineffectiveness, of the simulation.

The study involves you being given access to the virtual patient resource for a three month period to use as you wish. Data will be collected by the software on your use of the resource.

In the second month of access think-aloud sessions will be undertaken which involve the researcher videoing participants while they use the virtual patient and verbalise their thought processes.

In the third month of access focus groups will be used as a data collection method to explore your opinions of the virtual patient simulation especially in regard to its ability to facilitate clinical reasoning. The focus groups will be facilitated by the researcher.

The research will involve approximately 1 hour-1 hour 30 minutes if you agree to participate in the focus group or a think-aloud session. Beyond this the time you spend using the resource is entirely up to you.

Involvement in this research project is entirely voluntary and if you do agree to participate in this study you are free to withdraw at any time without prejudice.

Your participation in this study is entirely confidential. At no time will you be identified within the published results of this study.

The researcher is not receiving any funding or personal payment for this study. Ethical approval has been sought and granted from the University Ethics Committee.

Please complete the consent form on the reverse of this information sheet. Thank you for your time.

The participant should complete the whole of this sheet him/herself

Please tick the appropriate box

	YES	NO
Have you read the Research Participant Information Sheet?		
Have you had an opportunity to ask questions and discuss this study?		
Have you received satisfactory answers to all your questions?		
Do you understand that you will not be referred to by name in any report concerning the study?		
Do you understand that you are free to withdraw from the study:		
➤ at any time		
➤ without having to give a reason for withdrawing?		
➤ without affecting your future education?		
Do you agree to take part in the quantitative data collection phase of this study?		
Do you agree to take part in the focus group data collection phase of this study?		
Do you agree to take part in the think-aloud data collection phase of this study?		

I, _____ *(participant's full name) agree to take part in the above named project / investigation, the details of which have been fully explained to me and described in writing.

Signed

Date

(Participant)

I, Tracey Burge certify that the details of this project / investigation have been fully explained and described in writing to the subject named above and have been understood by him / her.

Signed _____ Date _____
(Investigator)

Please feel free to contact me in the future if you have any questions.

8.10 Coding tables for think-aloud

Initial reduction of think-aloud data									
Participant	R	A	D	K	N	J	G	C	M
Virtual Patient	CF	JP	CF	AJ	AJ	CF	AJ	AJ	JP
Verbalised clinical reasoning at first observation									
Adhering to process of subjective assessment									
NOT adhering to process of subjective assessment									
Verbalised wanting to adhere to predetermined process									
Verbalised hypotheses									
Pattern recognition verbalised from mechanism of injury									
Adherence to hypothesis from mechanism of injury potential error									
Clinical reasoning error from observation									
Verbalised error in knowledge									
Commented on feedback									
Time pressure affected use									
Use of abbreviations									
Issues with phraseology and VP									
Useful									

Reality of multiple issues in patients condition									
Lack of clinical reasoning in management plan									
Verbalisation of clinical reasoning in management plan									
THREAD									
Medication									
Terminology issue									
Using SIN to clinically reason assessment									
Holistic narrative									
Systematic appropriate OA									
Integration of propositional knowledge									
Verbalised integration of propositional knowledge									
Used VP in the way that should assess a real patient									
Empathy for VP									
Thinking as if patient real									
Analysis stimulating clinical reasoning									
Reflection in action self-correction of errors									
Conflicting data									
Lack of prepositional knowledge verbalised									
VP taught prepositional knowledge									
Collaboration of VP wishes in management plan									
Need to guide student how to use software									
Issue/idea of writing legal record notes									
Used notes section									
Spelling errors									
Reviewed assessment									

to create management plan									
Realised at management planning had not included patient									
Showed issues with usual teaching									
Student stimulated teaching at the end									
Comments on design									
Improvement suggestions									
Verbalisations of lack of reality									
Practice needed for usability									
Do I get a mark?									
Clinical reasoning error corrected by researcher									

Second reduction of think-aloud data	
Pattern code	Descriptive code
Fidelity	Empathy
	Thinking as if patient is real
	Used VP in the way should assess a real patient
	Verbalisation of lack of reality
	Including VP wishes in management plan
	Asked VP social history, hobbies, work
Subjective assessment	Adhering to process of subjective assessment
	Integration of propositional knowledge
	THREAD
	Medication
	Wanting to adhere to predetermined SA process
	Terminology issue
Objective assessment	Not adhering to process of SA
	Used SIN to CR objective assessment
	Integration of propositional knowledge
	Systematic appropriate OA
Clinical reasoning using VP	Used VP in the way should assess a real patient
	Integration of propositional knowledge
	Realised at management planning had not sought patient view point during assessment
	Reviewed assessment to create management plan
	Verbalisation of CR in management plan
	Lack of clinical reasoning in management plan
Verbalised CR while observing initial video	

