TECHNOLOGY ENHANCED LEARNING AND SIMULATION IN ORTHOPAEDIC POST-GRADUATE TRAINING

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CHAPTER ONE:

INTRODUCTION

Background

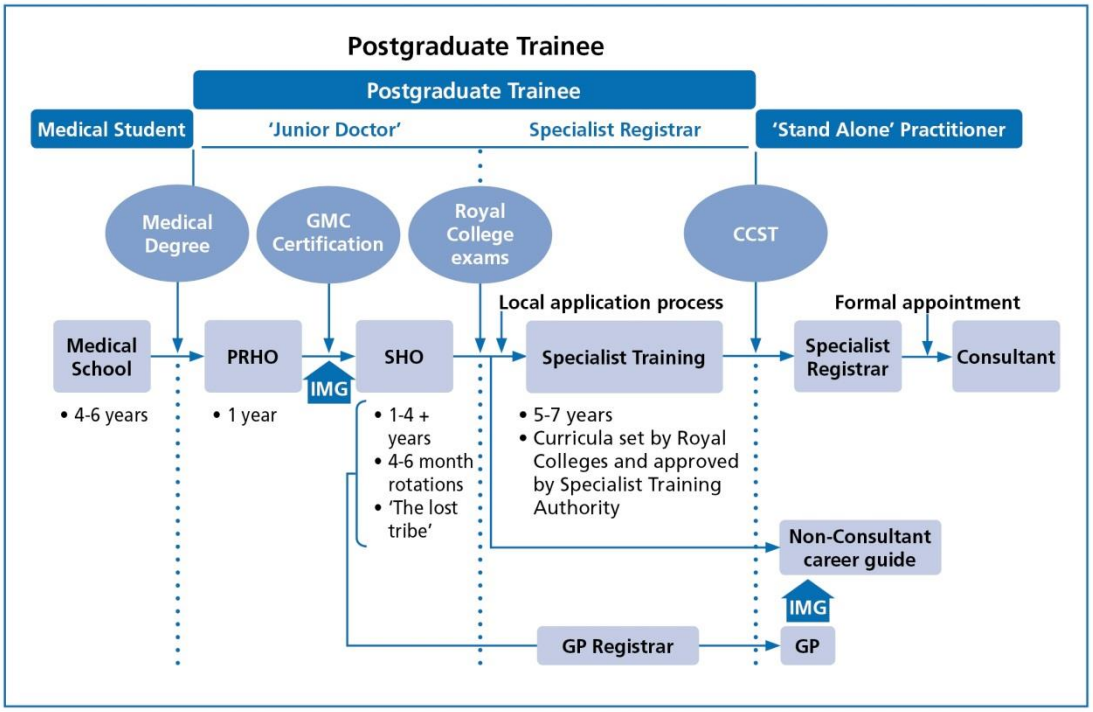
1.1 Recent reforms in Postgraduate Medical Education

Recent developments in health service delivery have had a profound effect on Postgraduate medical training. Professional Specialist training programmes for doctors at Registrar level within the United Kingdom National Health Service (NHS) have evolved over various phases (or periods) owing to continuous advances in medical and scientific technology, the natural need to improve on standards and continuous changes within the UK funding environment. In parallel with these service changes, emerging trends in medical education such as increasing accountability, professionalism and the pursuit of 'excellence' have come together in a number of high profile national policies and regulatory requirements.

Significant reforms to the postgraduate medical training system were instigated by then Chief Medical Officer Sir Kenneth Calman. The Calman reforms were initiated by the publication of *Hospital Doctors—Training for the Future* in 1993 and were mainly concerned with improving specialist hospital training. This led to the introduction of Specialist Registrar posts with explicit curricula, regular assessments of progress, and limited to a maximum of seven years (1). These 'Specialist Registrar' posts replaced the previous 'Registrar' and 'Senior Registrar' posts where, prior to the introduction of Calman Training in December 1995 a specialist registrar received on average, approximately 30,000 training hours over 10 – 15 years. In contrast, Calman trainees received only around 12,000 hours of training. The reforms also introduced the Certificate of Completion of Specialist Training, awarded by the General Medical Council (GMC). It is important to note however, that there is little evidence to translate hours worked, into useful operative

experience gained or useful training received. Time spent simply in attendance at the hospital is a poor surrogate marker for valid clinical activity on the ward, in outpatients or in the operating theatre. Similarly, simple assessment of the number of cases performed does not take surgical complexity or the training value of each case into account. The goal therefore was to target training opportunities and produce a shorter, more structured and organised training pathway. The changes to the training system following the implementation of the Calman reforms is shown in the diagram below:

Figure 1: UK Medical Training system following the Calman reforms, Adapted from (2)



In August 2002, Sir Liam Donaldson, then Chief Medical Officer for England, published a paper on medical training. The paper, *Unfinished Business* (3) set out principles for the reform of the Senior House Officer (SHO) grade and in order to achieve this, proposed the introduction of a 2-year "foundation programme" to immediately follow graduation from medical school. This would be followed by broad-based "basic specialist training programmes". In July 2003 the Department of

Health published another consultation paper, *Choice and Opportunity*. This paper addressed difficulties experienced by the doctors in Staff grade and Associate Specialist (SAS) posts, a term applied to doctors outside the formal training system and without consultant or GP status.

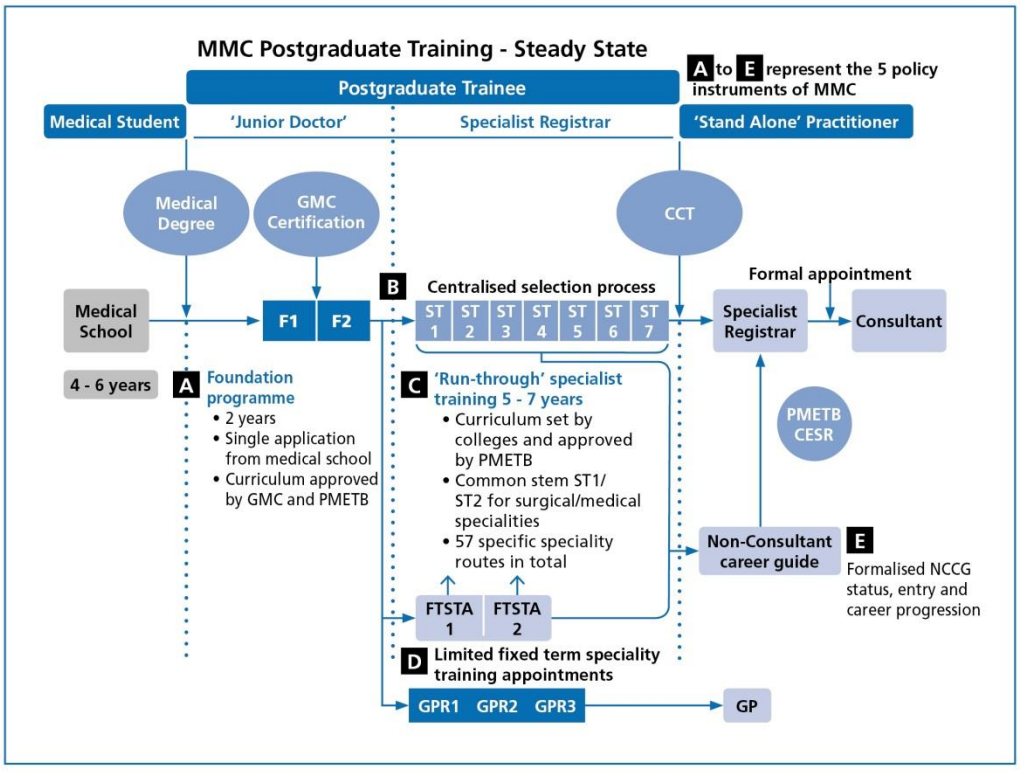
Unfinished Business and *Choice and Opportunity* described problems experienced by junior doctors throughout postgraduate medical training. In addition, there were several other factors and trends at work which influenced the implementation of reforms to the medical workforce:

- The *NHS Plan (2000)* set out a commitment to a health service increasingly delivered by fully trained doctors rather than those in training. This added to the pressure to reduce the minimum training times for completion of specialist training. There was also a significant pressure to reduce the amount of patient care traditionally provided by doctors in training posts; patients instead stating a preference to be treated by doctors who were designated as fully trained. This was underpinned by a major expansion in undergraduate medical school numbers with an increase of up to 60% between 1999 and 2005.
- A new regulator for postgraduate medical training, the *Postgraduate Medical Education and Training Board (PMETB),* was created in 2003. PMETB, which began work in 2005, was given responsibility for establishing and maintaining standards in order to protect the public. The creation of PMETB led to changes in the responsibilities of other bodies involved with postgraduate medicine, such as the Royal Colleges and Postgraduate Deaneries (2).
- The reduction in junior doctor hours brought to a head by *European Working Time Regulations,* catalysed a need to safeguard and improve the quality of the supervision received by trainees (4). Despite the reduction in the number of training hours afforded to trainees consequent upon implementation of the European Working-Time Directive (EWTD), service delivery targets were

expected to remain unaffected, if not enhanced. The current model of service provision relies on trainees to deliver much of this care, particularly out of hours. Following implementation of EWTD, the Association of Surgeons in Training (ASiT) / British Orthopaedic Trainees Association (BOTA) surveyed 1,600 surgical trainees and showed 84% of respondents worked in excess of their rostered hours and 67% were attending work out of rostered time to gain training experience (5).

In February 2003, the four UK health departments published *Modernising Medical Careers*, a joint initial response to *Unfinished Business*. A UK Strategy Group was formed in October 2003 by Sir Liam Donaldson to co-ordinate the introduction of the MMC reforms. This was followed in April 2004 by the publication of *MMC: The next steps—The future shape of Foundation, Specialist and General Practice Training Programmes* (6, 7). The central role of Specialty Training within the new system is demonstrated in the following diagram:

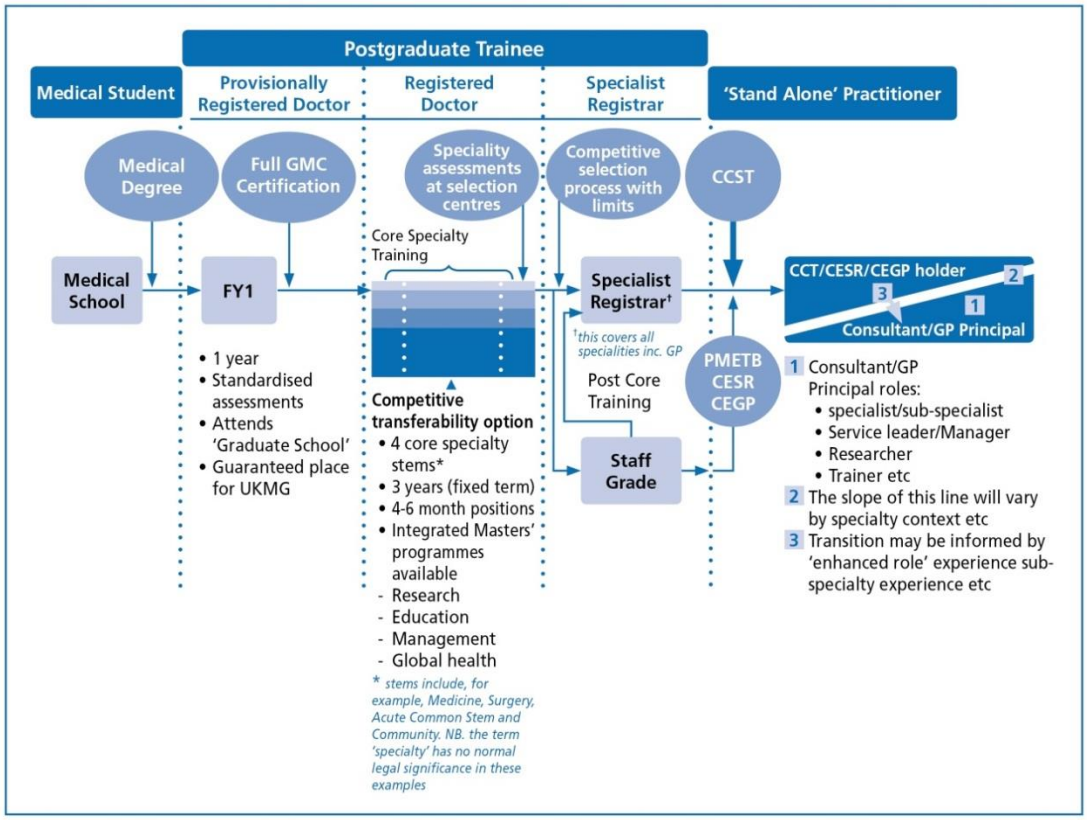
Figure 2: MMC Training system: role of specialty training programmes. Adapted from (2)



MMC was delivered via the Medical Training Application Service (MTAS), an on-line application system used for selection of candidates to training. Under MTAS, junior doctors were invited to submit an electronic application form on the MTAS website. Applications could be made to one speciality in four geographic areas (Units of Application or UoAs), or to two specialties in two UoAs, or four specialties in one UoA. There were twelve geographical areas: one each for Scotland, Wales and Northern Ireland; one covering the whole of London, Kent, Surrey and Sussex; and eight others. The MTAS application process also introduced the concept of automatic progression via a "run-through" system. Entry at ST1 was therefore seen as pivotal. Subject to adequate performance in competency based assessments individuals would automatically emerge with a CCT.

Although MMC was aimed at addressing long standing problems within the postgraduate medical training system, its introduction ran into significant problems and the subsequent crisis in 2007 was the subject of intense media coverage, causing a breakdown of relations between the Department of Health and the medical profession. In response, the Department established an independent inquiry led by Professor Sir John Tooke to look at the causes of the 2007 problems and the changes required to restore confidence in the MMC programme. The independent Tooke Review published its findings and recommendations in an interim report, *Aspiring to Excellence*, in October 2007 (2). Amongst the most significant of the recommendations for change were proposals for a further restructuring of the medical training system. *Aspiring for Excellence* called for the two-year Foundation programme to be split and for run-through programmes to be un-coupled into "Core" and "Higher" specialist training schemes, changes which would reverse the two key structural reforms brought in by MMC. Automatic progression of trainees in a run-through system was replaced with a mechanism to allow robust external assessment of the knowledge and skills acquired to date. The new training structure proposed by the Tooke review is shown below:

Figure 3: Structure of medical training recommended by the Tooke Review. Adapted from (2)



Shape of Training

As a result of the independent inquiry led by Professor Sir John Tooke, in 2011, Medical Education England (MEE) scoped themes that could be considered as part of further restructuring of medical training. In May 2011, the MEE Steering Group agreed that further work on the shape of training was necessary and should be taken forward, led by an independent chair. Professor David Greenaway was appointed in February 2012 and "The Independent Review of the Shape of Medical Training" was launched in March 2012. The Shape of Training Review looked at potential reforms to the structure of postgraduate medical education and training across the UK. The UK wide review focused on postgraduate medical education and training, including transitions from the Foundation Programme into specialty training and continuing professional development (CPD). The UK Governments felt that patients and the public needed more doctors who were capable of providing

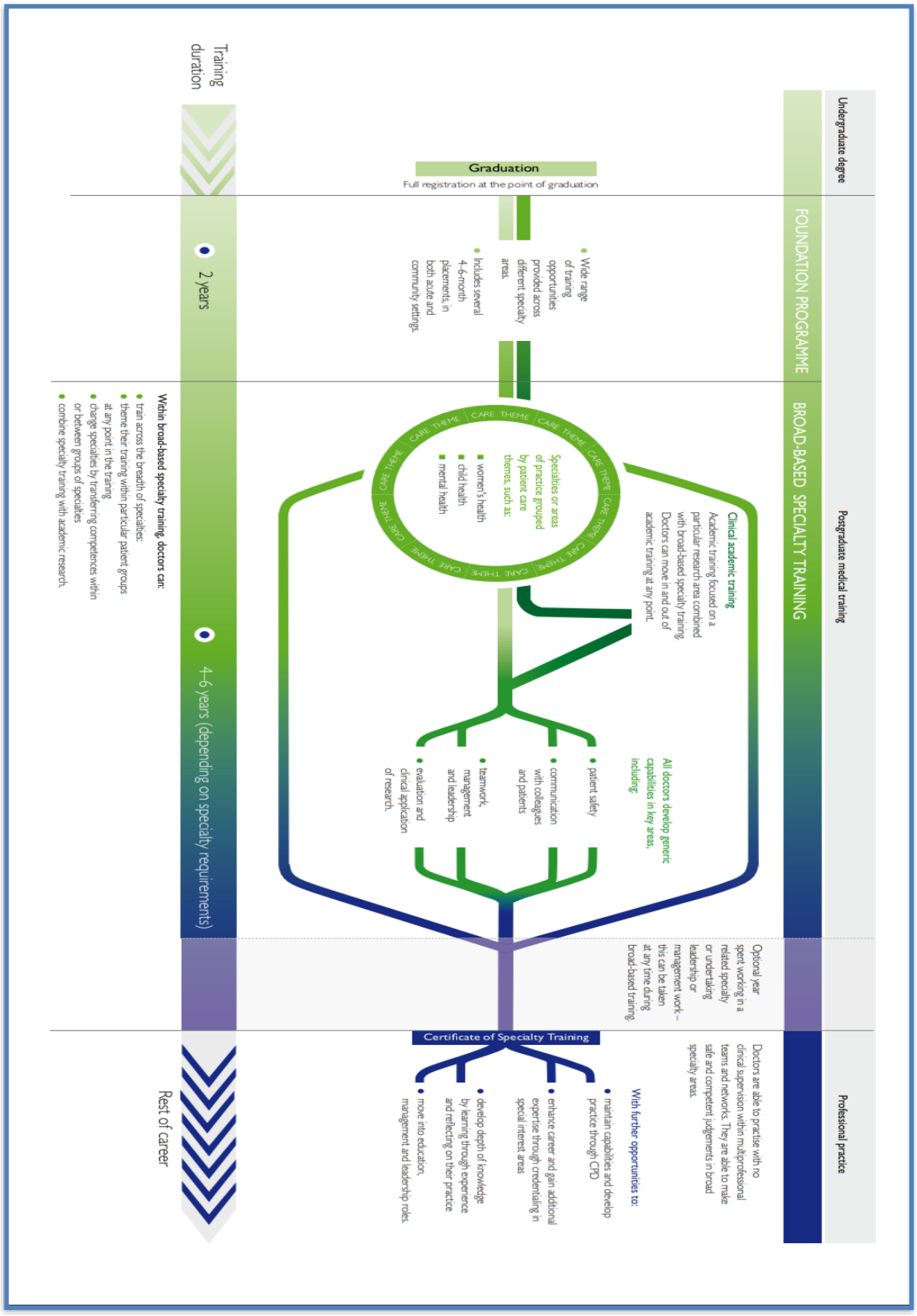
general care in broad specialties across a range of different settings. This was primarily driven by a growing number of people with multiple co-morbidities, an ageing population, health inequalities and increasing patient expectations.