	Used SIN to CR OA
	Analysis simulating CR
	Used VP in the way should assess a real patient
	Verbalisation of CR in management plan
	Conflicting data given by VP
Reflection in action	Reflection in action self-correction of errors
	Realised at management planning had not sought patient view point during assessment
Hypothetico-deductive reasoning	Verbalised CR while observing initial video
	Integration of propositional knowledge
	Verbalised CR while observing initial video in error
	Verbalised hypotheses
	Differentially tested verbalised hypotheses
	Verbalisation of CR in management plan
Pattern recognition	Hypothesis verbalised from mechanism of injury
	Integration of propositional knowledge
	Adherence to hypothesis verbalised from mechanism of injury leading to potential CR error
Narrative reasoning	Including VP wishes in management plan
	Realised at management planning had not sought patient view point during assessment
	Asked VP social history, hobbies, work
	Verbalisation of CR in management plan
VP taught prepositional knowledge	VP taught prepositional knowledge
Theory-practice gap	Reality of multiple issues in patients condition
	Conflicting data
	Terminology
	Raised issues with usual teaching
	Issues with phraseology and VP
Ease of use	Guide student how to use software
	Spelling errors
	Comments on design
	Practice needed for usability
	Wanting to adhere to predetermined SA process
	Issues with phraseology and VP
Feedback	Do I get a mark?
	Commented on feedback from VP
Usefulness	Useful
Issues with usual teaching	Raised issues with usual teaching
	Lack of prepositional knowledge verbalised
	Verbalised errors in knowledge
Unknown errors	Verbalised errors in knowledge
	Raised issues with usual teaching
	CR error corrected by researcher
	Lack of prepositional knowledge verbalised
Catalyst for	CR error corrected by researcher

teaching	Student initiated teaching
	Verbalised errors in knowledge
Time	Time pressure affected use
Improvement ideas for VP	Writing proper legal patient record
	Used notes section
	Improvement suggestions
	Spelling errors

Defining themes from think-aloud data	
Themes	Grouping of pattern codes
Facilitating learning of assessment process	Subjective assessment
	Objective assessment
	Theory-practice gap
Facilitating learning of clinical reasoning	Clinical reasoning using VP
	Reflection in action
	Information from patient stimulating CR
	Hypothetico-deductive reasoning
	Pattern recognition
	Narrative reasoning
	Theory-practice gap
	Unknown errors
Usability	Ease of use
	Usefulness
	Fidelity
	Feedback
	Theory-practice gap
Catalyst for learning and teaching	Feedback
	Issues with usual teaching
	Catalyst for teaching
	VP taught prepositional knowledge
	Theory-practice gap
	Ease of use
Improvements to VP design	Improvement ideas for VP
Usage	Time pressure affected use
	Ease of use
Bridging theory-practice gap	Theory-practice gap
	Fidelity
	Issues with usual teaching
	Usefulness
	Information from patient stimulating CR
Verbalisation detected errors	Catalyst for teaching
	Unknown errors
	Issues with usual teaching
	Theory-practice gap

Important findings from think-aloud data	
Facilitating clinical reasoning in the patient assessment process	Facilitating learning of assessment process
	Facilitating learning of clinical reasoning
Usability of virtual patients	Usage
	Improvements to VP design
	Facilitating learning of clinical reasoning
	Facilitating learning of assessment process
Supervised verbalising of patient assessment detects errors in clinical reasoning	Verbalisation detected errors
	Catalyst for learning and teaching
	Facilitating learning of clinical reasoning
Response fidelity bridging the theory-practice gap	Bridging theory-practice gap
	Facilitating learning of clinical reasoning

8.11 Coding tables for focus groups

Initial reduction of focus group data			
Description	A	B	C
Made me interpret results			
Better than each other because gives real information to think about			
Improves objective because good subjective information			
Revision of subjective and pulling assessment together			
Made me think about what I needed to ask			
Made me practice writing information down to get the bigger picture			
Helped cement correct process of assessing			
Good to sit alone and practice with no classroom distraction			
More scenarios to practice			
Use instead of paper PBL as a discussion tool, be better			
Better than each other because makes you think about pathology			
Made me clinically reason			
Got me thinking loads about what could be wrong			
Seeing video helped			
It got me thinking about goals			
Feedback useful to know if you're getting it right			
Come up with idea in subjective then prove in objective			
Really convenient any time, place			
Practice makes perfect			
Good for clinical reasoning as don't get to use real patients			
More realistic than lectures/paper PBL			
Interpreting the video			
Good as testing knowledge			
Less pressure than role play, not being judged			