Published in 2013, the Shape of Training (8) set out recommendations for the structure and delivery of training for the next 30 years including a framework and timescale for this reconfiguration. Key recommendations were that:

- Full GMC registration should move to the point of graduation from medical school.
- The Foundation Programme should continue as a two-year programme, facilitating broad-based learning in community and secondary care settings.
- Following the Foundation Programme, doctors will enter 'broad-based specialty training' in a general area of practice to proceed for between 4 and 6 years.
- There will be the option of a single year to be taken within training to expand management/educational/clinical experience.
- The Certificate of Completion of Training (CCT) will be replaced by a Certificate of Specialty Training (CST)
- The future CST holder will be eligible to apply for consultant-level posts in the generality of their training area.
- Subspecialty skills will be acquired after obtaining the CST by a process of 'credentialing'.
- All changes in training (and therefore the products of the proposed training system) will be based on the local needs of the population.

The new training structure proposed by Shape of Training is below:

Figure 4: Structure of medical training recommended by the Shape of Training. Taken from (8)



Health Education England (HEE) subsequently commissioned the Royal College of Surgeons of England (RCSEng) to identify and recommend improvements to the quality of surgical training and lead a feasibility study and cost/benefit analysis of these options. The resulting publication, entitled 'Improving Surgical Training', set out the recommendations from this consultation process (9). Key recommendations from this report stated that Trainee progression should be competence based rather than time based, but with pre-determined maximum and minimum times for the duration of training. In each phase of training, it was stated that there should be clear targets to determine whether the trainee is able to progress to the next phase. Those targets include knowledge, clinical skills, technical skills and professional capabilities. Interestingly for this work they also recommended that simulation should be embedded and enhanced within the surgical curricula and there should be sufficient resource to ensure availability for all trainees.

Standards in Specialty Training

The speciality training currently in place broadly follows the model outlined above. Some changes have occurred within the infrastructure; for example PMETB was responsible for the standards of postgraduate medical education and training until it was merged with GMC in April 2010. Standards set by PMETB remain in force although The Medical Royal Colleges and Faculties develop the specialty curricula in accordance with the principles of training and curriculum development established by PMETB and subsequently carried forward by the GMC.

There has been the adoption of competency based training as opposed to the traditional 'time-based' training. Accreditation bodies such as the Intercollegiate Surgical Curriculum Project (ISCP) now mandate demonstration of competence prior to certification (10, 11), whilst at the same time trainees are afforded even less dynamic clinical exposure. Once a trainee has completed a specialty training programme they will achieve a Certificate of Completion of Training (CCT). Award of a CCT entitles them to entry onto the specialist or GP Registers. The GMC's *Generic Standards for Training* remains the regulatory benchmark (12).

An example of such standards is shown above in Box 1 *taken from the Gold Guide 2010.* (13)

- Standard 3: The curriculum must set out the general, professional, and specialty specific content to be mastered, including; - the acquisition of knowledge, skills, and attitudes demonstrated through behaviours, and expertise; the recommendations on the sequencing of learning and experience should be provided, if appropriate; and the general professional content should include a statement about how 'Good Medical Practice' is to be addressed.
- Standard 4: Assessments must systematically sample the entire content, appropriate to the stage of training, with reference to the common and important clinical problems that the trainee will encounter in the workplace and to the wider base of knowledge, skills and attitudes demonstrated through behaviours that doctors require.

Work place based assessments, including the CBD (Case Based Discussion), PBA (Procedural Based Assessment), CEX (Clinical Examination Exercise) and Mini-PAT (Peer Assessment Tool) are tools used for continuous assessment at all levels(10). These allow competence and also underperformance to be documented. Although these tools have great versatility, they depend on the relationship and experiences of the trainer and trainee working together to be able to use it to its best effect. Trainees are required to keep records of reflective practice in their portfolio and log

book of surgical procedures, and these tools are said to encourage that practice. It is hoped that reflection will be used to evaluate failing trainees, to extend good trainees, and to develop evaluation skills. The use of continuous assessment, with more emphasis on work place based assessments is also being used increasingly in the undergraduate curriculum, led by Dundee and Liverpool. These assessment tools are described as having no value on their own – except for giving feedback, and should be thought of as "formative". En mass in a portfolio with other evidence however, they have will have summative value. It is therefore important to encourage trainees to use these to reflect and to plan further learning targets, with a continuing cycle of performance and learning.

The Joint Committee on Surgical Training (JCST), the Specialty Advisory Committees (SACs) and the Core Surgical Training Committee have developed a series of Quality Indicators (QIs) to enable the quality of training placements within each surgical specialty and at core level to be assessed (10). The QIs will be used to identify good and poor quality training placements, measured through the JCST trainee survey. They are thought to create a method by which the quality of a training placement can be assessed, thus enabling the SACs to identify both good and poor quality training placements. The Trauma & Orthopaedic SAC has stated they believe the completion of PBAs, MSFs and CBDs to be powerful learning tools to use with trainers in theatre, outpatient clinics and on the wards and to enable trainees to reflect upon their learning experiences.

Work Place Based Assessments (WPAs) provide a means of demonstrating that trainees are meeting the standards of the curriculum and are competent in relevant operative procedures. The JCST requires completion of 40 WPBAs per year, although they have tried to reassure trainees that the QIs will not be used to assess the achievements of individual trainees, but will be used to assess the opportunities

they were afforded during individual training placements in order to identify where improvement is required.

Ongoing problems and the need for innovation

Trainees receive less operative exposure and experience than prior to the introduction of EWTD. It is now expected that after the introduction of "Modernising Medical Careers" (MMC), specialist registrar training will be reduced to 6,000 hours over 5 – 7 years. These changes represent an 80% reduction in available training hours for specialty trainees before they are considered ready for appointment as Consultants. Although it has been said that the intensity of the work has increased when on duty, due to a decrease in the number of doctors available at any one time, it can be argued that the increase in intensity leads to further reduction in the time for experiential learning, less opportunity for reflection and interaction, and reduced opportunities for shared learning within the medical team (14). Shift patterns have been described by many as being detrimental to training, leading to a reduction in in-service learning and attendance at formal educational sessions, as well as difficulty in obtaining study leave to attend courses (15). As mentioned above, it is important to note, that there is little evidence to translate hours worked, into useful operative experience gained or useful training received. Time spent simply in attendance at the hospital is a poor surrogate marker for valid clinical activity on the ward, in outpatients or in the operating theatre. Similarly, simple assessment of the number of cases performed does not take surgical complexity or the training value of each case into account. Emphasis is now on the competency of performance over logbook numbers alone.

Thus, one of the main challenges facing the NHS in the delivery of specialty training is for the system to continue to deliver cost-effective high-quality training whilst also maintaining competence and clinical quality, within the current service and financial constraints.

A possible solution to the issues raised above is to devise innovative methods of delivery of learning. Through improvements in the effectiveness of training and the introduction of simulation based learning into the curriculum, it might be possible to compensate for this reduction in experiential training time. To this end then, I believe that Simulation, Virtual Learning Environments and virtual patients present a potential way of reconciling this conflict between service, hours and training.

1.2 Simulation and Virtual Learning Environments: Solutions to challenges in medical education?

The obvious criticism levelled against Simulation and virtual patients is that at best, they are poor mimics of the real patient with the attendant unpredictability, inter-individual variations amongst patients, patients presenting clinically from varied and uncontrolled patho-physiological baselines and unpredictable responses to pharmaco-therapy (etc.). Notwithstanding these factors the author believes it is still valid to explore the merits of technology-assisted learning. Here, we can ask the following questions?

1) Does simulation have a role in the acquisition of skills or performance assessment?

2) What is the appropriate balance of simulation vs. real life acquisition of surgical skills?

When considered from a theoretical standpoint, there is no reason why technology enhanced learning and simulation cannot be further developed until it is effective to help to ameliorate the impact of reduced hours and shift working by accelerating the acquisition of technical skills and transferring learning away from the patient. In the

digital age, trainees are becoming increasingly adept at using digital technology (16). The question still remains as to whether technology assisted learning can be used for selection into surgery, and whether simulation may have a role in the acquisition of skills or performance assessment. In 2006, Lord Darzi re-introduced the concept of simulation-based training for surgeons (17), and the Temple report (4) recommended increased investment in simulation to fully realise the benefits to training. There are numerous examples of successful use of simulation equipment ranging from simple procedural skills such as suturing to high fidelity team-based training (18-21).

Initially developed for pilots and the airline industry, the baton has been handed over to the gaming industry, where now patient simulators are used to replicate realistic physiological responses to an ever-increasing range of defined clinical interventions on sophisticated mannequins. Instructors can now create, control, and deviate clinical scenarios through sophisticated software and in this way optimise learning opportunities. Though tools have been available for almost a decade, the integration of such tools into training curricula has been patchy. Recent studies have shown that not only did simulation-based training improve performance subsequently on real cases, in terms of reduced time taken, fewer errors and decreased patient discomfort, but it also reduced the amount of time taken to achieve laparoscopic skills (19-21). Not only is simulation a more cost effective method of training, but it also leads to enhanced levels of patient safety and trainee confidence (17, 19, 20, 22).

Orthopaedic surgeons have been using simulation in different forms for decades. AO courses have used sawbones to teach surgical management of common fractures. Practical sessions involve the fixation of common diaphyseal and articular fractures on real size artificial bone models, using AO instruments and implants. The use of cadaveric specimens is common on orthopaedic courses, e.g. basic hip and knee arthroplasty, and basic knee arthroscopy. Standardised and simulated patients are

widely used in assessment and teaching especially undergraduates. Orthopaedic surgeons are therefore well experienced in simulation for training and probably lead the medical profession.

But before setting up a simulation programme within any training programme we must ask ourselves "What is the purpose of this?" Higher education platforms and websites are littered with empty wikis, deserted discussion fora, and rarely visited online course areas. This may be due to several factors, but often there is insufficient purpose to the intervention. E-learning is rarely an effective tool when there is little support, either for the trainee or trainer. There needs to be recognition that it is time consuming for the trainer, and requires the trainer's presence as much as during other types of training. In a study presented by Brennan at the "Surgical Simulation: Problems and Pitfalls with Pretending" conference at the RCSEd in Feb 2011, over 50% of trainees questioned did not have access to a simulator, and felt that ongoing barriers to their use were the lack of access to this type of equipment, lack of time and instruction. We must therefore make sure that such systems are easily accessible i.e. embedded in working area to allow access by the trainees during working hours. Time must be taken to help trainees, and oversee training, including logging, booking time, teaching, maintaining and developing. Their performance should also be assessed, to make these meaningful to the trainee.

So rather than asking the question "Are Virtual Learning Environments and simulation in surgical training an effective teaching method?", the author proposes to explore how technology-assisted training methods can be implemented effectively and utilised in surgical training. The project will initially be focused on the author's area of Specialty, Trauma and Orthopaedics, but has application for all areas of surgical training.

The research question

To what extent can eLearning and simulation-based learning tasks actively engage orthopaedic trainees to achieve their educational outcomes?

The aim of this project is therefore to explore the use of eLearning and simulation-based training to facilitate the achievement of improved learning outcomes for orthopaedic trainees.

CHAPTER TWO:

THE SCOPE OF THE STUDY

In this chapter, the research questions, aims and objectives of the study are presented. The programme of research to answer the aims and objectives is also described.

The Primary Research Hypothesis states:

To what extent can eLearning and simulation-based learning tasks actively engage orthopaedic trainees to achieve their educational outcomes?

The aim of the study

The aim of this project is to *investigate the use of eLearning and simulation-based training to facilitate the achievement of improved learning outcomes for orthopaedic trainees.*

The objectives of the study are:

1. To critically explore the use of existing technology enhanced learning resources, in particular, Virtual Learning Environments and simulation based technologies. This has two sub- objectives:
    a. To determine where we are now in the availability and scope of technology enhanced learning resources.
    b. To investigate methods of using these resources that have been successful in facilitating surgical trainees to improve learning outcomes

2. To evaluate the level of engagement among orthopaedic trainees with existing resources, as well as the newly developed eLearning and simulation-based learning activities.

3. To critically design and develop eLearning and simulation-based learning tasks using:
    a. A Virtual Learning Environment (VLE) platform
    b. An Arthroscopy simulator

4. To assess the effectiveness of the eLearning and simulation-based learning activities in facilitating trainees to achieve required outcomes.

Detailed plan of Investigation and Scientific procedures:

The MD project is divided into a number of smaller tasks. The overall structure these smaller projects (or work packages) will take, and in doing so how they align with the learning objectives, is detailed below:

<u>Project 1: Literature review.</u>

This is aligned with Objective One: *To critically explore the use of existing technology enhanced learning resources.*

This will expand on the background presented in Chapter One, with a more detailed review of the literature. This will focus predominantly on the use of eLearning and simulation-based learning, and their role in medical education. The literature review will also include relevant evidence from the use of other forms of e-learning, web-based learning and simulation based techniques.

<u>Project 2: Evaluate the existing Virtual Learning Environment (VLE) platform.</u>

This is aligned with Objectives One and Two:

- *To critically explore the use of existing technology enhanced learning resources.*
- *To evaluate the level of engagement among orthopaedic trainees with existing resources*

We will first look at the use of Virtual Learning Environments for Orthopaedic Postgraduate trainees. The Virtual Learning environment represents a form of technology assisted learning and support for orthopaedic trainees. We aim to look at its current use and the tools available, in particular, blogs, wikis and online case based discussion. Moodle online learning resource is already in place for trainee interaction. 32 Orthopaedic specialist trainees have access to the website, and will be approached for the purposes of this project. Moodle was developed as a Virtual Learning Environment (VLE) to support social constructionist pedagogy, and contains tools to encourage discussion, such as the online discussion fora (including journal clubs). Tools to support collaborative working are also available including Case Based Discussion (CBD) and wikis. We will assess participation in its current format.

<u>Project 3: Qualitative Study: An investigation into the use of technology-enhanced learning environments in orthopaedic postgraduate medical education (Virtual Learning Environment).</u>

This is also aligned with Objective Two: *To evaluate the level of engagement among orthopaedic trainees with existing resources*

The qualitative study aims to inform the development of the existing orthopaedic VLE / Training resource. This will determine:

- How often postgraduate orthopaedic trainees currently use the VLE?
- What barriers currently prevent trainee interaction on the VLE?
- Positive attributes of the current training resource
- Priorities for development of the VLE
- What measures can be introduced to improve trainee engagement?

The study will utilise a mix of qualitative research methods, including semi - structured interviews and focus groups. The first part of this research will illuminate current trainee and trainer interaction with the Moodle / VLE. We will aim to assess

their engagement in the VLE, barriers to its use, and factors they feel will improve the current VLE. 32 Postgraduate specialist trainees in Trauma and Orthopaedics on the School of Surgery south rotation will be invited to take part along with 15 consultant Orthopaedic surgeons who will purposively be selected for inclusion in this study. Data will be handled using the NVivo computer package and analysed following the conventions of thematic analysis (23). This formulation of thematic analysis is a structured, inductive approach to data which prioritises the perspective of the research participant and seeks to identify important and recurring themes across multiple respondents. Each population (consultant, trainee) will be analysed independently and it is expected that analysis will generate a thematic map for each population which connects factors such as lack of time, lack of motivation, lack of peer or senior participation (examples of barriers to the VLE) and others. The limited prior work in this area necessitates an exploratory approach to the topic. Qualitative thematic analysis (24) facilitates this form of exploratory research, although is often criticised for lacking precision and being vague in its processes and undertaking. A structured thematic approach described by Braun and Clark (23) addresses these concerns by providing guidelines for a rigorous and systematic investigation of the data whilst allowing for an exploratory approach.

<u>Project 4: Prospective randomised trial of Postgraduate specialist trainees in arthroscopy simulation.</u>

This is aligned with Objectives Three and Four:

- *To critically design and develop simulation-based learning tasks using:*
    - *An Arthroscopy simulator*

- *To assess the effectiveness of the eLearning and simulation-based learning activities in facilitating trainees to achieve required outcomes*

The arthroscopy simulator project will form the second facet of the MD work, and will aim to look at technology assisted learning in improving technical skills for surgical trainees. While the VLE project aims to assess how we can utilise technology assisted learning to improve clinical reasoning and knowledge, this look specifically at the other key aspect of surgical training: technical skill.

The project will aim to assess the effectiveness of virtual reality simulation for training in arthroscopic knee surgery. Junior orthopaedic trainees will be recruited from a single training rotation in Leicester. We must therefore acknowledge that the trainees will be recruited from and working within an established training programme. This may impact on their availability, recruitment and time available for additional training. Each trainee will be randomised using sealed envelopes into one of two groups. One group will receive a fixed protocol of simulator training, while the other group will continue to receive traditional training in theatres only. The additional simulator training will consist of 9 hours simulated knee arthroscopies during a six month period and will follow a fixed protocol for diagnostic arthroscopy of the knee as agreed by surgeons experienced in this area. The Arthro VR arthroscopy knee simulator will be used in all cases in a designated bio skills laboratory.

Each trainee will be assessed at the beginning and end of the study period. Each trainee will be allocated a theatre session with an experienced consultant knee surgeon who will be blinded to their training status. They will then be assessed as each trainee performs a diagnostic arthroscopy. Assessment will be made using the Orthopaedic Competency Assessment Project (OCAP) Procedural Based Assessment (PBA) tool for diagnostic knee arthroscopy. OCAP was developed by the British Orthopaedic Association and the Orthopaedic Specialist Advisory Committee as a framework for specialist training in Orthopaedics (11). Its curriculum was been

incorporated into the competency based surgical training structure implemented by the surgical royal colleges in the United Kingdom.

The primary outcome measure will be the difference in performance between the simulator group of trainees and the non-simulator group on the assessed PBA. Secondary outcome measures will be the improvement shown over the study period of simulator training between the first and second assessed arthroscopies. The difference in improvement will also be compared between the two groups.

Project 5: Implementation of improvement to the Virtual Learning Environment.
This is aligned with Objective Three: *To critically design and develop eLearning and simulation-based learning tasks using a Virtual Learning Environment (VLE) platform*

Guidelines for the development of the VLE will be informed by the work completed in Stage Three of the study. Tools to support collaborative working are available including Case Based Discussion (CBD) (10) and wikis. Improvements will be made to the VLE with interventions staged at timely intervals, and assessments made of participation after each intervention and throughout the study timeline. Online journal clubs will run each month and assessment can be scored based on online participation and compared with the current monthly Foot and Ankle journal club, which is run on a face-to-face basis.

Likely methods to improve trainee engagement may include:

- Mobile moodle app development
- Increased need for trainees to show evidence of CBD assessment (20 per year).
- Increased need for trainees to show evidence of ability to critically assess journals.
- FRCS (Tr & Orth) examination contains critical appraisal of a paper – this provides an opportunity to practice exam technique

- Improve access to site via INsite (University Hospitals of Leicester NHS Trust website)
- Students offered options of participating online, or in traditional postgraduate didactic lectures.

Outcome measures will be:

- Number of hours spent by trainees on VLE before and after intervention.
- Number of posts made by trainees on VLE before and after intervention (number of words, and number of key words)
- Case Based discussion scoring system.
- Credit scores - standard deviation, and correlation with participation on the VLE.

Project 6: Collaboration with other centers and in other deaneries / medical schools.

This is aligned with Objectives Three and Four:

- *To critically design and develop eLearning and simulation-based learning tasks*
- *To assess the effectiveness of the eLearning and simulation-based learning activities in facilitating trainees to achieve required outcomes*

Liaison with other medical schools has already begun and discussed with Dr Iman Haq (Director of Undergraduate Education and Head of Medical Education Unit at Brighton and Sussex Medical School) regarding the trial of the VLE software in Brighton. We aim to invite other local postgraduate students from schools including Birmingham and Nottingham. Collaborative work with the Institute of Learning Innovation at the University of Leicester has also been possible.

CHAPTER THREE:

CRITICAL REVIEW OF THE LITERATURE – VIRTUAL LEARNING ENVIRONMENTS

A review of the findings from the literature searches for Virtual Learning Environments is presented. This chapter provides a review of the literature in relation to the research objective one:

Objective One:

To critically review the literature, especially of the use of existing technology enhanced learning resources, to include ***Virtual Learning Environments*** and simulation based technologies. This has three sub- objectives:

a. To determine scope of technology enhanced learning resources
b. To determine the availability of those resources
c. To investigate which of these methods have been successful in facilitating surgical trainees to improve learning outcomes

A description of the methods used is presented. This chapter concludes with a summary of the findings from this review.

3.1 Methods

A critical review of the literature may provide the basis for informing future policy or practice, and the author feels is particularly important in fields such as this where the research is rapidly evolving. Conducting a thorough search to identify relevant studies is a key factor in minimizing bias in the review process (25). The CRD states that search process should be as transparent as possible and documented in a way that enables it to be evaluated and reproduced. A review protocol was constructed as per the CRD guidelines (25) which sets out the methods to be used in the review. Decisions about the review question, inclusion criteria, search strategy, study selection, data extraction, quality assessment and data synthesis are addressed.

3.1a Selection Criteria

When considering the literature for Virtual Learning Environments the author was interested in gathering literature from all research disciplines using a variety of experimental and observational methods, the inclusion criteria were extended to include all designs of studies, including randomised controlled trials, quasi-randomised, cohort, case-control studies and qualitative studies including interviews with users.

3.1b Search Strategy

Medline and Embase were searched using the following medical subject headings (MeSH) terms and the following free text terms: virtual learning environment*, virtual learning system*, course management system*, VLE, virtual patient, virtual train*, educat*, virtual*, train*. Trade names for Virtual Learning Environments in common use were also used in the search string: Moodle and Blackboard*.

Initial results were limited to human studies, and publications years 2005 – 2013. During the writing up period an additional literature search was performed to ensure that newly published work can be included in the critical review. The search strategy was performed in the same way as the original search. Medline and Embase were searched using the following medical subject headings (MeSH) terms and the following free text terms: virtual learning environment*, virtual learning system*, course management system*, VLE, virtual patient, virtual train*, educat*, virtual*, train*. Trade names for Virtual Learning Environments in common use were also used in the search string: Moodle and Blackboard*. Results were limited to human studies, and publications years 2005 – 2016. References of the identified trials were also searched to identify further relevant trials. We did not contact investigators of the published articles.

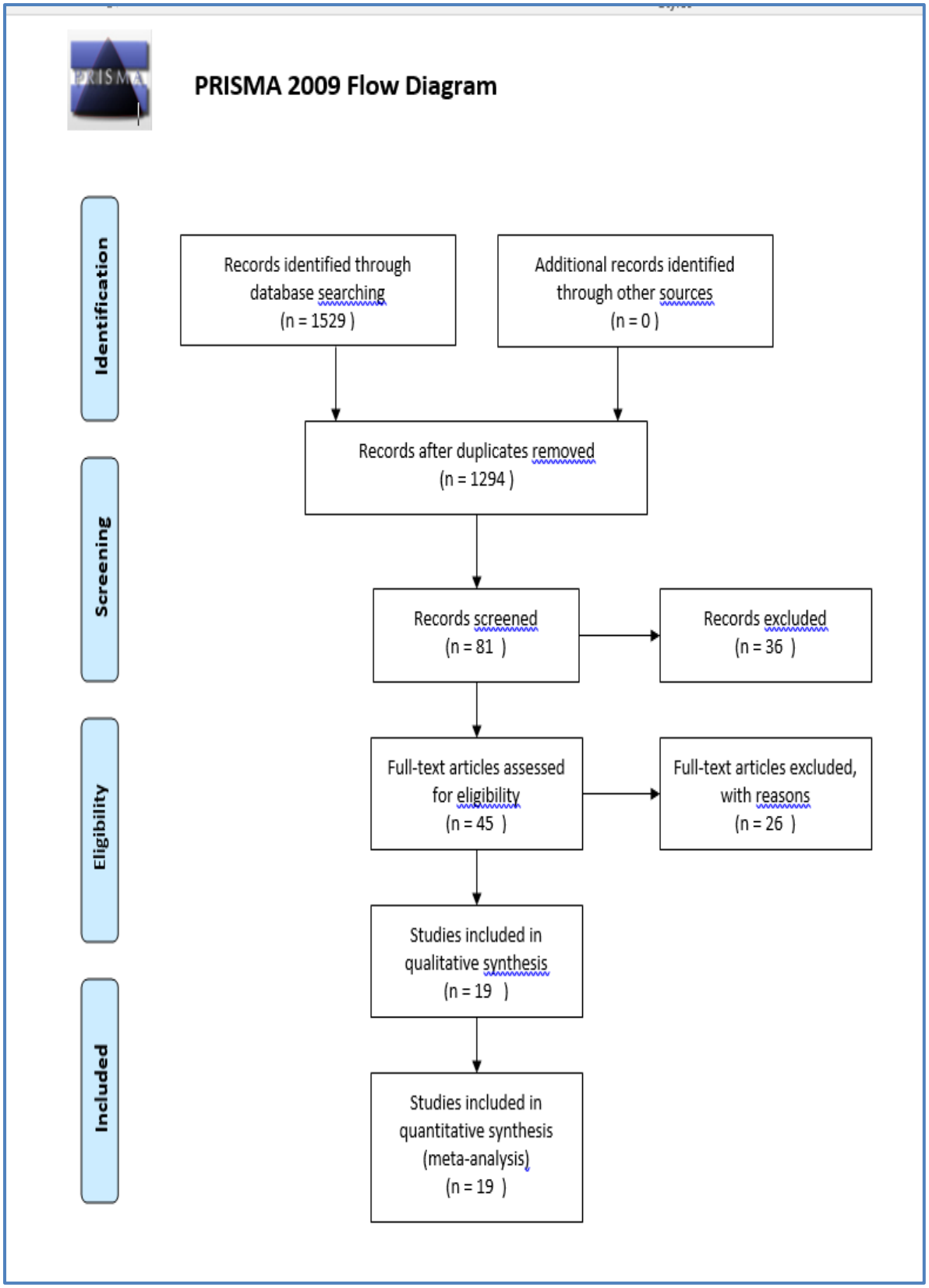
3.1c Study Selection

The abstracts were identified for inclusion and screened for relevance. Full text articles were obtained for all potentially relevant studies fulfilling inclusion criteria or for studies for which insufficient information could be obtained from the title and abstract alone.

PRISMA methodology with the appropriate checklist and flowchart were used to identify and selection appropriate studies for inclusion in the review (26) (see flowchart below).

Although the resources available for this research study did not include a panel of experts to support the critical review, the quality of the studies was evaluated using a validated appraisal tool (27). The Critical Appraisal Skills Programme (CASP) appraisal tool assesses the research aims, research design, data sampling, data analysis, results and ethical implications, as well as the overall contribution of the research to existing knowledge and understanding. This tool was used in the absence of an expert review group.

Figure 5: A flow chart summary of study selection process, Virtual Learning Environment



3.1d Data Extraction

Data was extracted related to author and year of publication, inclusion and exclusion criteria, participant characteristics and details of training, such as the software used. We excluded studies that did not specifically look at a form of Virtual Learning Environment. We included e-learning, online learning and web based courses, but excluded online document stores/repositories. We also excluded those studies that discussed the development of these resources rather than their usage.

3.1e Data Analysis

Because of the heterogeneity of the studies with regard to aims, interventions and outcomes, it was not considered appropriate to pool results and conduct a meta-analysis. Results are therefore presented using a descriptive format to summarize and evaluate the studies.

3.2 Results of the literature review

A wide variety of Virtual Learning Environments or "Learning Management Systems" are used in the literature. The two most commonly used platforms were Moodle, which is freely available and was the technology used in 4 of the 13 papers reviewed (28-31), and Blackboard, a commercial system, was equally commonly used, cited in 4 papers (32-35). Other systems mentioned include ICON, SIAS, CASUS and WebCT. Because of the wide variety of e-learning systems available, direct comparison is difficult; however, each contains similar mechanisms for delivering web based learning. Most systems also facilitate student registration, delivery of course materials, communication, student testing and tracking or usage statistics. These features form the basis for many of the studies considered in the critical review of the literature.

The majority of papers have looked at the use of Virtual Learning Environments (VLEs) in medical students (28, 32, 33, 35-37). Two of the papers looked at nursing students (38, 39); two looked at allied health professions (29, 30); while only two papers assessed the use of VLEs among post-graduates (31, 34). These were in Canadian physicians (34) and by the Royal College of Surgeons in Ireland (RCSI) as a web-based distance learning tool to trainees on the Basic Surgical Training (BST) program (31). Two studies used online resources to supplement traditional training for Post-graduate surgical trainees (40, 41). No papers assessed the use of a VLE in Orthopaedic trainees. This supports the assertion that although the tools have been available for almost a decade, the integration of such tools into surgical training curricula has been patchy.

3.2a Facilitators to the use of the VLE

Despite this, we know that e-learning applications are becoming an indispensable part of the modern medical curriculum (36). So how can we facilitate the use of the VLE among students? Munoz (28) states that in order for the Virtual Learning environment to be successful, content needs to be relevant and logically organized. Furthermore, it should be flexible enough to be adapted to the students' needs. The systems developed should be evaluated regularly, easy to use and maintain and provide students' feedback, guidelines and supporting material in different formats.

The study described by Moule *et al* (39) described 'facilitating factors to engagement';

- Flexibility in learning
- Speed of communication
- Perceived relevant to the course

It is also interesting to note that making the VLE mandatory was seen by some of the study participants as key to achieving student participation. This is discussed by

Hege *et al* (36) in their study on methods of VLE integration and will be considered later in the chapter (see section 3.2c).

Similarly the study by Guan *et al* (34) found that although the student participation overall was low, when asked what factors motivated them to overcome these barriers (*see section 3.3g Barriers to the use of the VLE)* the students described the following facilitators:

- Practicality and usefulness of the course (67%)
- Strong desire for learning (47%)
- Greater personal commitment (45%)
- Facilitator's enthusiasm (36%)
- Better time management (33%)
- Course credit (31%)
- Peer enthusiasm (24%)

Other motivating factors reported as comments were strong desire to finish on time, being motivated by the needs of patients, reading postings, helpful support from course administrators, and facilitator's regular input and feedback. This is echoed in the paper by De Leng *et al* where students felt that the VLE was the most useful for information gathering during self-study.

3.2b Feedback as a facilitator to use of the VLE

Feedback is an important component of the learning process but can be difficult to incorporate into electronic learning. It is clear from the literature that tutor feedback is an important facilitator to use of the VLE. The study by Beddy *et al* (31) highlights this clearly: the Royal College of Surgeons in Ireland (RCSI) established 'School for Surgeons'' as a web-based distance learning tool for trainees on the Basic Surgical Training (BST) program delivered using Moodle. Eighty-two trainees were enrolled in the School for Surgeons and received 21 assignments over an 8-month period. Each assignment was composed of a clinical case that requires interpretation of

patient history, laboratory data and radiological images. Students were required to formulate a management plan including differential diagnosis, further investigations required and a treatment plan with details on relevant operative techniques. The number of assignments submitted was used as the gold standard measure of active participation. The study demonstrated overall log-in rates of 83% in the first term, and 85% in the second term. Feedback was then given to students by peer ranking based on number of assignments submitted during the first term. The study demonstrated that feedback significantly increased median assignment submission to eight per trainee in the second term from a median of four assignments submitted in the first term.

3.2c Integration strategies for the VLE

In the study by Beddy *et al* (31) student participation was entirely voluntary. We have seen in the study described by Moule *et al* (39) that a number of the tutors interviewed felt that making the VLE mandatory was seen as key to achieving student participation. Hege *at el* (36) addressed this issue, comparing five different strategies for integration of e-learning into the curriculum. The study used the CASUS system to deliver online cases to medical students at the University of Munich. They compared five different strategies for integration:

- Voluntary access to cases
- Mandatory cases to be completed to succeed in the course
- "Learning by teaching" with students producing the cases
- Cases for online exam preparation
- Combined

The authors found that student motivation was very strong when tutors expressed explicit exam relevance of cases compared with the strictly voluntary use which they found disappointing. The percentage of cases used was highest in the mandatory strategy, but taking into account that only two completed cases were required, 16% completed all cases compared with 62% in the combined strategy and 90% in the

"exam strategy". In the voluntary setting 8.8% completed one or more cases, while only 0.4% completed all the available cases. In the mandatory setting 54.7% went on to look at more than the required cases.

Other studies described here have shown better levels of participation when the usage is voluntary, but it would suggest that perceived relevance to the course is a highly motivating factor in use of the VLE. The paper by Hege *at el* (36) actually suggests that making cases voluntary may reduce self-motivation to master the learning objectives. Instead they recommend using cases as preparation for exams. They do note however that this requires competent tutors available who can manage the course as well as review and revise the cases.

3.2d Tutor interaction in the Virtual Learning Environment

A study by Nathoo *et al* (37) used qualitative methods to assess the characteristics of effective online and real-time interaction and qualities of an effective faculty tutor. Undergraduate medical students at Harvard Medical School used clinical cases on the ICON system. Interviews were undertaken and thematic analysis performed. Students revealed a number of variables that were of benefit to the learning process including the "establishment of longitudinal relationships with the faculty tutor and invited faculty mentors". Students also noted two limitations:

- The reliance on a well-invested faculty mentor and discussion leader
- The increasing amount of time and resources required by faculty to successfully participate in the learning process.

Students reported that online interaction was most effective when the faculty tutor actively facilitated discussion. Students described that faculty were most effective when they had an ability to effectively facilitate online and real-time discussion, had a desire to participate and were knowledgeable about the case, but pointed out that their expectations of the tutor were largely similar to their expectations for tutors in traditional tutorials. It is well known that e-learning is rarely an effective tool when

there is little support, either for the trainee or trainer. There needs to be recognition that it is time consuming for the trainer, and requires the trainer's presence as much as during other types of training.

3.2e Student learning styles and use of the VLE

When considering facilitators to the use of any VLE, we must also consider that student's own attitudes and indeed learning styles may be powerful barriers or facilitators to the use of any online learning system. The study by Halbert *et al* (32) aimed to determine whether students with particular learning styles preferentially utilized online learning materials. Medical students with access to blackboard were asked to complete an anonymous survey to quantify their use and assess the utility of the on-line learning materials. Students were also provided with a brief description of four bipolar domains of learning (active-reflective, sensing intuitive, visual-verbal, and global-sequential), as described by Felder and Soloman (42).

The students were given descriptions of a model of learning styles generally referred to as the 'Felder-Silverman model'(42). The model was originally formulated by Dr Felder in collaboration with Dr Linda K. Silverman, for use by college instructors and students in engineering and the sciences, although it has subsequently been applied in a broad range of disciplines. Learners are described as "Active or Reflective", "Sensing or Intuitive", "Visual or Verbal" and finally "Sequential or Global learners". Active learners tend to retain and understand information best by doing something "active" with it, either applying it or explaining it to others. Reflective learners prefer to think about it quietly first. Sensing learners tend to like learning facts, intuitive learners often prefer discovering possibilities and relationships. Visual learners remember best what they see, and might prefer pictures, diagrams, films, or demonstrations. Verbal learners prefer written and spoken explanations. Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. In contrast, Global learners

may be able to solve complex problems quickly or put things together in novel ways once they have grasped the "big picture". In the study described here by Halbert *et al* (32) students were asked to check the box that most accurately described their learning style.

Overall participation was high, with 82% of students accessing the online materials. The percentage of survey respondents who reported actual usage of the accessed materials (61%) was lower, suggesting that a subset of students who accessed the materials chose not to use them. Those students that did access the VLE reported a better understanding of the course materials. Halbert reports that students who had declared themselves active, intuitive, and global learners were twice as likely to use the online environment as the reflective, sensing, and sequential learners. Visual learners were 1.5 times more likely to use the online environment than verbal learners. They felt that this suggested that active learners, who enjoy brainstorming and gathering input from various sources, were more likely to use the online materials than reflective learners, who prefer to work independently. Intuitive learners, who prefer to seek out relationships within topics and concepts (consistent with the intent of the materials), were also more likely to use the online study aids. Visual learners also preferred the online materials, which were largely diagrams and flow charts, compared to verbal learners.

It is interesting to note however, that regardless of learning style, they did not find a correlation between the student course grade and the number of times the online materials were accessed by the student. So is there any benefit in the use of online learning materials in medical education? We will go on to discuss this is the following section.

3.2f Benefits of utilising an online learning environment in medical education

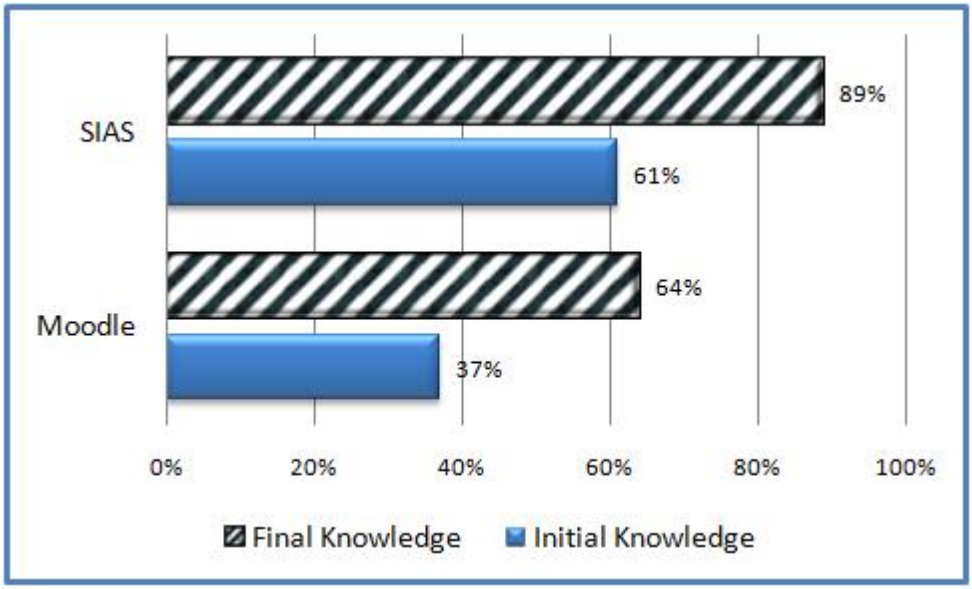
There is no clear consensus in the literature on the effectiveness of Virtual Learning Environments in medical education. There was only one paper in the literature that provided a direct comparison between online environments and traditional lecture based, or face to face teaching (38). One paper assesses the effectiveness of a Moodle VLE but with no comparison to other teaching methods (30). Two further papers compare the use of different Virtual Learning Environments (28, 29).