Patient was real			
Good preparation for real patients			
Did differential testing			
Left likely painful/positive tests to last			
Can make mistakes without hurting patient			
Better than paper PBL because gives really information to think about			
Difficulty with question inputting			
Feedback not specific enough			
Wording of questions not as in reality			
Use of question lists would be better			
More structured patient record to input data into			
Feedback should show pass or fail			
More images i.e. of range of movement and posture			
Unexpected symptoms make you clinically reason			
More complex patients			
Weird answers from VP			
No body language			
VP had more complex problems than taught in lectures			
Blocked pop ups			
Mechanism of injury – pattern recognition			
Believed the medical diagnosis			
Feedback unconstructive			
Computer asking why you did something would help clinical reasoning			
Useful to work together on VP helps clinical reasoning			
Could not make VP work on computer			

Second reduction of focus group data	
Pattern code	Descriptive code
VP facilitated clinical reasoning	Made me interpret results
	Made me clinically reason
	Got me thinking loads about what could be wrong
	Come up with idea in subjective then prove in objective
	Good for clinical reasoning as don't get to use real patients
	Did differential testing
	Left likely painful/positive tests to last
	Unexpected symptoms make you clinically reason
	Unexpected symptoms make you clinically reason
	Mechanism of injury – pattern recognition
	Believed the medical diagnosis
	Interpreting the video
	Useful to work together on VP helps clinical reasoning
Better than role play	Better than each other because gives real information to think about
	Better than each other because makes you think about pathology

	Less pressure than role play, not being judged
Helped learn assessment process	Revision of subjective and pulling assessment process together
	Helped cement correct process of assessing
	Made me think about what I needed to ask
	It got me thinking about goals
	Good as testing knowledge
Writing patient assessment record	Made me practice writing information down to get the bigger picture
	More structured patient record to input data into
Good for self-directed individual learning	Really convenient any time, place
	Good to sit alone and practice with no classroom distraction
Would enhance current PBL methods	Use instead of paper PBL as a discussion tool, be better
	Better than paper PBL because gives really information to think about
	More realistic than lectures/paper PBL
	Useful to work together on VP helps clinical reasoning
Feedback needs improving	Feedback useful to know if you're getting it right
	Feedback not specific enough
	Feedback should show pass or fail
	Feedback unconstructive
Deliberate practice	Practice makes perfect
	Good preparation for real patients
The video was useful	Interpreting the video
	Seeing video helped
	More images i.e. of range of movement and posture
	Blocked pop ups
Fidelity	No body language
	Patient was real
Practice safely	Can make mistakes without hurting patient
Improvements to VP design	Computer asking why you did something would help clinical reasoning
	More structured patient record to input data into
	Use of question lists would be better
	More complex patients
	More scenarios to practice
Issues with technology	Blocked pop ups
	Could not make VP work on computer
Theory-practice gap	VP had more complex problems than taught in lectures
Use of VP	Could not make VP work on computer
	Useful to work together on VP helps clinical reasoning
	Difficulty with question inputting
Issues with free-text questions	Difficulty with question inputting
	Wording of questions not as in reality
	Use of question lists would be better

	Weird answers from VP
--	-----------------------

Defining themes from focus group data	
Theme	Grouping of pattern codes
Practice of assessment process	Helped learn assessment process
	Writing patient assessment record
	Deliberate practice
Clinical reasoning	Caused clinical reasoning
	The video was useful
Usability	Issues with free-text questions
	Fidelity
	Issues with technology
	Feedback
	The video was useful
Learning and teaching methods	Better than role play
	Would enhance current PBL methods
	Good for self-directed individual learning
	Theory-practice gap
	Feedback
Improvements to VP design	Improvements to VP design
	Feedback
	The video was useful
	Writing patient assessment record
Usage	Issues with technology
	Use of VP

Important findings from focus group data	
Facilitating the learning of the patient assessment process	Practice of assessment process
	Clinical reasoning
Using VPs to improve usual learning and teaching methods	Learning and teaching methods
	Improvements to VP design
Usability of virtual patients	Usage
	Usability

1 **8.12 John: think-aloud transcript**

2 Facilitator: just try and tell me what you're thinking.

3 John: All right.

4 Facilitator: There's nothing wrong, you know, just tell me speak to me.

5 John: Yes, so. So, obviously just looking at his posture and the way he
6 walks in. Erm, so for this guy I've noticed the way he is sitting first of all.

7 And the fact that he's not weight bearing on his, what looks like to be his
8 injured side. Erm, so just starting off by asking him what his current

9 problem is. Err, just to find out obviously why he's seeing a Physio. and just
10 noting down, just for my own, just so I can remember exactly what's going
11 on. Erm, so, he's told me the mechanics behind the injury, so, and how it
12 happened. How long ago it happened. So, err, I need to find out how bad
13 the pain, err, yeh, "How bad is the pain?", 'cos he's said, err, OK, I will ask
14 him if it's painful. (laugh) Err.

15 John: So, he's confirmed that it's painful, so I will ask, err, how painful.

16 John: Yes, erm, just really phrasing the question. It doesn't like that. Erm.

17 Facilitator: Trying to get a pain score. Are you?

18 John: Yes, I have got it before.

19 John: Yes, erm, right. Got that. Erm.

20 Facilitator: So does it make you think anything, the information that you
21 are getting?

22 John: Erm, the, it's 6 at worse, so, I'm just thinking that it's relatively severe.

23 Err, erm, well it is at its worst but it does ease off quite a lot, down to 2.

24 Erm, so I just need to find out what it is at the moment. Erm.

25 John: Right this is what I was going to go onto next, it's telling me, erm,
26 what makes it worse. Erm, so, just to try and think about the mechanics
27 again already of anatomically what's, yeh, anatomically wise what's going
28 on to make it worse.

29 Facilitator: Uh, hum

30 John: Erm, and also give you an idea of treatment wise, no, well

31 assessment and treatment wise what you can and can't do and get a link in

32 later to, erm, maybe goals and things, 'cos he's saying here about getting in

33 and out of the car. So, that might link in at the end towards goals and
34 problems and things.

35 Facilitator: Uh, hum

36 John: Erm, right, erm, so, erm, I've found out that he's in pain, how it
37 happened, the levels of pain, what makes it worse, what makes it better.
38 So, I'll find out if there is a daily pattern that makes it good or bad. Erm,
39 which he says, "no". Trying to think what that would show (laugh). Erm,
40 he's saying it's just when he twists, so that's making me think it's just a
41 mechanical, mechanical problem because obviously it's when he
42 specifically does something. Whereas if it was something through the day it
43 could be more, I'm thinking more pathology. I think.....

44 Facilitator: Uh, hum

45 John: Erm, so, that's kind of, I'm thinking that's probably it for history of
46 current problem. So I need to find out if he's had any past knee problems,
47 past medical problems. Whether it be specific to the knee, or, erm, anything
48 else. Erm, if I can phrase it right.

49 John: Erm, so he's not had any past knee problems and he's not been sick
50 recently. So, there's probably not many contraindications or, erm, kind of
51 complications with the injury. So, erm, so I need to, so I've got the current
52 medical history, so I need to find out about kind of how it affects his life a bit
53 more maybe. Erm, erm.

54 John: Just got to find the right way to ask it (laugh)!

55 Facilitator: Did you get an answer that time?

56 John: Yeh, got an answer that time. So, it can't stop him from playing
57 football, which is the main thing. So, well the only thing he says, so again,
58 that's going to link into, erm, goals to help kind of motivate him. So linking
59 in with your treatment and time scales and everything, erm, and problem
60 list.

61 John: Erm, just find out, so he's got no other medical problems, just to
62 check for contraindications, erm, erm, I will go through THREAD with. Do I
63 need, if I ask? Yeh.

64 Facilitator: Uh, hum

65 John: Oh, that's probably. Erm, so obviously just doing the red flags, erm,
66 erm.

67 John: Erm, erm, so doesn't seem to have any red flags, so move on to, erm,
68 medications just to check if he's taking any medications. So, he's saying
69 that he sometimes takes Paracetamol, so, I need to see if he's actually, I
70 can see if he's on it, taking it now 'cos that may affect his pain ratings. I'm
71 not sure I got an answer to that one though.

72 Facilitator: Did you?

73 John: No well, the same answer, so I would, I'm on Paracetamol for pain if I
74 need it, but I don't take it much.

75 Facilitator: Right.

76 John: I would assume he's probably not at the moment then.

77 John: Erm, so, I've done past medical history, current problem, social
78 problems, erm (laugh). I've just realised that I have forgotten some of the
79 main things that I'm.....

80 Facilitator: Like what?

81 John: Name, age, date of birth (laugh), but I think that's because he's not
82 there. Shall I do it anyway or?

83 Facilitator: No. That's fine. For the purposes of the tape you have just told
84 me you forgot it so that's fine.

85 John: Erm, so obviously that includes consent.....

86 John: Erm, right, so, I think I am probably going to move on to objective.
87 Yeh, so, I think I have asked everything I need, so, I'll move onto objective.