The study by Campbell *et al* (38) compared the use of a WebCT online learning environment and face to face seminars among nursing students at the University of Manchester. It is interesting to note that students were not randomised to a method of learning but allowed to choose based on their own preference; students were offered a choice of weekly face to face seminar or an online discussion using the discussion board within WebCT. The primary outcome measure was the mark achieved by the student on the summative assignment essay. Secondary outcome measures were pass/fail for the course as a whole. Usage statistics were also noted.

There was no significant difference in the pass/fail between the two groups ($p= 0.601$). They did note a significantly higher mean assessment mark for the online discussion students (60.8) versus the face to face discussion group (54.4, $p= 0.002$). Increased online activity was associated with higher assignment marks; increased frequency with which students read the online postings and increased frequency of contribution to online discussion were both strongly associated with higher marks. Whilst this might suggest that those who were active online were more engaged and hence gained higher marks, we must consider that this group of students had chosen to participate in this way, and therefore there may be an element of selection bias in place. Are those who *chose* to participate in online discussion more likely to be active online already?

The study by Mazzoleni et al (30) reported the evaluation of a Moodle course for Occupational medicine students in Italy, but with no direct comparison to other methods. Their primary outcome measure of effectiveness was defined as "knowledge improvement" and measured using the result of a mandatory initial test (one attempt allowed) and a final test at the completion of the course (four attempts allowed). Their results show a significant improvement in knowledge following completion of the course; at the initial test 17% of students achieved a score between 80 – 100%, compared with 84% of students in the 80 – 100% range at the final test. The authors do not comment on the effect that multiple attempts at the final test may have on the result. They do acknowledge that the final test score is a mean of all attempts, and that scores improved with the number of attempts. They also note that the number of attempts does not correlate with the number of connections to the final test. One test shows a mean number of 2 attempts, but with a mean number of 6.53 connections. They suggest that users are able to suspend the test, which allows them to revise the module and then reconnect to complete the test. This must therefore have a significant impact on the results, and explain why such an increase in the scores is seen. There is no qualitative data given in the paper on the behaviour of the users, so we cannot speculate on the reasons for the differing number of connections and attempts.

Other studies have shown a similar improvement in scores pre and post course regardless of the style of the VLE used. The study by Munoz *et al* (28) measured the performance of the eLearning platform (SIAS-Tutor) against a Moodle Learning Management System. Student knowledge was measured using a pre-test that contained questions related to each topic in the domain. A post-learning test was performed to compare the student's knowledge level at the end of the course. Results were presented in the following table:



In their analysis and discussion of the results the authors clearly state that "*acquired knowledge level using SIAS-Tutor is 25% higher than that achieved with Moodle*". This is taken from the post test scores of both groups (64% with Moodle, 89% with SIAS). However, from the table presented we can see that both groups show a significant improvement in scores, but that there is no difference in the *percentage improvement*; using the Moodle resource students improved scores by 27% versus an improvement of 28% using the SIAS-Tutor resource. There is no mention made of this by the authors. Whilst their qualitative data suggests that students found that the SIAS resource was easier to navigate and that Moodle was confusing at times, the quantitative data does not support their conclusion that the SIAS allows significantly better knowledge improvement.

This is supported by the study from Wessa *et al* (29). This paper compares course design of the VLE; course centred versus content centred. The primary outcome measure was pass/fail of the course, but no significant difference was seen between the two groups. However, we must consider that simple pass or fail is too crude a measure to see a real difference between the designs of the course as we have seen previously that poor course design can be an important barrier to the use of the VLE.

3.2g Barriers to the use of the VLE

There was a consensus in all papers that there have been significant problems with the introduction of e-learning. This is summarised in the paper by Munoz *et al* (28). They cite a lack of quality standards and trainers with skills to develop e-learning materials. This has been addressed in part by the Online Learning Task Force (OLTF) report (43). The Online Learning Task Force was established in mid-2009 by HEFCE to address how UK higher education might maintain and extend its position as a world leader in online learning. Developing and adopting appropriate pedagogy for its exploitation in learning and teaching has been less rapid than the corresponding technological developments, and the skills and organisational changes that are needed alongside this may take even longer. Online learning thus presents challenges on many fronts. At the same time, current and future generations of students expect high-quality, flexible online learning experiences. Six recommendations were made by the report:

1. Technology needs to enhance student choice and meet or exceed learners' expectations
2. Investment is needed to facilitate the development and building of consortia to achieve scale and brand in online learning
3. More and better market intelligence about international demand and competition is required
4. Institutions need to take a strategic approach to realign structures and processes in order to embed online learning
5. Training and development should be realigned to enable the academic community to play a leading role in online learning
6. Investment is needed for the development and exploitation of open educational resources to enhance efficiency and quality

The paper by Munoz *et al* (28) also reports problems related to the usability of e-learning platforms including support for students' guidance and feedback. They

state that from the pedagogical perspective, e-learning content is of poor quality and mostly incomplete, described as inadequate to support the level of interaction, personalization and engagement demanded by clinicians, care givers, and the patient themselves. They also report a resistance against changing teaching methods, for example, students need appropriate content and different alternatives for teaching strategies according to their learning styles. From our own initial experience of the platform, this seems to be a common problem, and anecdotally, reflected in the uptake of e-learning platforms and web based learning in postgraduate surgical trainees both locally and nationally. Munoz feels that current e-Learning systems are inadequate to support the level of interaction, personalization and engagement demanded by the users.

This is supported by Moule *et al* (39) who performed a mixed methods study, but primarily qualitative in nature, with a thematic analysis of focus group discussions with 41 students. Interesting themes emerging were the 'Factors inhibiting use' and 'facilitating factors to engagement'. Students using Blackboard described 4 main factors that inhibited their use of the VLE:

- Limited computer access
- Poor computing skills
- Technical difficulties (e.g. offsite access)
- Lack of group commitment.

This is also seen in a similar qualitative study by Guan *et al* (34). The authors felt that online learning "failures tend to occur at the social level far more than they do at the technical level and therefore designed a study to determine the impact of social inter-action on online learning and focusing on participation in online social activities and perceptions of their impact on discussion. This qualitative study assessed student perceptions of barriers and motivating factors to participation. The study found that participation by both participants and facilitators in the online social forums was low. 35% had participated in online social activities and 24% in

fact discontinued their participation in social activities as a result of poor peer response. Students reported a number of barriers to use of the VLE including;

- Limited time (49%)
- Lack of social bonding (22%)
- Pacing of the module (18%)
- Low peer participation (15%)

Others indicated that their own attitudes were barriers, including lack of commitment to the program (9%), dislike of expressing oneself in writing (7%), and unwillingness to speak in public (5%). Other barriers mentioned pertained to the content, the group size, and the delivery format. Only 5% of respondents cited lack of facilitator input as a barrier.

A similar study by McHarg *et al* (35) using Blackboard, found that only half the students were satisfied with the quality and quantity of resources on the VLE. Quantitative data were collected by questionnaire; with the questionnaire responses forming the basis of semi-structured focus group interviews. On the whole feedback was positive in that the students had found the VLE useful; however, there were four areas which merited concern: problems with access, the library links through the VLE, lack of user friendly navigation and poor training. Interestingly the use of the electronic library was not seen to replace the use of a traditional library when the traditional library was unavailable.

Again, this is supported by studies by Halbert *et al* (32), and De Leng *et al* (33). Halbert's study found that of the students who utilized the online materials, 57% responded that the online material ''rarely'' or ''never'' replaced the course materials, while De Leng's study also found that students gave a significantly negative judgement of the stimulation of interaction during self-study. They found that the discussion board did not stimulate distance discussions in between face-to-face group meetings.

3.2h Use of Virtual learning Environments with Post-graduate surgical trainees

In the original review of the literature, only one paper by the Royal College of Surgeons in Ireland (RCSI) used trainees on the Basic Surgical Training (BST) program (31). We did not find any studies using Post-graduate Orthopaedic trainees. In contrast, the supplementary literature review found 3 additional studies that used online resources to supplement traditional training for Post-graduate surgical trainees.

The paper by Brown *et al* (40) describes the use of Moodle for Post-graduate medical and surgical trainees within the Wales Deanery. They used an online resource known as "PLATO" (Postgraduate Learning and Teaching Online). This mixed methods qualitative study reviewed the impact of the resource among medical and surgical trainees. Trainees were invited to participate in 5 courses available within the resource. No quantitative usage statistics are given in the paper. The authors state that 79% of users felt that the use of the online resource is important for their Continuing Professional Development (CPD). PLATO was rated as "good" or "very good" by 87% of the respondents. Qualitative thematic analysis suggested that participants felt that the flexibility for learners, and having a central point of reference were facilitators to their use of the tool.

A similar paper from the North of Scotland Deanery by MacDonald *et al* (41) describes the use of an online resource to ameliorate the problems encountered by General surgical post-graduate trainees in accessing training over the largest geographical area in the UK. Web based teaching resources were used as an adjunct to traditional face to face learning. The online course material was developed as an augment to a face-to-face teaching day, designed for revision and for trainees that were unable to attend. Online discussion could take place via forums and discussion boards. Trainees were also able to watch operative videos performed by their own trainers. This was reported as helping them to prepare for new rotation, and the

local relevance acts as another facilitator to the online resource. They found that trainees in the first year of the teaching programme accessed the resource a mean of 3.3 times, with a mean usage of 26 minutes per trainee, while usage decreased in the second year of the programme, with a mean usage of 16 minutes per trainee. The authors felt that the trainees preferred face to face learning. As the teaching programme was designed to prepare trainees for the MRCS and FRCS examinations, which are examined in a *Viva-voce* style, this may drive the preferred face-to-face method of engagement.

3.2i Use of Up-to-date Methods for online interaction

The study by Hennessy *et al* (44) used social media in the form of Twitter to facilitate communication and learning for undergraduate medical students during their neuroanatomy module at University of Southampton. They created a Hashtag to support learning and answer questions. The "#" symbol is used to signify a key word in the body of a Tweet. When this symbol is inserted directly before a character string it labels the Tweet with a hashtag. By clicking on a Hashtag, Twitter users can easily view all other Tweets containing it. The paper suggests that for undergraduates who communicate in the moment using instant messages or social networking, it is possible that online discussion boards and email are no longer current enough methods for communication, due to the delay in receiving a reply. A study by Jaffar *et al* (45) suggests that students also feel uneasy with the presence of their lecturers on Facebook, within what they perceive to be their personal space. Hennessy *et al* (44) suggest that the ability of Twitter users to create multiple accounts, allowing separation of academic/professional and personal accounts may allow students to feel less inhibited in their interactions on the site. This is supported by the high levels of engagement seen in the study, with 91% of the participant sample used the hashtag created for the module. However, the majority of students chose to follow and observe the Twitter feed rather than contribute to it.

The study also did not show any correlation between the frequency of contribution to the feed and student performance in the final examination. They did note that students who failed the final examination had little or no interaction with the site. They postulate that this lack of engagement with online resources may be a way to identify potential "at-risk" students and offer them timely academic support.

Another study by Pickering *et al* (46) used screencasts to replace the *live* element of the anatomy lectures. Medical students at the University of Leeds were given access to a short video file of an anatomy drawing, which describes and captures specific structures in real time while the drawing progresses. Usage was monitored via the Blackboard facility. 92.8% of students accessed the screencasts at least once, with the mean of 5.4 downloads per students. Number of downloads was seen to increase prior to the module assessment. The authors felt that the high level of engagement was due to the ability of students to access the material via their own mobile devices and in a way that is individually suited to their own learning style.

A further "up-to-date" method to consider in this section is the growing use of Massive open online courses, or "MOOCs". MOOCs address an unlimited number of participants ("massive"); are offered free of charge or impose only low participation fees ("open"); are available "online"; and the content consists of instructional lectures and assessment ("courses"). In the context of MOOCs, students have freedom to determine what, when, where, and how they will learn. The materials are freely available, which creates the opportunity for students to pick and choose, in ways may not have been possible in earlier models of online education. These can have a negative effect on student motivation and online identity however. The high volumes of posts seen on MOOCs can be poorly managed, with topics becoming fragmented over many threads and a lack of search facilities. Drop-out rates are thought to be disproportionately high. Yang *et al*. (47) used social network techniques to investigate forum posts in a Coursera MOOC and concluded that high

post duration (time between first and last posts) was related to a lower likelihood of drop out in any given week, but quoted drop-out rates of 91 – 93% in undergraduate students.

3.3 Local and National Policy

In addition to searching the literature I have also included current local and national policy guidelines, and this will necessarily influence future work into technology enhanced learning and simulation.

3.3a National Policy

Department of Health (DoH)

In November 2011, the Department of Health published "A Framework for Technology Enhanced Learning" (48). A number of recommendations were made regarding the use of TEL and simulation in medical training.

- Patient centred and service-driven
    - Trainees should have appropriate access to allow them to learn skills in a simulated environment prior to undertaking them in clinical practice, with regular review of facilities available to all.
- Educationally coherent
    - Strategic leads should integrate TEL into the curriculum in a blended fashion to meet specific educational needs.
- Innovative and evidence based
- Deliver high quality educational outcomes
    - With a clear learning outcomes for each technology, and trained educators to deliver those outcomes.,
- Value for money
    - The DoH recommended a national register of technologies to allow collaborative working.

- Equity of Access and quality of provision
    - With agreed technical standards across all users.

Trainee Societies (BOTA)

In response to this, both ASiT (Association of Surgeons in Training) and BOTA (British Orthopaedic Trainees Association) released statements to clarify the trainee position on TEL. The statement by ASiT was published in November 2011 (49), and BOTA in April 2013 (50). Both support the use of simulation in surgical training, but as a supplement to training, and recommended that they should not replace direct operative experience. Both societies recognise that there are numerous challenges still in place, including a lack of access to facilities, which is not sufficient at present nationally. In order for this to occur, both recognise that funding must be identified. ASiT in particular wanted recognised and accredited courses to maintain national standards.

British Orthopaedic Association(BOA)

This is also seen in the document released by the British Orthopaedic Association (BOA) in December 2012 (51), outlining the BOA Training and Education strategy for 2013. They aim to develop the scope and content of simulation to support training. They also aim to produce a high quality online resource for all orthopaedic surgeons to ensure equitable access for all.

Specialty Advisory Committee (SAC)

The Specialist Advisory Committee (SAC) in Trauma and Orthopaedic Surgery defines the standard to which a surgeon is assessed as having completed their training and at which they might be deemed ready for the award of the Certificate of Completion of Training (CCT). The first curriculum to include simulation was published in 2013 on the Intercollegiate Surgical Curriculum Programme (ISCP)

website. Simulation was highlighted as an important aspect of training that the SAC felt will increase in significance over the next 5 years.

The curriculum states that to improve patient safety, many surgical/procedural, clinical and communication skills should be practiced in the simulated environment. The SAC recognised however, that cost and availability of facilities may limit access locally. Three simulation pathways were suggested by the SAC for the T&O curriculum:

- Dry Lab Simulation (Surgical approach learnt in Anatomy Lab +/- Cadaveric Surgery e.g. Total Hip Replacement, Bones, models, simulators etc)
- Wet Lab Simulation (Surgical approach learnt in Anatomy Lab +/- Cadaveric Surgery e.g. Knee Model, simulators e.g. arthroscopy) arthroscopy
- Simulation practical (models, simulators, simulated patients e.g. +/- Simulated Scenarios e.g. Musculoskeletal examination, peers)

The level of technology and fidelity of each simulation pathway is likely to vary from region to region. However, even low tech, low fidelity simulation can help to mind map a clinical skill. They do state that whilst the Training Standards Committee is anxious to embrace technology enhanced learning; their priority must be the expert supervision of trainees and appropriate preparation of trainers.

3.3b Local Policy

In October 2011 East Midlands Healthcare Workforce Deanery published the East Midlands Simulation strategy for 2010 – 2015 (52). In this they identified many challenges faced in the region including:

- Variable access to simulation facilities and equipment.

- A requirement for increased local resources.
- The need for a network of experts to be established.
- A requirement for simulation to be included in job plans, in order to ensure the availability of a skilled faculty of educators.
- The necessity of establishing a baseline level of consistency for faculty, facilities and processes.
- The need for further research to demonstrate evidence of impact.
- A role for the Deanery in leading the creation of a strategic approach to simulation across the East Midlands.

Their approach to solving these challenges aims to use existing resources (people, equipment, facilities) more effectively to contribute to improved patient outcomes. This approach will focus on:

- Ensuring there is access to simulation facilities, equipment, skilled personnel and learning opportunities.
- Developing a distributed network, so that common systems are in place, as per the DoH document.
- Training and development of the faculty of simulation educators, so that high standards of delivery are provided.
- Growing the evidence base for the effectiveness of simulation, so that there is continuing improvement in the East Midlands.

3.4 Summary of findings

This chapter presents a review of the literature in relation to the research objective one:

Objective One:

To critically review the literature, especially of the use of existing technology enhanced learning resources, to include ***Virtual Learning Environments*** and simulation based technologies. This has three sub- objectives:

a. To determine scope of technology enhanced learning resources
b. To determine the availability of those resources
c. To investigate which of these methods have been successful in facilitating surgical trainees to improve learning outcomes

From our review of the literature we can see that there is still no clear consensus on the use of Virtual Learning Environments in post-graduate surgical trainees. Only one paper by the Royal College of Surgeons in Ireland (RCSI) used trainees on the Basic Surgical Training (BST) program (31). Two studies used online resources in Post-graduate trainees, although the uptake seems to be slow, and more senior trainees have described a preference for face to face learning (41), which may be driven by the more traditional forms of assessment employed by the Royal College of Surgeons (53).

From the critical review of the literature we have been able to identify many factors that act as barriers and facilitators to the use of the Virtual Learning Environment. The most important barriers appear to be divided into two groups; issues that concern technical problems (including limited computer skills, limited access or lack of training) and issues around poor peer participation or lack of commitment. The most important facilitators to use of any VLE are flexibility, feedback and its perceived usefulness or relevance. Younger users also seem to value immediacy of response in any online resource.

Distance learning is currently a relatively small element of the higher education landscape, with only 5.3 per cent of undergraduates registered as studying in this mode (54). However, the widespread digitisation of journals and resources for online access, and the use of online technologies in institutions for libraries, timetable management and communication, highlight the existing integration of online technology in undergraduate and post-graduate education.