88 Facilitator: OK

89 John: Erm, so, I'm thinking to start off with, erm, now I think I wouldn't do
90 something like sit to, like functional, sit to stand, because I have watched
91 him do that. So, from what I saw I'm happy that I can see it's clearly some
92 kind of, you know, I think I picked up enough from the first time.

93 Facilitator: Uh, hum

94 John: So, erm, and I have watched him walk as well as he came in, so I
95 don't think I'd get him to do that again. So, I think I'll just go into the active
96 range of movements.

97 Facilitator: Uh, hum

98 John: So, I probably won't pick up the previous abbreviations but I'll see.
99 Nope.

100 Facilitator: What did you put in?

101 John: I just A ROM knee, but.....

102 Facilitator: No. What you need to, you don't need to put in range of
103 movement, you do need to put in active.

104 John: So, active knee flexion.

105 Facilitator: But, and also, which knee.

106 John: Yeh, so, his I have just got to check his right knee first 'cos it's the
107 good knee.

108 Facilitator: Uh, hum

109 John: So, full range of movement, as we would expect. So, I'm just going
110 through all the different ranges of movement, erm, start sticking with all the,
111 I'll do all the active on one side and then do them on the other side.

112 Facilitator: Uh, hum

113 John: Erm, so again normal, erm, so, erm, I have done it for the good side.
114 Erm, so, active for the bad side now, erm, err. So, erm, I'm just going to do
115 active for all of them before I kind of think about it, if you get what I mean.

116 Facilitator: Uh, hum

117 John: So, I'd get them all first and then I'd look more at them what I'm
118 thinking....

119 Facilitator: Right

120 John: their meaning. Erm, I just find it easier to get them done before I start
121 thinking

122 John: Erm, erm, right, so, so I have done the active now on the bad side, so
123 the problems are with flexion and medial rotation. No sorry, flexion and
124 lateral rotation. So, erm, and the lateral rotation is more painful, but the
125 pain is on the medial side. So, I'm thinking kind of ligament, medial
126 ligament or a cartilage problem on the medial side, possibly. Erm, so, but
127 I'll do passive range of movement just to kind of check for muscular, just to
128 check whether it's jointy or muscular.

129 Facilitator: Uh, hum

130 John: So, erm, so again need to do it on the good side first as suspected, all
131 clear. So, on the bad side.

132 Facilitator: Why are you looking puzzled?

133 John: Erm, right, I was just checking. It's given exactly the same result as
134 on the active.

135 Facilitator: Uh, hum

136 John: so I was just checking and I was thinking to myself then about my
137 comment about it being muscular or jointy.

138 Facilitator: Uh, hum

139 John: Erm, thinking well passive would usually, if it was pain on passive you
140 are looking at jointy. So, erm, yeh, I was just kind of confusing myself.

141 Facilitator: Uh, hum

142 John: Thinking well, I was thinking for a moment that ligaments would come
143 under muscular but they don't, they would come under jointy I am
144 assuming. 'cos this is obviously suggesting then that it's jointy because
145 there's pain on passive.

146 Facilitator: Uh, hum

147 John: So, I was starting', starting to think ahead (laugh) which I try not to do
148 (laugh) too much, although I do confuse myself. So, left knee just asked the
149 same question again. So, again, the lateral rotation is giving the same as
150 on the active movement, which again is kind of expected.

151 Facilitator: What movements are you doing now?

152 John: Passive lateral medial rotation.

153 Facilitator: Right, OK.

154 John: Erm, so because of the pain though, then you wouldn't over press,
155 erm, so, obviously this is leading me to think that it's some sort of jointy
156 problem, 'cos of his age and everything you are not kind of thinking
157 pathology, erm, and 'cos of where the pain is and how it happened you
158 think, I am thinking ligament or, cart., either the collateral ligament or
159 cartilage. So, I think my next test will be, kind of specific....