The rapid development of technology will require higher education institutions to continually review their approaches to teaching and research methods, both for Undergraduate Medical Students, but also for Post-graduate Trainees within surgery, as my work focuses on delivery to this post-graduate group. One driving factor will be improved domestic access to high speed broadband. In 2005 only 25 per cent of homes in the UK had a broadband connection, increasing to 70 per cent in 2009 (55). Other drivers will be changing social attitudes in relation to the use of technology, and the rapid innovation in online technology, including mobile devices and cloud computing. These learning technologies will provide the ability to reach a much larger volume of students with fewer resources, and the ability to reach students over much longer distances, while maintaining a direct interaction in real time through shared online spaces. The increasing integration of online learning methods and skills into secondary school curricula may also influence the implementation and uptake of online learning at higher levels. We must consider these factors carefully when considering the design and improvement of our own Virtual Learning Environment.

CHAPTER FOUR:

CRITICAL REVIEW OF THE LITERATURE – ARTHROSCOPY SIMULATORS

A review of the findings from the literature searches for Arthroscopy simulation is presented. This chapter aims to critically review the literature, with regard to ***simulation based technologies***. The objective addressed can be seen in Chapter 3.

A description of the methods used is presented. This chapter concludes with a summary of the findings from this review.

4.1 Methods

A critical review of the literature may provide insights to future policy or practice, and the author feels is particularly important in fields such as this where all aspects are rapidly evolving.

4.1a Selection Criteria

We included randomised controlled trials (RCTs) relating to the use of simulation in arthroscopic procedures. We excluded randomised control trials that did not meet the CONSORT (Consolidated Standards of Reporting Trials) statement for the description of randomised controlled trials (56). We also excluded those studies which did not involve training on a virtual reality simulator, and also excluded studies that were not arthroscopic, such as those looking at laparoscopic surgery.

4.1b Search Strategy

Initial results were limited to human studies, and publications years 2005 – 2013. During the writing up period an additional literature search was performed to include up to 2016, to ensure that newly published work can be included in the

critical review. The search strategy was performed in the same way as the original search. These were searched as keywords and combined using Boolean operators where necessary. Articles were limited to those in the English language as the cost of interpretation of articles could not be covered. Results were limited to human studies, and publications years 2005 – 2016. References of the identified trials were also searched to identify further relevant trials. We did not contact investigators from published articles.

4.1c Study Selection

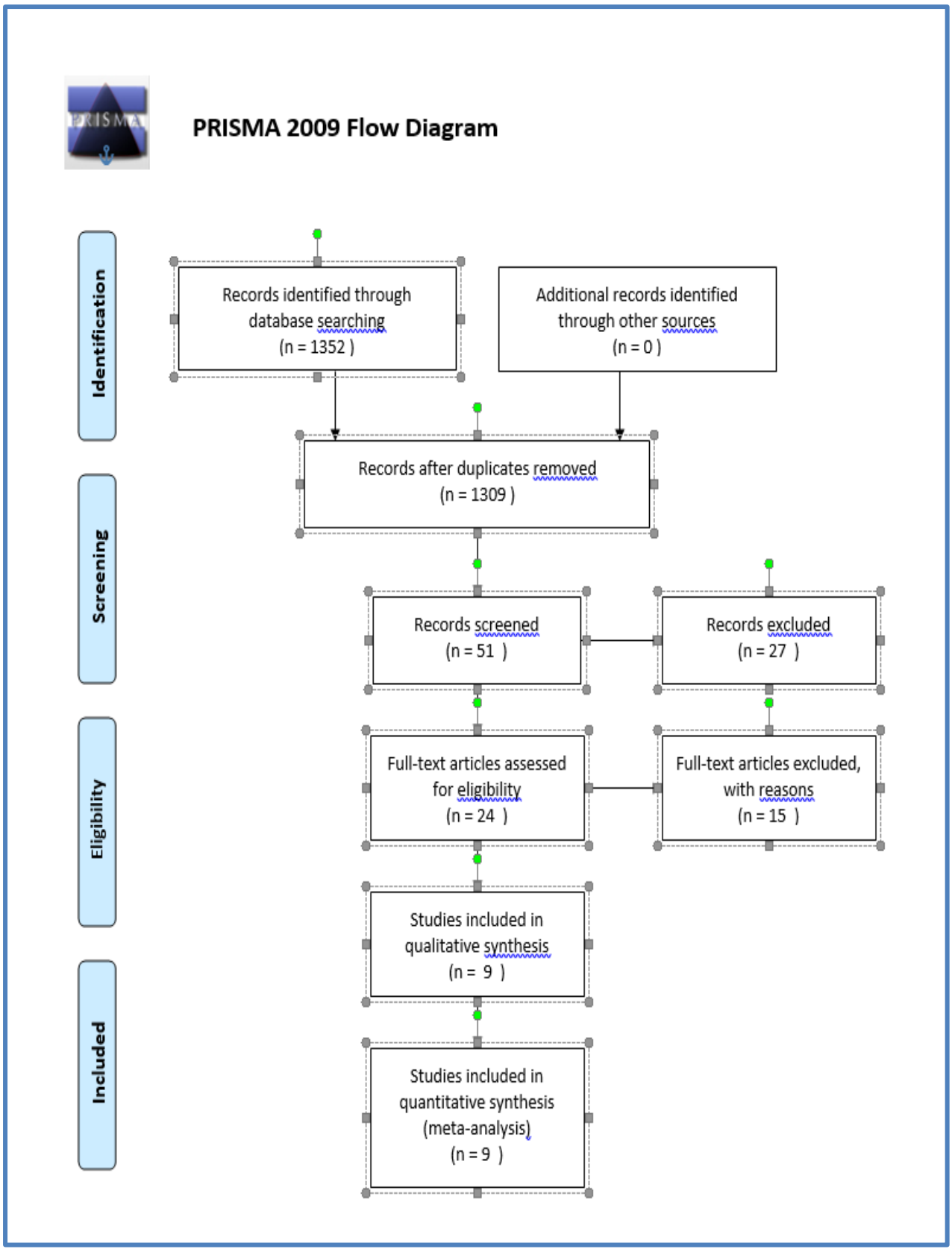
The abstracts were identified for inclusion and screened for relevance. Full text articles were obtained for all potentially relevant studies fulfilling inclusion criteria or for studies for which insufficient information could be obtained from the title and abstract alone.

PRISMA methodology with the appropriate checklist and flowchart were used to identify and selection appropriate studies for inclusion in the review (26) (see flowchart below).

Although the resources available for this research study did not include a panel of experts to support the critical review, the quality of the studies was evaluated using a validated appraisal tool (27). The Critical Appraisal Skills Programme (CASP) appraisal tool assesses the research aims, research design, data sampling, data analysis, results and ethical implications, as well as the overall contribution of the research to existing knowledge and understanding.

The flow chart summary of the study selection process is shown in figure 8:

Figure 6: A flow chart summary of study selection process, Arthroscopy simulation



4.1d Data Extraction and Analysis

Data was extracted related to author and year of publication, inclusion and exclusion criteria, participant characteristics and details of training, such as the software or type of simulator used. Because of the heterogeneity of the studies with regard to aims, interventions and outcomes, it was not considered appropriate to pool results and conduct a meta-analysis. Results are therefore presented using a descriptive format to summarize and evaluate the studies.

4.2 Results

Nine studies were selected for the critical literature review. Six out of the nine studies assessed the use of a shoulder arthroscopy simulator (57-62), while only one assessed the use of an ankle arthroscopic simulator (63), and two the use of a knee arthroscopy simulator (18, 64). All papers were published after 2008, which reflects the recommendations made by Lord Darzi in 2006, where he re-introduced the concept of simulation-based training for surgeons (17), and the Temple report (4) in 2006, which also recommended increased investment in simulation to fully realise the benefits to training. Virtual reality simulators have proven beneficial in other surgical fields, such as gynaecology and laparoscopy (17, 19, 20, 22, 65) but the literature remains small for arthroscopic procedures.

All papers used a simulator with some form of haptic feedback. In surgery, haptic or force feedback refers to the sense of touch that a surgeon experiences—both consciously and unconsciously—while performing surgery. It is thought that realistic procedural simulations with haptic feedback lead to reduced surgical errors and potentially increase patient safety. The majority of studies report benefits when adding force feedback to simulation and, in fact, indicate drawbacks when haptic feedback is absent (66).

4.2a Validating the Arthroscopy Simulator

All papers examined for the critical literature review consider that arthroscopy simulators can be used to increase surgical skills without risk to patients and without the time and financial constraints of traditional surgical education. The first paper to consider is one of an increasing number of studies being conducted to validate the simulator, with the hypothesis that more experience in surgical arthroscopy will correlate with better performance on a computerized simulator. The paper by Gomoll *et al* (58) presents a study aiming to validate the use of an arthroscopy shoulder simulator as an evaluation tool.

In this study the subjects were not randomised, but were divided into 4 groups: Group 1 had no prior experience of arthroscopic procedures; Group 2 had declared experience equivalent to residents in their second or third postgraduate year of training; Group 3 were those with experience equivalent to residents in their fourth or fifth postgraduate year of training; and Group 4 had experience level equivalent to a sports medicine-trained specialist such as a sports medicine fellow or attending. Each of the groups was asked to complete a training module 6 times on the Procedicus arthroscopy simulator (Mentice Corp, Göteborg, Sweden). They were evaluated for time to completion, distance travelled with the tip of the simulated probe compared with a computer-determined optimal distance, average probe velocity, and number of probe collisions with the tissues. Comparing the least experienced with most experienced groups, the average time to completion decreased by 62% from 128.8 seconds to 49.2 seconds; path length and hook collisions were more than halved from 8.2 to 3.8 and 34.1 to 16.8, respectively; and average probe velocity more than doubled from 0.18 to 0.4 cm/second. The authors state that this demonstrates that performance on the computerized shoulder arthroscopy simulator improved with increasing real surgical experience. The authors have suggested, based on this work, that the simulator can be used to

evaluate surgical trainees. Whilst this may require further work, it does suggest that the simulator has validity in assessment of surgical performance.

The same group published a follow up study, assessing the improvement of the inexperienced group 1, with a further three years surgical training (57). This study hypothesised that the group would show improved performance on simulator retesting several years after the initial baseline evaluation (seen in the earlier study) (58) corresponding to their increased surgical experience. The study indicates that gains in experience over time within the same group are accompanied by gains in simulator performance. The authors found that the extent of improvement in simulator performance was consistent with the differences that had previously been found across the four groups in the previous study (see above). This data provides important additional support for the intrinsic value of simulator testing by showing individual improvement in simulator performance when additional surgical experience was gained.

4.2b Improvement with simulator training

If the simulator can be shown to be valid, then the next logical step would be to assess the performance of surgical trainees in the operating room and correlate their performance with the extent of simulator training. This would clearly demonstrate whether simulator training not only measures but also directly improves arthroscopic expertise.

The next study we will consider assesses whether training with an arthroscopy simulator will improve performance, but does not test surgeons in the operating room, but tests their performance on a standardised test on the simulator. The group from Denmark, led by Andersen *et al* (59) tested 21 surgeons on insightMIST, an arthroscopic trainer manufactured by GMV (Tres Cantos, Madrid, Spain). This is

a similar model to the virtual reality trainer that we have locally, and that will be used for my MD project. 14 inexperienced surgeons were randomized into an intervention group and a control group. 7 experienced surgeons we recruited as a second control group. Experience was defined as performing at least one independent arthroscopic procedure per week. All were tested twice on the simulator within a period of 6–15 days. The intervention group also received a 5-hour training program on the VR unit. Again, similar parameters were used for assessment; time to complete the exercise, number of collisions with surrounding tissue, maximum depth of collision with surrounding tissue, and paths travelled with both camera and probe. Although the intervention group showed significant improvement in all the parameters measured when compared with the inexperienced control group, there was no significant difference between the intervention group and those in the experienced control group. The authors suggest that the fact that experienced surgeons performed better than inexperienced doctors on a VR unit indicates that the skills required in arthroscopy may be transferable; such as hand-eye coordination, triangulation, and the ability to work in 3 dimensions while watching a 2-dimensional screen. These are skills that can be trained using a VR unit, and are necessary in order to perform arthroscopy in an operating theatre as well as on a simulator.

The next step from this study would be to compare the performance of doctors with no simulator training to doctors *with* simulator training in an operating theatre. This study was performed in Oxford by Howells *et al* (18). The aim of the study was to investigate the transfer validity of arthroscopic skills from simulator training to the operating theatre. Junior orthopaedic trainees were recruited and randomised to receive an additional fixed protocol of simulator training, or to receive traditional training only. The training consisted of three sessions of six simulated knee arthroscopies during one week. Their performance in the operating theatre was then assessed, the primary outcome measure being the difference in performance

between the simulator-trained and the untrained groups. The simulator-trained group were seen to significantly outscore the untrained group in both assessments performed in the operating theatre (p=0.0007 and p=0.0011).

Whilst the results have shown that trainees who undergo a period of simulator training go on to demonstrate improved performance in the operating theatre compared with an untrained group, it is interesting that the surgical trainees were not assessed in the operating theatre *before* the period of training to establish a baseline of their technical skills. Although junior trainees were selected with minimal experience of arthroscopy, there will be variation among trainees (some lack psychomotor skills, others may be more gifted) which may affect the results. It would be interesting to see how much the training can improve their performance from a baseline already established. It is interesting to note that the training took place over one week. In his report (17), Lord Darzi suggested that simulation-based training for surgeons be integrated into the curriculum, and in my project we aim to assess the effectiveness of a simulation training programme that is embedded in the curriculum and continues over several months, rather than as a one off event.

4.2c Transfer of skills from a Simulator to in-vivo surgical skills

The study by Waterman *et al* (62) attempt to establish transfer validity for an arthroscopic shoulder simulator model. Trainees were provided with an orientation session on an arthroscopic shoulder simulator, and thereafter randomised into two groups. All participants performed a baseline diagnostic shoulder arthroscopy in the operating room. These were assessed using the ASSET tool (67). Those assigned to the simulator then received four simulation training sessions lasting 15 minutes each. These took place over a 3 month period. After the simulator intervention, both groups were assessed again on both the simulator orientation exercise, and a second diagnostic shoulder arthroscopy in the Operating room. The study reports that the simulation group had significantly better ASSET scores than the standard group,

completed the arthroscopy faster, and were more efficient with the arthroscopy probe. They did report that both groups demonstrated significant improvements on the ASSET score from baseline.

The study using an Ankle Arthroscopic simulator (63) also assessed the performance of trainees using an assessed Arthroscopy pre and post intervention. These were not performed in an operating theatre, but on Cadaveric models. Pre-intervention all participants performed a diagnostic ankle arthroscopy on a Sawbones ankle arthroscopy simulator (Sawbones, Vashon Island, WA) and were assessed using the ASSET score (67). Those assigned to the simulator then received four simulation training sessions lasting 15 minutes each. After the simulator intervention, both groups were assessed again with a second diagnostic ankle arthroscopy on the cadaveric model. The simulator group achieved significantly higher ASSET scores post intervention than the control group. This time the control group actually demonstrated a depreciation of skill.

4.2d Retention of skills learned on an Arthroscopy simulator

So if the simulator can show a significant improvement in operating theatre performance over a week training course, can that improvement be maintained? Arthroscopy simulators are often used in one day training courses, but how valuable is that training? The Oxford group performed a follow up study to assess the capacity of surgeons to retain the skills learned on an arthroscopy simulator (60).

Howells *et al* (60) recruited six consultant orthopaedic surgeons with an interest in lower limb surgery, who then performed twelve arthroscopic procedures on the shoulder simulator, procedures which they would have been unfamiliar with (Bankhart repair). After six months, they repeated the twelve procedures. The primary outcome measure was the difference in performance on the simulator

between the initial tests and the repeat tests at the six month interval. This was objectively measured using the parameters of time taken, total path length of surgeon's hands, and total number of hand movements. Both studies showed that the surgeons improved with repetition ($p=0.005$) but there was no significant difference in the parameters between the first and repeat attempts. This suggests that there was no significant retention of the improved level of technical skills that had been acquired; after six months without practice, the level of performance was lost.

As the authors have stated, even experienced surgeons can lose newly acquired technical skills without practice, and therefore in order to maintain the best performance, continued practice is required. This supports the project plan to embed the simulator within the curriculum, and allow surgical trainees to practice the skills throughout the six month placement. It would be interesting to note whether there is improved retention after six months of continuous training, rather than again, a one off period lasting less than one week.

4.2e Maintenance of skill over time

A follow paper to the Waterman study (62), by Dunn *et al* (61) aims to assess whether the improvement seen with simulator training can be maintained over time. All participants performed a baseline diagnostic shoulder arthroscopy in the operating room. These were assessed using the ASSET tool (67). Those assigned to the simulator then received four simulation training sessions lasting 15 minutes each. These took place over a 3 month period. After the simulator intervention, both groups were assessed again on both the simulator orientation exercise, and a second diagnostic shoulder arthroscopy in the Operating room. The study reports that the simulation group had significantly better ASSET scores at first assessment, however when participants were re-tested at 3 month and 6 month intervals this was not

maintained. There was no significant difference in the ASSET scores on testing after one year. During that year the study participants did not use the arthroscopic simulator.

4.3 Summary of findings

From the review of the literature is it clear that simulators present a valid method of assessing surgical experience (57, 58). It is also clear that simulation technology is beneficial in Orthopaedic training, to increase the total acquisition of surgical skills without risk to patients and without the time and financial constraints of traditional surgical education (18, 59).

The literature also suggests that there is transfer validity to in-vivo operating, and an improvement in performance when using a simulator model for training (62, 63). It is clear that the quality of simulator is important, with participants achieving better performance in simulators with Force or Haptic guidance (64).

As yet, I have not been able to find any study that examines the effectiveness of simulation when it is embedded within a training programme. This continues to be a problem for surgical trainees; in a study presented by Brennan at the "Surgical Simulation: Problems and Pitfalls with Pretending" conference at the RCSEd in Feb 2011, over 50% of trainees questioned did not have access to a simulator, and felt that ongoing barriers to their use were the lack of access to this type of equipment, lack of time and instruction. This is also important, as we have seen in the literature that without continued practice, these skills are not retained (60, 61).

CHAPTER FIVE:

VIRTUAL LEARNING ENVIRONMENT QUANTITATIVE DATA ANALYSIS

This chapter presents the findings from the analysis of the quantitative usage statistics from the Virtual Learning Environment in relation to the research objective two:

> **Objective Two:**
>
> To evaluate the level of engagement among orthopaedic trainees with existing resources, including the newly developed eLearning and simulation-based learning activities.

This chapter describes the quantitative data analysis of the use of the Health Education East Midlands (HEEM) Virtual Learning Environment for Orthopaedic Postgraduate trainees. The Virtual Learning environment represents a form of technology assisted learning and support for orthopaedic trainees. Moodle was developed as a Virtual Learning Environment (VLE) to support social constructionist pedagogy, and contains tools to encourage discussion, such as the online discussion fora (including journal clubs). This chapter describes the use of the tools available; in particular, online case based discussion, journal club, educational resources and administrative resources. Moodle online learning resource had been in place for trainee interaction since April 2011, but anecdotally usage was deemed to be poor, and the site was not well populated with content.

Participation and usage statistics were examined for the website in its original format prior to any intervention by the lead researcher. 43 Orthopaedic specialist trainees, 62 Consultant Orthopaedic surgeons and 4 course leaders (a combination of three specialist trainees within the Orthopaedic department and the Training Programme Director) have access to the website. Statistics for their usage were examined for the purposes of this project. Usage data was provided by the Moodle Website, and anonymised. Data on participant training grade, sex and age were

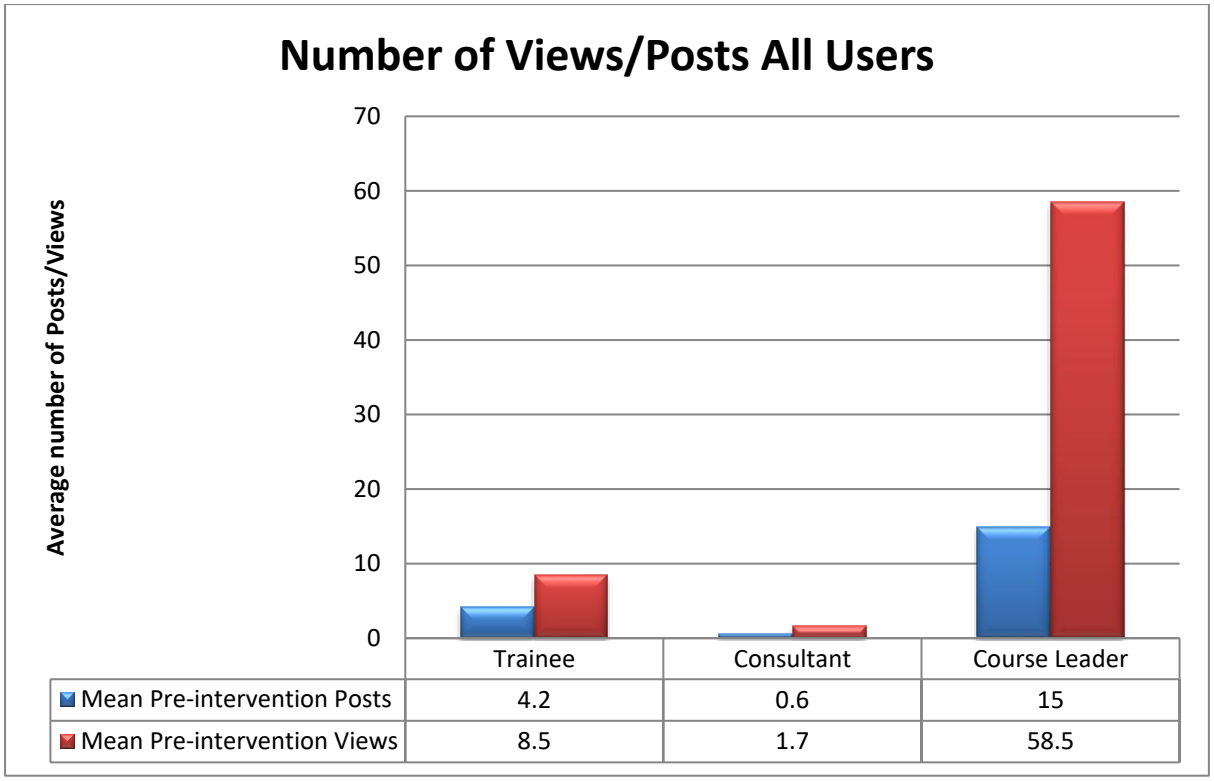
available in an anonymised format. The usage is examined from the creation of the site in April 2011 until September 2012, when the study period commenced. This was to ensure that the usage statistics were not influenced by any intervention from the lead researcher.

The following outcomes were assessed:

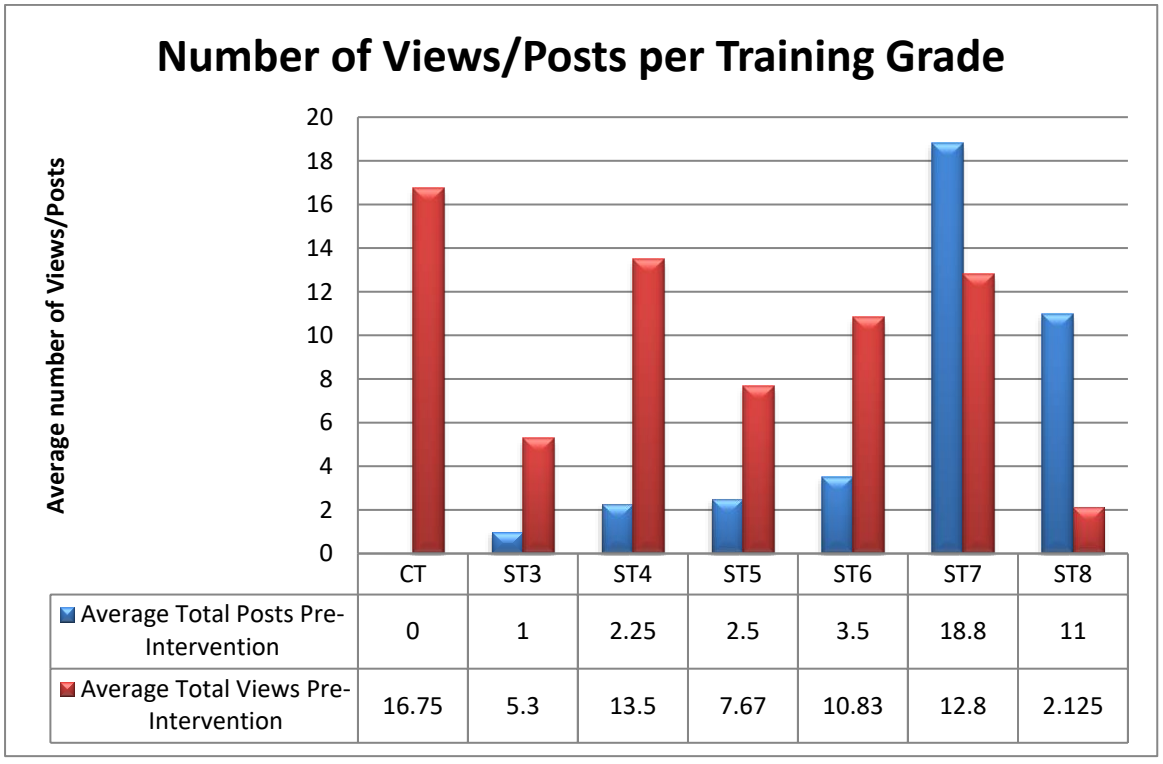
- Total number of posts by individual participant
- Total number of views by individual participant
- Domains visited and posted upon by individual participants
- Postings over time, including monthly and annual usage data.

5.1 Total VLE activity

Usage statistics were examined from the website to determine the total number of views and posts across all users. Overall usage was low in all three groups; trainees, trainers and the course administrators. Number of views was seen to exceed the number of posts in all groups, but particularly in the course leaders. Average number of views was two times the average number of posts in trainees. Average number of views was 3.2 times the average number of posts in Consultants, while average number of views was 3.9 times the average number of posts in the Course leaders. Consultant activity was lowest of the three groups overall. This is demonstrated in Graph 1 (see below).



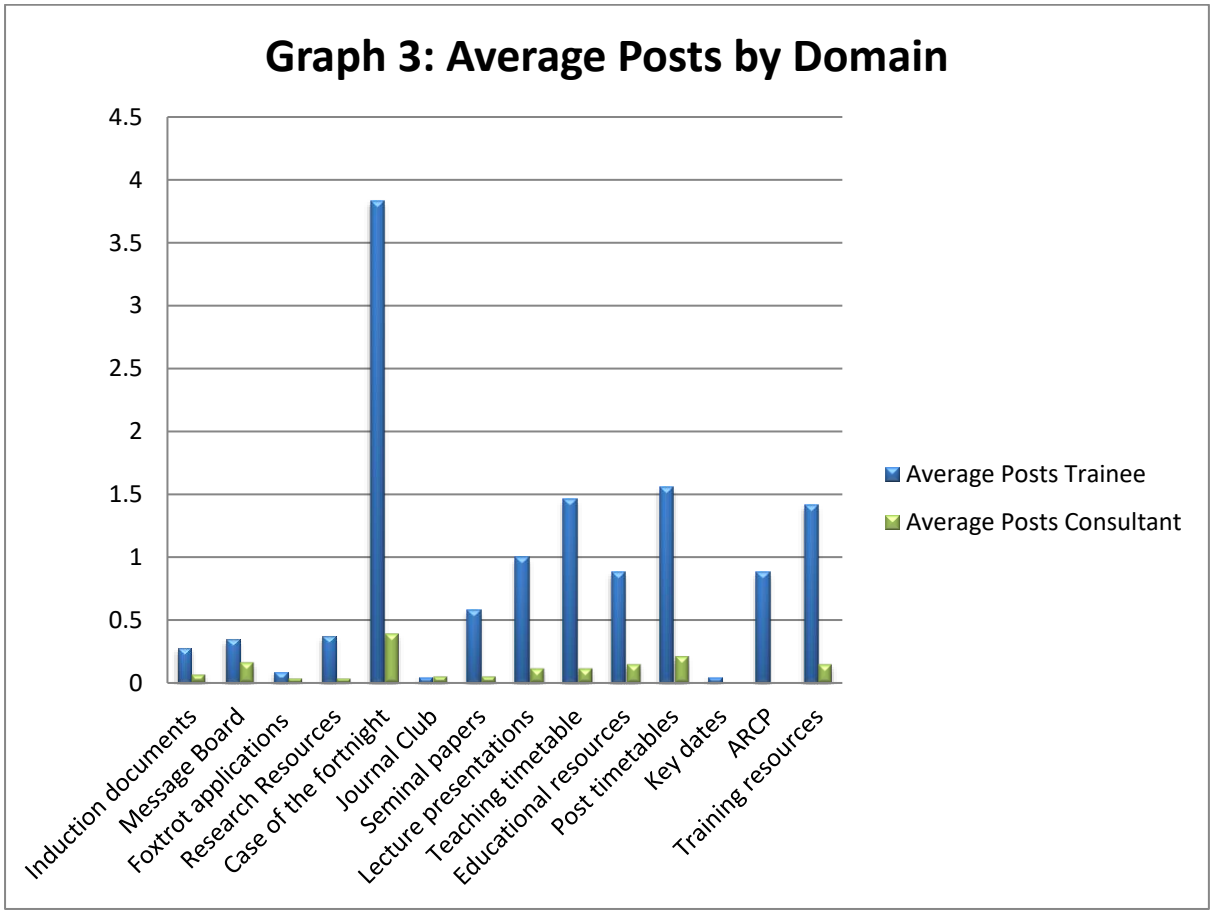
Average number of views and posts has been further examined by grade of training, seen in Graph 2 below:



We can see that the number of views does not vary significantly across each training grade, but the number of posts made increases significantly as the grade of training increases.

5.2 Domain usage across the VLE

The domains visited on the site have been examined and are seen below in Graph 3. The area of the site most visited by both trainees and consultants is the area "Case Based Discussions" where cases are discussed on a monthly/fortnightly basis.

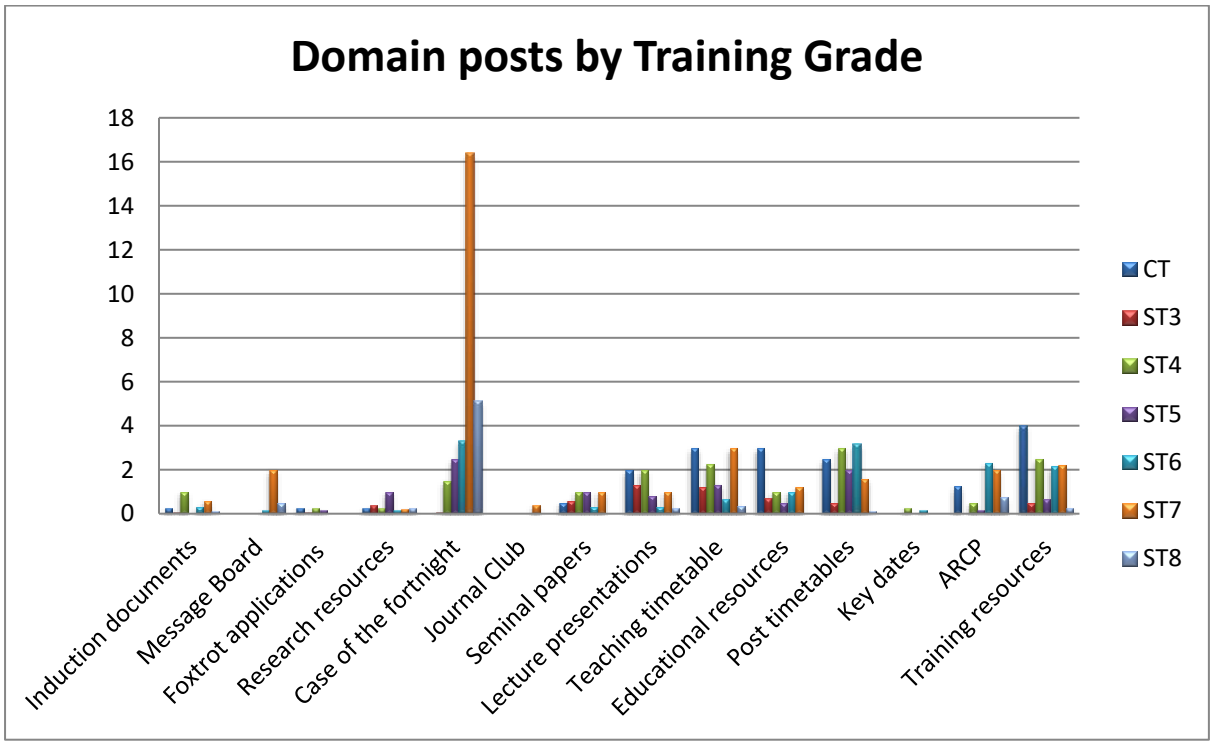


We can see from the graph above that the next most visited domains for trainees are the teaching timetable and post timetables. These represent more administrative areas where the trainees can access information directly relevant to their current job, or future job (trainees rotate posts every 6 months), including a weekly job plan. The teaching timetable details the upcoming topics for the Deanery-wide mandatory face-to-face teaching that takes place within the region every Friday afternoon.

Other resources used by trainees are the training resources which include documentation required for the ARCP (Annual Review of Competence Progression), lecture presentations and other educational resources (including quizzes for exam revision). Consultant usage of other domains was universally low.

5.2a Domain usage by Training Grade

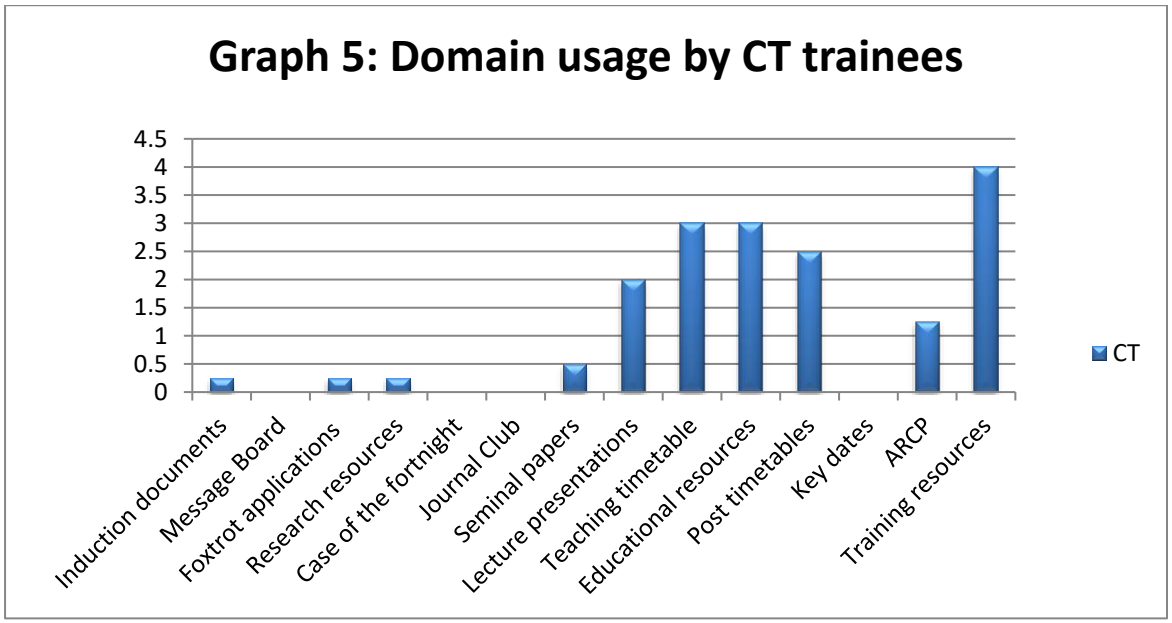
Total usage of the VLE by training grade is shown in the graph below:



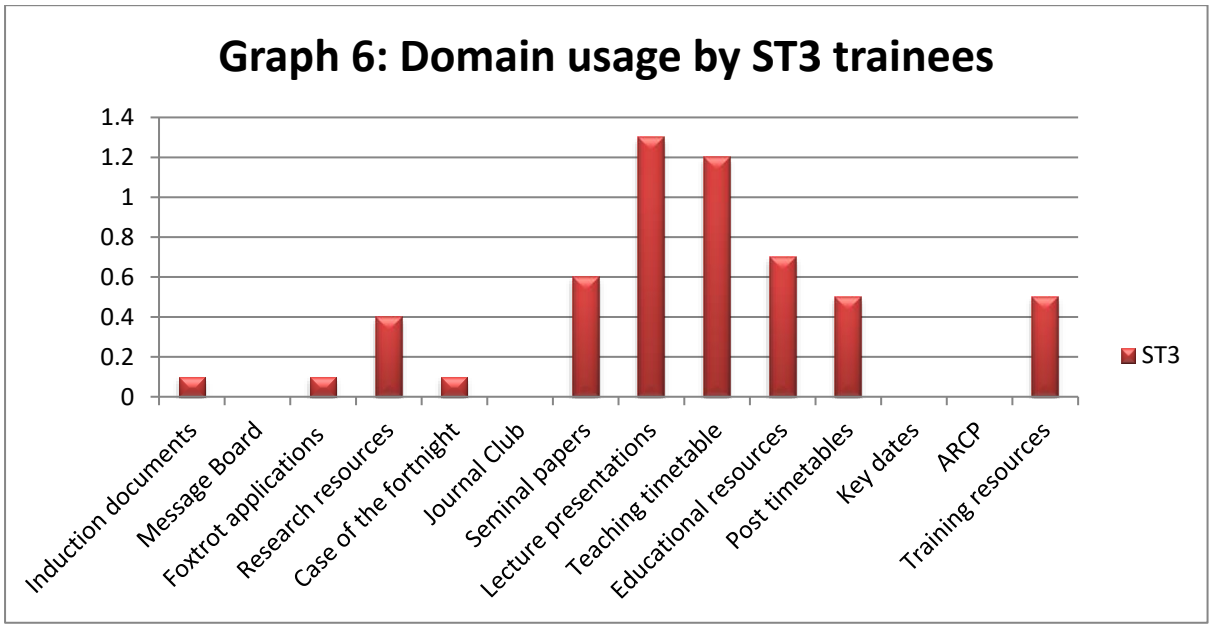
This graph represents posts by training grades in each area of the site. The engagement with the Case Based Discussion area is the highest, with the highest level of engagement seen by the ST7 Trainees. This is further broken down for clarity into graphs representing the domain usage for each training grade, so that usage by each training grade can be examined. Update data can be viewed in Chapter Nine.