160 Facilitator: Uh, hum

161 John: test. Erm, I don't think it's relevant to clear the hip or anything
162 because again how it happened.

163 Facilitator: Uh, hum

164 John: Erm, so active range of movement, passive range of movement. So,
165 erm, I would start off with the erm, stress test for the medial lateral
166 ligaments on the good leg again. Erm, so obviously the good one, as
167 expected is negative. So, erm, on the valgus stress test of the left knee

168 there's pain and instability, so that's suggesting that it is the medial
169 collateral ligament. Erm, so I'll just write that down first (laugh).
170 John: So, that's suggesting then that's, erm, medical collateral, erm, but I
171 still want to check the meniscus, erm, because they're all kind of interlinked
172 on the medial side, I think. So, I'm going to do McMurray's again on the right
173 left first. So that's negative on both sides, which would suggest that it's not
174 meniscus. Erm, just thinking for a second there about his movement that he
175 had, just to check that test would be good enough, 'cos you need full knee
176 flexion. So, I think I'll just check with Apley's as well because of the
177 restriction in his movement. Don't know how to spell Apley's?
178 Facilitator: A P L E Y, apostrophe S
179 John: Yeh, that's what I tried. I think.
180 Facilitator: Oh, OK, did you tell it which knee?
181 John: Yeh, I tried without the apostrophe.
182 Facilitator: Did you put in test?
183 John: Erm, just check, I know it's not a double "p" but you never know.
184 Facilitator: Erm, I think Apley's is programmed in there. Maybe it isn't!
185 John: It's not coming up.
186 Facilitator: Never mind. It's the thought that counts.
187 John: So, (laugh), right, so, I think with that, that's probably enough. Erm, I
188 think that's enough for the objective because, because it's painful on active
189 and passive, don't need to do resisted erm, 'cos the passive suggests as I
190 said, that it's jointy. Erm, so, obviously I'm thinking that it's definitely the
191 medial collateral ligament. Erm, and in the left knee, erm, just saying tear
192 because I don't think I've really gone into.....
193 Facilitator: Uh, hum
194 John: Different levels. So, I think that's it for objective. So I think I need to
195 go onto problems and things.
196 Facilitator: OK
197 John: So, erm, let's just check what I've done. These aren't in, they don't
198 need to be in order, do they?
199 Facilitator: No
200 John: So, just wondering, don't know if you can do this, if you can ask the
201 patient, erm. No, erm....

202 Facilitator: What are you asking him?
203 John: Just seeing if he, if you can ask him what his biggest problem was....
204 Facilitator: Uh, hum
205 John: or anything about goals, but.....
206 Facilitator: Uh, hum
207 John: It's not coming up with anything, so I'll just do it, 'cos obviously you
208 would check with the patient.....
209 Facilitator: Uh, hum
210 John: to agree with that. So, erm, so, just put that he can't play football as
211 one problem. Erm, pain in left knee, erm, which was VAS between 2 and 6.
212 Erm, reduced knee flexion, reduced lateral rotation. So, I'm just trying to put
213 in specific values so that you can make specific goals from that.
214 Facilitator: Uh, hum
215 John: Erm, can't play football, pain in left knee, reduced flexion, and
216 reduced rotation. Forgotten what his other problems were. Twisting and
217 getting in and out of the car.
218 Erm, so, I've got 5 problems there which I think I'll probably stick at. So,
219 short term goals, erm, long term goal, I'll do first, which will probably be play
220 football. Erm, time frame, erm, just make it up, wants it in days, so, I'm
221 going to say, I'm saying 60, I don't know if that's anywhere near.
222 John: I'm thinking 6 to 8 weeks.
223 John: Erm, so, short term goals, going to be reduce pain, erm, erm, I'm just
224 going to put to zero. Erm, hope for the stand in 2 weeks. Erm, increase
225 knee flexion to normal, I'm going to say 1 week for that. Increase lateral
226 rotation to normal, a week as well. Erm, so, I'm going to put get into car
227 pain free. So, treatment wise.....
228 Facilitator: Sorry, can you just tell me what your goals were? Your short
229 term goals were again?
230 John: Short term goals, reduce pain in left knee to zero in 14 days.
231 Increase knee flexion and lateral rotation to normal within 7 days and get
232 into the car pain free, 14 days....
233 Facilitator: All right, OK.
234 John: 'cos I've said about getting the VAS to nought.
235 Facilitator: Uh, hum

236 John: Which is going to take 14...so, obviously, getting into the car, takes
237 the same.

238 John: Erm, so, treatment, erm, one thing that I thought was education 'cos
239 of the way he was walking.

240 Facilitator: Uh, hum

241 John: Erm, he is not putting any weight on it, so, I don't know whether that's
242 just, a, whether it's 'cos he can't or whether maybe he is just thinking that he
243 shouldn't...

244 Facilitator: Yeh. Uh, hum

245 John: so getting him to walk on it and that will hopefully help with range of
246 movement as well, if he's using that more. So, erm, so, erm. Oh, erm, I'm
247 saying active range of movement exercises...

248 Facilitator: Uh, hum

249 John: again to, yeh, to help with the range of motion. Just thinking how to
250 reduce the pain.

251 John: I'm thinking R.I.C.E. Principles but it was 2 weeks ago so it might be
252 too late for that, 'cos, erm, I'm not sure whether the exercising and getting
253 more movement in it anyway would reduce the pain anyway. Erm,

254 John: Erm, so, I'm just saying strength exercises.

255 Facilitator: Which problem's that going against?

256 John: Strength exercises are going to, I think, be towards most of them, in
257 fact, all of them because he's going to need to, if he strengthens up, kind of
258 quads and stuff, it will take it, quads are going to help with the knee
259 strength. Erm, and by doing those exercises it will help with the range of
260 movement. It's going to help towards playing football and again getting in
261 and out of a car.

262 Facilitator: Uh, hum

263 John: So, I'm thinking, erm, trying to think of treatments. All of mine are just
264 different exercises, functional exercises (laugh).

265 Facilitator: (laugh)

266 John: Erm, I'm well, but erm, but some sort of like frictions....

267 Facilitator: Yeh.

268 John: or accessory movements, err, I'll just say frictions.

269 Facilitator: Uh, hum

270 John: Erm, which should help with the pain and I would have thought the
271 movements, well when I say directly help with the movements....
272 Facilitator: Uh, hum
273 John: but, obviously it could be frictions or ultrasound.
274 Facilitator: Uh, hum
275 John: Erm, I think that will probably do now.
276 Facilitator: OK Fine by me.
277 John: Yeh, I could probably think of more treatments but we haven't really
278 done that, have we? So, I think that'll probably be it from what I can think.
279 Facilitator: OK, anything else you want to say whilst the tape's rolling?
280 John: Erm, do you want anything about the program, like...
281 Facilitator: You can say anything you like.
282 John: Erm, well the main thing that I said about obviously I didn't ask name
283 and stuff, I think it's just a thing, 'cos you are sitting at a computer.
284 Facilitator: Uh, hum
285 John: I, it didn't even occur to me first of all, you know, err, you are just
286 thinking, oh...
287 Facilitator: Uh, hum
288 John: I've got to ask about problems, erm, just phrasing of the questions,
289 erm, you know, you know what you want to ask but it's putting it in the right
290 words to get what you want out of it. Erm, yeh, I mean, I don't know it's just
291 generally hard, 'cos you've not got, you've not even got a pretend patient
292 there to do it on.
293 Facilitator: Uh, hum
294 John: Erm, but I think it's good in terms of it does get you thinking a lot more
295 and the fact that it does want everything in kind of long hand does make
296 you think more....
297 Facilitator: Uh, hum
298 John: which it will probably help in the long run.
299 Facilitator: Uh, hum
300 John: Erm, that's probably it.
301 Facilitator: OK. Thank you very much.
302 John: Was that really 47 minutes?
303 Facilitator: Yes, it really was.

304 John: But 'cos see this is the other thing, right sorry,
305 Facilitator: That's all right.
306 John: It's saying like how many possible questions I could have asked. Is
307 that specific to this case....or is that?
308 Facilitator: Yes, but a few of them will be multiple ways of asking the
309 same question
310 John: Oh, right. Yeh.
311 Facilitator: 'cos it can't differentiate yeh, but for instance under that would
312 come all your name, address, you know all the stuff you didn't ask which is
313 very important, yeh?
314 Facilitator: So all that kind of thing, erm, yeh, so the number's high but
315 you are probably never going to actually reach the number but it is just to
316 give you an idea, yeh.
317 John: cos just thought that like, blimey, like 51 possible and I asked 6.
318 Facilitator: Erm, but there is also a lot more stuff around function that you
319 might have asked.
320 John: What like?
321 Facilitator: Occupation, like you do know (indistinct)
322 Oh, yeh, well, obviously (indistinct)
323 Facilitator: All that kind of stuff, so.
324 John: It's cos I think I guess what if you've got a patient as well you can
325 sometimes stumble across things.
326 Facilitator: Yes
327 John: cos you talk to them so you actually get a conversation going.
328 Facilitator: Yeh, and I don't know whether for instance you asked him
329 whether he took steroids, anti-coagulants,
330 John: No, I didn't. No, I just asked well, I just asked medications and he said
331 "No", not on any.
332 Facilitator: Yeh, but you see it would say that, this would say that asking
333 about steroids is a very important question and I am not saying that, you
334 know, if you did ask about meds, but it's kind of one of those questions that
335 you...
336 John: That you need to do still, yeh.
337 Facilitator: you should really do specifically. Yeh.