Graph 5 demonstrates the usage by Core Trainees. As mentioned in chapter one, these are trainees who do not yet have a speciality training number, but who may be

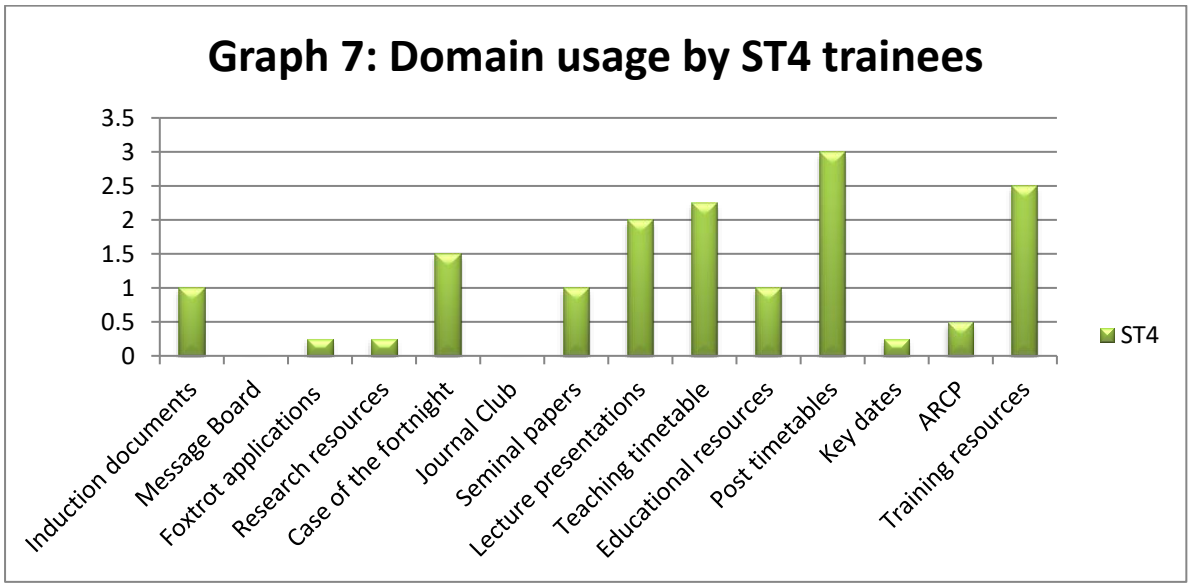
working in the Orthopaedic department. It is shown that the CTs access knowledge based resources (lecture presentations and educational resources) as well as administration based resources (e.g. teaching timetables) but do not participate in the case based discussions.



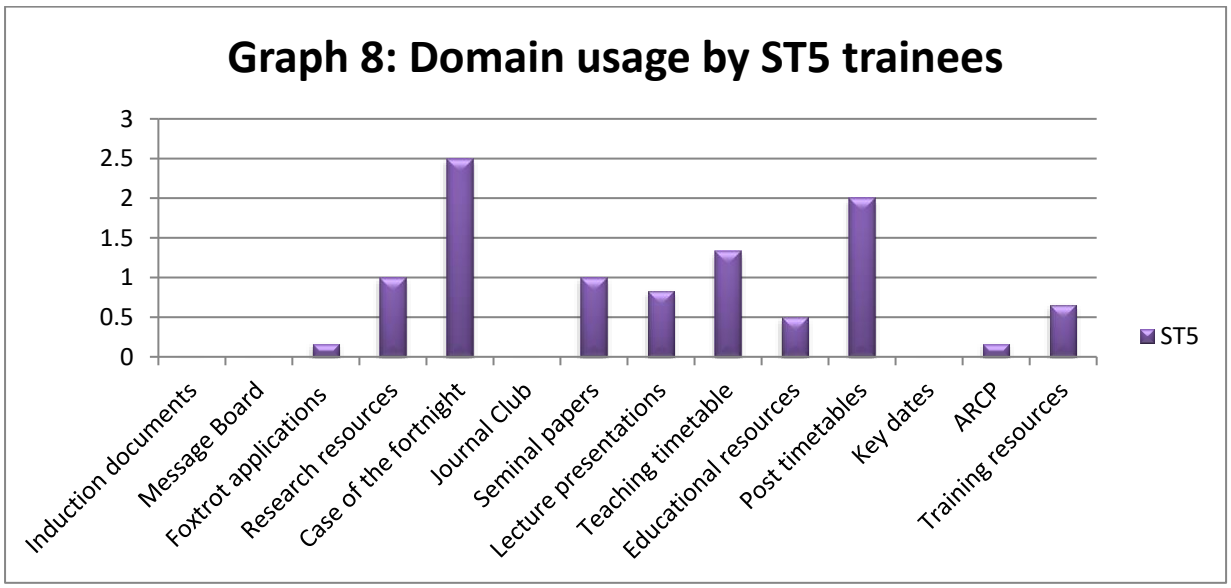
ST3 trainees also access knowledge based resources (lecture presentations and educational resources) as well as administration based resources (e.g. teaching timetables) and only rarely participate in the case based discussions.



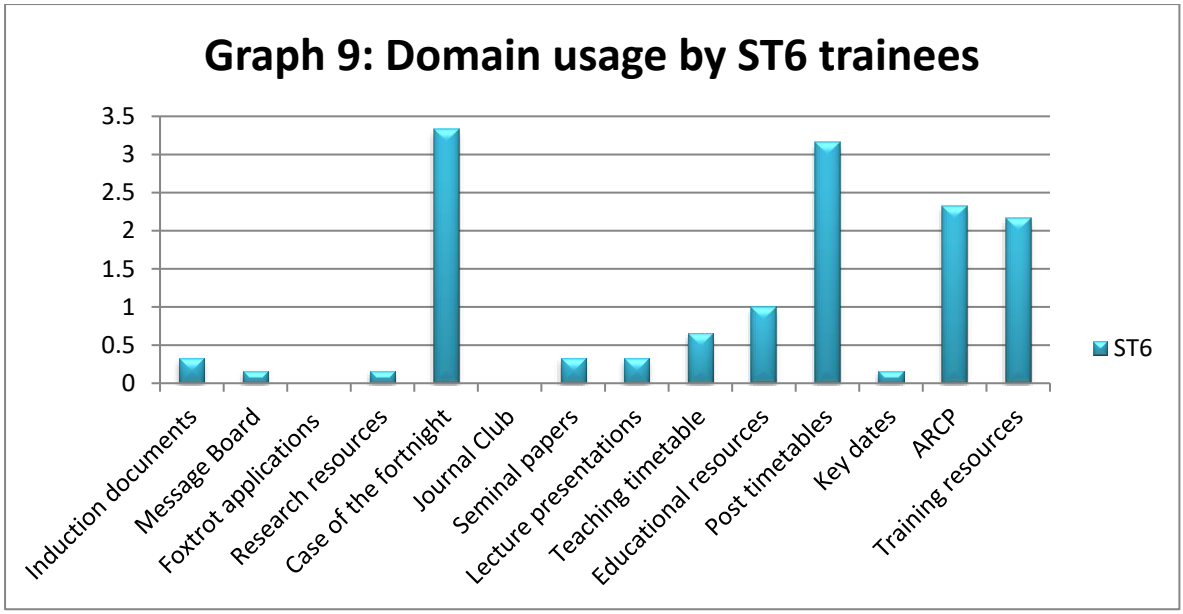
ST4 trainees begin to show a more even spread of usage across all domains. There is an increased participation in the case based discussions.



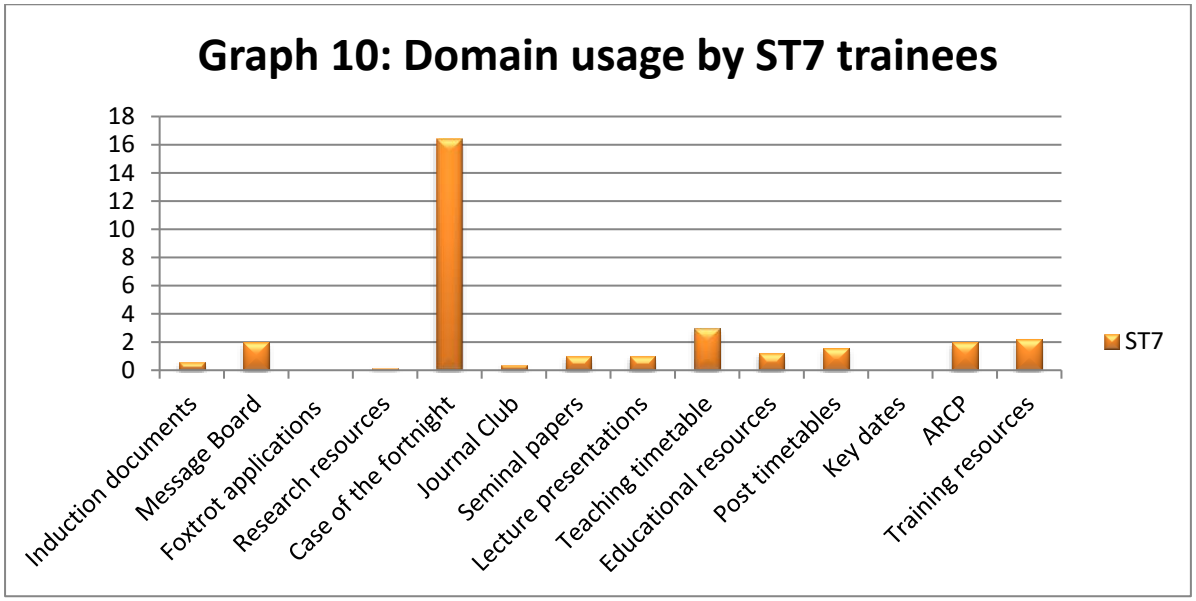
ST5 trainees show increased participation in the case based discussions. They did not access either the message board or the induction documents, but show fairly widespread usage of other domains.



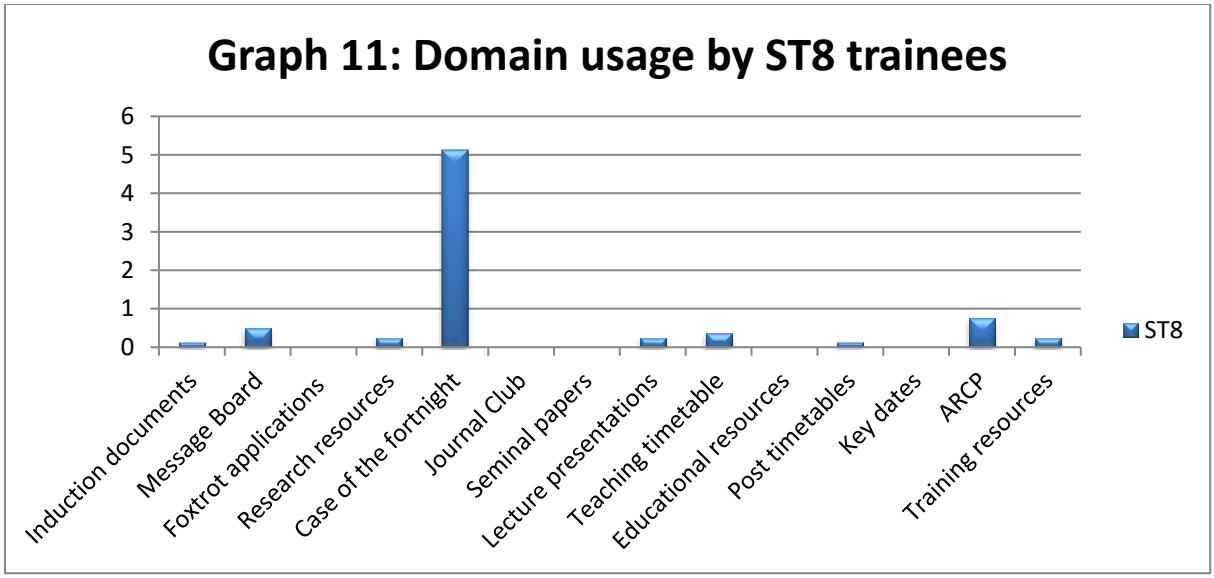
Similarly ST6 trainees show increased participation in the case based discussions. They show widespread usage of almost all other domains, in particular the post timetables, training resources and documentation required for the ARCP (Annual Review of Competence Progression).



ST7 trainee show the highest usage of the case based discussions, and only limited use of all other domains.

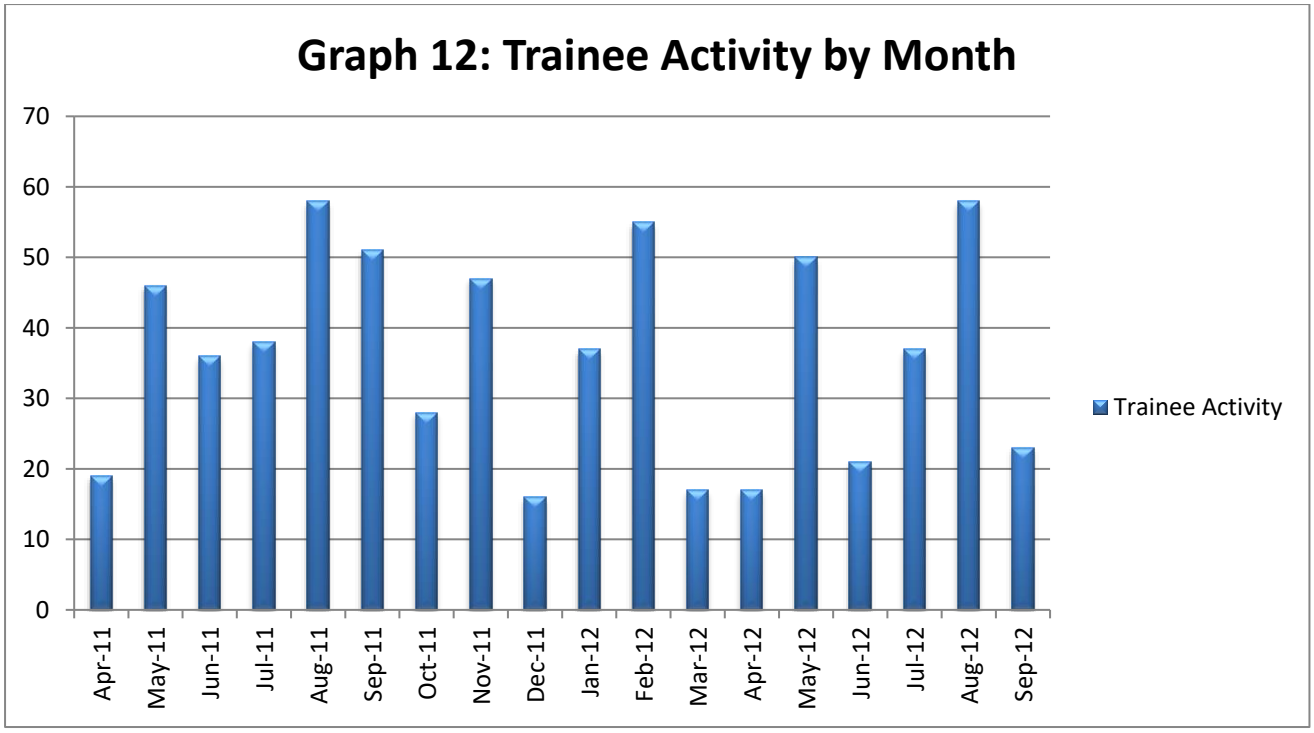


ST8 trainees show limited use across all domains, and although the most usage is seen in the Case based discussion domain, usage is significantly less than that of the ST7 trainees.



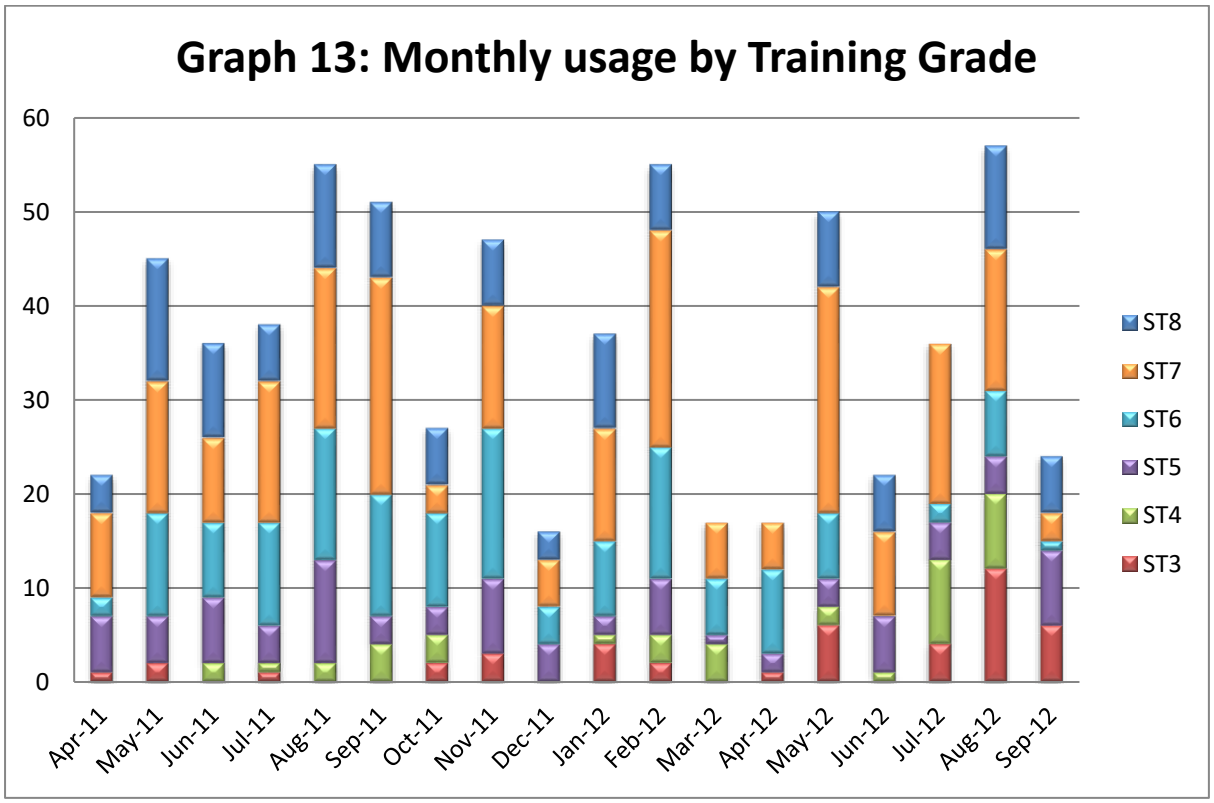
5.3 Monthly usage data

Activity on the site over time is shown in Graph 12 below. Peaks of usage are seen in August 2011, February 2012 and August 2012. This correlates with the start of new posts for doctors in Training, who change post every 6 months, and within this region, start new jobs every August and February. Increased usage is also seen in May 2011, September 2011, November 2011, and May 2012. Usage is lowest in December 2011, but also low in April 2011 (at the introduction of the site) and March and April 2012. Data is examined only to September 2012, at the date of my analysis.