338 John: Erm, yeh, I asked, it didn't recognise respiratory.
339 Facilitator: No
340 John: "Do you have any respiratory problems", so, I had to ask, "Do you
341 have asthma?"
342 Facilitator: Yes, but that's because it doesn't recognise jargon. It does in
343 the objective but not in the subjective...
344 John: Oh, right.
345 Facilitator: It's because it's a patient..
346 John: Yeh
347 Facilitator: so you can't use medical terminology with it because it doesn't
348 understand...
349 John: Oh, right, OK Do you reckon it would have recognised it if I said
350 breathing problems?
351 Facilitator: Yes
352 John: Oh, right, OK. I thought, shall I ask breathing or asthma. Oh, I'll do
353 asthma, but...
354 Facilitator: Yes, it will recognise either or those.....
355 John: Probably should have asked both really.
356 Facilitator: on the theory that a normal person would know either of
357 those...
358 John: Yeh
359 Facilitator: and they don't necessarily know what respiratory means. The
360 programming is still all very much under development but there are certain
361 things, like you can't put abbreviations in.....
362 John: Yeh, well, I think it is, although as you do it, it's a bit kind of like, oh
363 God!, you know, but like I say, I've not used this until the other day and I
364 think it certainly helps 'cos it, by doing it all kind of long hand, and having to
365 think, it does make it sink in a bit more and stuff like that and it helps. And, I
366 am really struggling just with all the VIVA's and stuff at the moment. I am, I
367 feel like I'm struggling quite a lot worrying about different patients and I do
368 think this, if I can use this more, it will help.
369 Facilitator: Uh, hum
370 John: Erm, but, yeh, it's good.
371 Facilitator: Well, that's good. Thank you very much.

372 John: No, that's all right. I hope it helps.

373 Facilitator: Oh, it will, because it's just gathering all the data really,

374 Facilitator: Erm, what was I going to say to you? Muscle testing. You
375 didn't do any muscle testing. OK, now, you know you were saying about
376 active/passive meaning its muscle or joint?

377 John: Yeh

378 Facilitator: Yeh, to a certain extent your, what you say is true. But if you
379 had a muscle that goes across the medial side of the joint, for instance, that
380 goes where the ligament goes and you do a passive, it could be the muscle
381 in the same way it could be the ligament, 'cos you are still stretching it. So,
382 the only way you could differentiate that would be to do resisted contraction
383 of that muscle, which would mean you should have done resisted medial
384 rotation of the knee cos then you would be testing the contractile structure
385 that you would be stretching if you do lateral rotation.

386 John: OK, and you'd look for an increase in. Would it be painful, no it
387 wouldn't be painful anyway until he'd done it.

388 Facilitator: For him, it wouldn't be painful yet, because if he's a medial
389 ligament. If you do resisted medial rotation it's not going to hurt 'cos you
390 are not stressing the ligament, but it if was a medial muscle then it would
391 hurt because you would be contracting the structure....

392 John: Yeh. OK

393 Facilitator: as a just, a sort of general. Does that make sense?

394 John: OK

395 Facilitator: So, yes, active and passive does do what, kind of what you
396 said it did.

397 John: Yeh

398 Facilitator: But not necessarily in exactly the way that you kind of said.

399 John: To be honest, muscular stuff we do seem to have skipped over quite
400 a lot. All of the stuff that we have been doing is very much kind of like it's a
401 joint, or joint and ligament testing.

402 Facilitator: and that was the other thing, when you said you were going to
403 do strengthening exercises

404 John: Yeh

405 Facilitator: but you haven't got any weakness on your problem list.

406 John: Oh, right, yeh

407 Facilitator: So, why do you need to strengthen something...

408 John: Oh, right, yeh. OK

409 Facilitator: if you don't even know it's weak?

410 John: Yeh

411 Facilitator: So, why do you need to strengthen something, if you don't

412 know it's weak, because you didn't do any muscle testing?

413 John: Yeh. OK

414 Facilitator: at all. If that makes sense. Whereas potentially, probably with

415 that patient, I would have tested quads and hams just because, like you

416 say, they are the big stabilisers of the knee and, if you found a weakness,

417 which potentially you might do. And the other thing you didn't test was you

418 didn't test his ACL and his PCL and from the mechanisms of injury.....

419 John: Yes, especially 'cos its medial it's attached to.....

420 Facilitator: So, you could have had, you didn't because you tested your

421 meniscus and but you could have had like an O'Donoghue's Triad. You

422 know..

423 John: Yeh

424 Facilitator: where you have got ACL, medial...

425 John: Medial, yeh, yeh

426 Facilitator: collateral and meniscus all gone.

427 John: Yeh, OK. Yeh, that makes sense. OK

428 Facilitator: So, that's my little lesson for today.