5.3a Monthly usage by Training Grade

Monthly usage is shown graphically for all grades of training:



ST3 trainees show significantly increased usage in August 2012. This seems to correlate with the start of their posts, and would explain the access to administrative

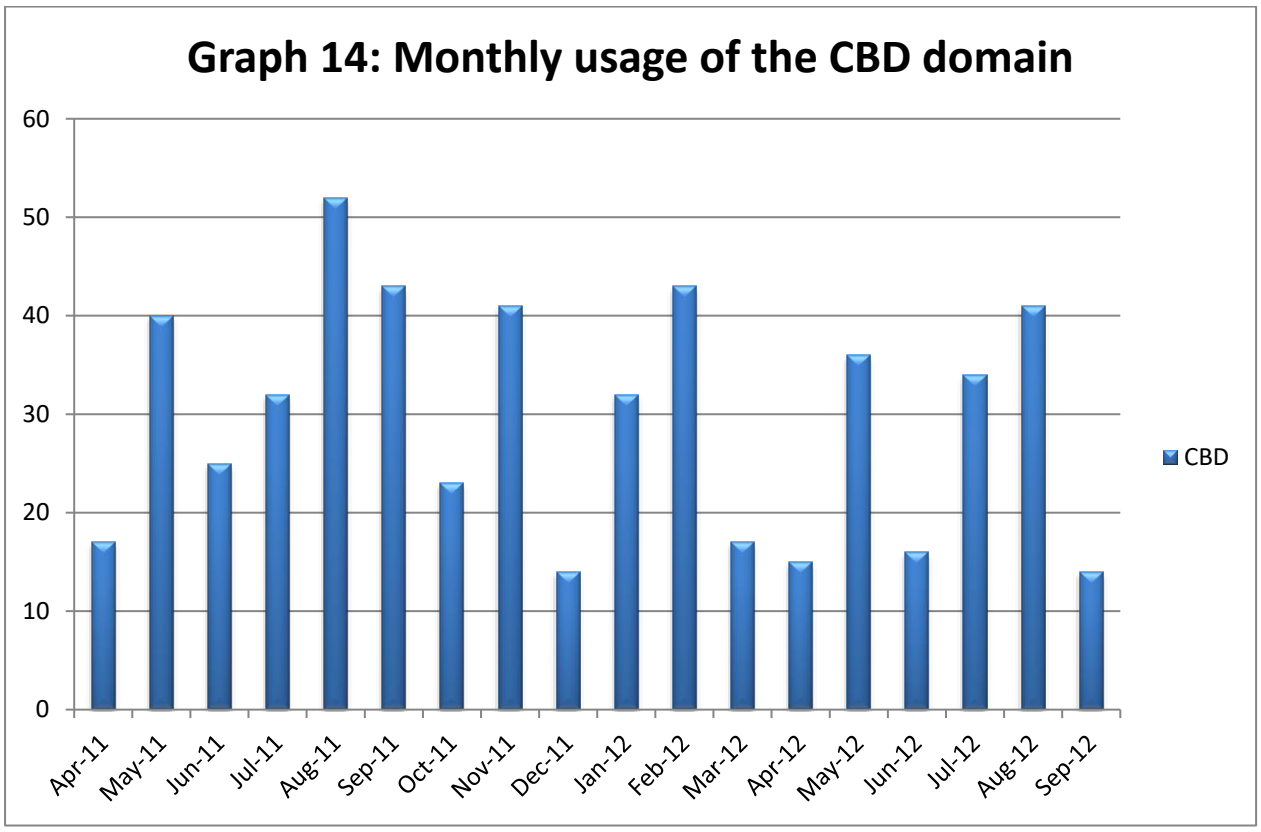
resources. There is limited usage across the rest of the year. No usage at all by ST3 trainees is seen in March and June 2012. ST4 trainees show an increased usage in July and August 2012, and similarly limited usage across the rest of the year. There is no ST4 usage in November and December 2011, and April 2012. ST5 trainees show widespread usage across the year, although peak in August 2011. Lowest ST5 usage is seen in March 2012. In comparison with many other training grades, there are no months where there is no activity at all.

ST6 usage is initially high, peaking in November 2011. Low usage is seen in December 2011, and although there is a second increase in February 2012, overall usage is seen to decrease thereafter, with no usage at all in June 2012 by ST6 trainees. ST7 trainees show 3 peaks of usage; September 2011, February 2012 and May 2012. There is also increased usage in July and August (both 2011 and 2012), as well as May 2011 and November 2011. Interestingly the peaks of usage appear to correlate with the dates for the Orthopaedic Speciality examination (FRCS Tr. & Orth.), which take place in May, September, November and February each year at ST7 level of training. ST7 trainees also show the most activity overall in comparison with the other training grades. Like the ST5 trainees usage is seen in all months of the study period by the ST7 trainees. ST8 trainees are the most senior, and are at the stage where training is almost complete. Peaks of usage by ST8 trainees are again seen in May and August 2011, and August 2012. There is increased usage in June 2011 and January 2011. There is no ST8 trainee usage at all in March, April and July 2012.

5.3b Case Based Discussion usage by month

The Case Based Discussion domain has already been shown to be the most used domain across the VLE, with the greatest number of posts and views. Therefore I chose to look at this domain's usage across the month, to determine if there were also any seasonal variations to the usage.

There are no months where no usage is seen at all, in contrast with many of the other domains. The peak usage is seen in August 2011. Increased usage is also seen in May 2011, September 2011, November 2011, Feb 2012, May 2012 and August 2012. It may be, as mentioned above, that these peaks correspond with the dates for the Orthopaedic Speciality examination (FRCS Tr. & Orth.), which take place in May, September, November and February each year (see discussion). It may also be that increased usage takes place in the preceding months, as seen in Jan 2012.



This is further examined when the usage of the CBD domain is reviewed by grade of training. Participation by ST8 trainees is seen up to August 2011 and then decreases during the remaining study period. ST7 usage of the CBD domain is universally high in all months of the year. Peaks of usage for ST7 trainees are seen to occur in May 2011, August, September, February and May 2012 which do appear to correlate with the dates for the Orthopaedic Speciality examination (FRCS Tr. & Orth.), which

take place in May, September, November and February each year at the ST7 level of training. Usage by ST6 trainees is seen in all months of the study period, except June and July 2012. There is a peak of ST6 usage in November 2011. Overall there is increased usage by ST8, ST7 and ST6 trainees in comparison with the lower grades of training. Participation in the Case Based Discussions by ST3, ST4 and ST5 trainees is low in all months of the year, although ST3 usage increases in August and September 2012. Update data can be viewed in Chapter Nine.

5.4 Summary

This chapter presents the findings from the analysis of the quantitative usage statistics from the Virtual Learning Environment in relation to the research objective two:

> **Objective Two:**
>
> To evaluate the level of engagement among orthopaedic trainees with existing resources, as well as the newly developed eLearning and simulation-based learning activities

Overall usage of the site is seen to be low, with particularly low activity from the Consultant group. The number of views is much higher than the number of postings across all groups. The Case Based Discussion area is the most active domain on the site, with the ST7 trainees being the most active group on the site, with significantly more posts than all the other training grades. The site is used across the year, but with peaks in August 2011, February 2012 and August 2012. Increased usage is also seen in May 2011, September 2011, November 2011, and May 2012. These peaks may correspond with the dates for the Orthopaedic Speciality examination (FRCS Tr. & Orth.) and also with the start of a new training post, which occurs every August and February. This is supported by the literature that states that perceived relevance to

the course is a highly motivating factor in use of the VLE. In the study by Hege *et al* (36) the authors found that student motivation was very strong when tutors expressed explicit exam relevance of cases compared with the strictly voluntary use which they found disappointing. 90% of their online cases were accessed by students when tutors stressed the case relevance to exams (so called "exam strategy"). Further information will be gathered regarding the site usage using the qualitative investigation (chapter 6).

CHAPTER SIX:

VIRTUAL LEARNING ENVIRONMENT QUALITATIVE DATA ANALYSIS

This chapter presents the results of the qualitative study: An investigation into the use of technology-enhanced learning environments in orthopaedic postgraduate medical education (Virtual Learning Environment).

The qualitative study was planned to inform the development of the existing orthopaedic VLE / Training resource and to determine:

- What barriers currently prevent trainee interaction on the VLE
- Positive attributes of the current training resource
- Facilitators to trainee use of the VLE
- Priorities for development of the VLE
- What measures can be introduced to improve trainee engagement

The study took approximately 9 months to complete. It utilised a mix of qualitative research methods, including semi -structured interviews and focus groups.

6.1 Generating trainee/trainer perspectives – Data collection.

The first part of this research aimed to illuminate current trainee and trainer interaction with the Moodle Virtual Learning Environment. We assessed their engagement in the VLE, barriers to its use, and factors they felt will improve the current VLE.

6.1a Sample selection

- 15 consultant Orthopaedic surgeons were selected for inclusion in this study. From the consultants available, a convenience approach was utilised initially, as only consultants working in University Hospitals Leicester NHS trust were sampled. Thereafter a purposive approach was used, aiming to achieve a range of male and female consultants, and a mix of new and older consultants (with respect to their date of appointment in post). The sample included trainers more or less directly involved in trainee education, all of whom had access to the VLE. Consultants were approached via email to participate. A sampling framework was constructed to ensure that a representative sample was taken from the consultant body, including male and female, and number of years since appointment to the post of consultant. The sampling framework can be seen in Appendix One.

- All Postgraduate specialist trainees in Trauma and Orthopaedics on the School of Surgery south rotation were invited to take part. They were also approached via email.

6.1b Data collection

Consultant orthopaedic surgeons were interviewed independently by the lead research interviewer. Initial topics for the interview and focus groups were developed in conjunction with the lead researcher, and assisted by an experienced qualitative researcher, Paul Leighton, based on the original research question. Each interview was undertaken in confidence and was guided by a broad topic guide (see Appendix Two) – topics for consultants included:

- Access to the VLE,
- Perceptions of the resources,
- Barriers to the use of the VLE
- Factors they feel would improve the site
- General usage of the VLE, including their own experience/usage.

Interviews were chosen as the best method to engage the consultant population, as it was felt by all researchers that to attempt focus groups with the consultant body would limit uptake due to lack of time and conflicting timetables among participants. Semi-structured interviews of the kind performed here allowed the interviewee considerable scope in directing the discussion and as expected, the precise nature of each of interview varied significantly in accordance with the interviewee's responses and the aspects of the discussion which they preferred to focus upon (68). Allowing an emergent design flexibility allowed us to adapt enquiries as understanding deepened and pursue new topics as they emerge. Interviews were recorded with permission and transcribed in full.

Three focus groups (total of 18 participants) were undertaken with Postgraduate specialist trainees in Trauma and Orthopaedics from the East Midlands Deanery (School of Surgery South rotation). All trainees sampled had access to the VLE, but attempts were made to include trainees who were both users and non-users of the site. Trainees sampled included a range of training grades, from CT and ST3 to ST7. We were unable to sample any ST8 trainees. Focus groups were guided by a topic guide, developed from the literature and expert review (see Appendix Three). Information given to the participants can be seen in the information leaflet in Appendix Four. During the focus groups topics for discussion included:

- Access to the VLE
- Perceptions of the resources
- Barriers to the use of the VLE
- Factors they felt would improve the site
- General usage of the VLE, including their own experience/usage

Topics were described and participants asked to discuss. They were also asked specifically to consider the use of the VLE for online Case Based Discussion (CBD), or work place based assessment.

Focus groups were chosen as an appropriate method for exploring participant's knowledge and experiences, including not only what they think, but *why* they hold those opinions (68). The interaction between participants helped to further the understanding of the topic, and in a situation such as this, where the participants are all co-workers, and used to working well together, this helped to take the discussion to new directions, with participants questioning, challenging and disagreeing with each other. The second focus group shows this particularly well, with some participants acting almost as co-researchers, facilitating discussions of their own. The lead research interviewer for the focus groups was assisted by a focus group facilitator and experienced qualitative researcher, Paul Leighton. Focus groups were recorded with permission and transcribed in full. A field diary of all interviews and focus groups was also kept by the lead researcher but was not utilised in the formal data analysis.

6.2 Data analysis:

The limited prior work in this area necessitates an exploratory approach to the topic. With little to guide this research, questioning is broad and inclusive, seeking to generate a dialogue with participants in order to tap into their detailed experiences. Similarly analysis is broad focused, inclusive and exploratory; I felt that the analytic processes should not 'close doors' but should rather push open the myriad of topics and concerns that the participants introduced. The analysis takes an Abductive research strategy, allowing the lead researcher to discover explanations and theory, which emerge as the lead researcher is able to move back and forth between data, their own experiences and ideas, and existing social science concepts. This takes into account how the lead researcher is embedded in the process.

6.2a Thematic analysis

Qualitative thematic analysis (24) facilitates this form of exploratory research, although is often criticised for lacking precision and being vague in its processes and undertaking. A structured thematic approach described by Braun and Clark (23) addresses these concerns by providing guidelines for a rigorous and systematic investigation of the data whilst allowing for an exploratory approach. It is for these reasons that Grounded theory approaches or narrative analysis were not felt to be appropriate in this analysis as we are aiming not to impose any existing model on the data.

Braun and Clark describe a six-stage process for thematic analysis (23) in order to progress in a rigorous way. However, the suggest analysis should not be thought of as a *linear* process where you simply move from one phase to the next, but more *recursive* process, where you move back and forth as needed, throughout the phases.

Phase 1: Familiarising yourself with your data. Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.

Phase 2: Generating initial codes. This takes an inductive approach to the thematic analysis; i.e. themes will emerge from the data itself, rather than trying to fit the analysis into any pre-existing ideas or theories. This is an important choice, as mentioned before there is very little pre-existing work in this area, and the topic itself is so broad that it is important not to apply limits.

Phase 3: Searching for themes. Collating codes into potential themes, and gathering all data relevant to each potential theme. Themes will be analysed at both a descriptive level, and a latent level, with a clear attempt made to interpret the meaning of the data. To me, the explanation of the data provides the added value that is the key to

the research. There will also be some element of commentary and my own opinions on the analysis and data coding.

Phase 4: Reviewing themes. Here Braun and Clarke describe reflecting upon your coding to ensure that it makes sense. Reviewing the dataset takes two forms; checking that the coded data fits the coding attached, and considering whether the models describe the whole data set and address the research question. The process of mapping data and coding should be getting closer to a research solution. This helps to ensure that productive working to identify insight to answer your question and not just identifying interesting things. This is part of the process of checking the validity of data.

Phase 5: Defining and naming themes. The next phase is to identify that which you will focus upon in your write-up of the data. To include all codes or themes would be unmanageable so some codes/themes must be selected to focus upon them as most illustrative or as offering most explanatory power.

Phase 6: Producing the report. The final opportunity for analysis.

6.2b Reflexivity

We know that the analysis cannot occur in a vacuum and it is important to consider the theoretical standpoint of the lead researcher and their own perspectives. When one is constructing an argument it must be understood that the lead researcher is embedded in the process beyond that of the average researcher; in this case both a trainee using the Virtual Learning Environment who knows all of the subjects of the interviews and focus groups, both professionally and personally. The current role of the lead researcher sits between that of trainer and trainee may giving insight into both worlds; however it may mean that participants may be more guarded in talking, as the lead researcher will continue on in the training program when the research is complete. We must consider that arguments are constructed which evoke understanding experientially. The author has a background and knowledge coming

into this project that we must acknowledge is personal and subjective. Having worked with the system for some months, talked to trainees and trainers informally, the researcher has come into the project with expectations of difficulties and criticism of the site as flawed. Is objectivity possible? It may even be that the participants themselves may not be able to articulate the reasons for engaging with the resource; the culture of apprenticeship in the orthopaedic profession is so ingrained and normalised that they may not be able to perceive or articulate about it. Can we? To this end, the focus groups were conducted with the aid of an experienced qualitative researcher, Paul Leighton. All interview transcriptions were reviewed by him, and the coding and analysis also reviewed to prevent bias.

In addition to this the lead researcher has a background in Educational work with an understanding of educational theory. Much of the teaching done by the researcher within the medical curriculum is problem based learning (PBL). PBL uses triggers from a scenario to define learning objectives. Students subsequently do independent, self-directed study before returning to the group to discuss and refine their acquired knowledge. The scenario is not therefore about problem solving *per se*, but uses appropriate patient problems to increase knowledge and understanding. This method of teaching is very much student centered in its approach, and draws on both the constructivist theories and theories of adult learning. It is also designed to foster "deep" learning, one of the concepts introduced by Entwistle (69). Students can develop meaning on the grounding of the factual information, and internalise their learning. Prosser and Trigwell (70) state that this deep approach to learning is more likely to be associated with higher quality learning outcomes. It is likely that the ideas held by the lead researcher regarding Educational theory may have some impact on the work and analysis of the dataset. Problem based learning also draws on Knowles (71, 72) principles of adult learning, defined as "the art and science of helping adults learn". In this he made certain assumptions. Firstly he states that adults are independent and self-directing. We must therefore involve them in

planning and curricular content, and in formulating their own learning objectives. Knowles also states that adult learners are more motivated to learn by internal drives than by external ones. We have taken a constructivist approach to the collection of data: the social construction of knowledge, of finding meaning and answers in group exploration and group interaction. In a focus group, the participants enhance their own knowledge as they share, and are able to contribute and build that knowledge as a group. This constructivist approach is also reflected in the inductive approach we will take to the data - despite a distinct and positively biased position in relation to this training we are aiming not to impose any existing model on the data.

6.3 Methods.

Data was handled using the NVivo computer package and analysed following the conventions of thematic analysis as detailed above. This formulation of thematic analysis is a structured, inductive approach to data which prioritises the perspective of the research participant and seeks to identify important and recurring themes across multiple respondents. The population included both Consultants and trainees, both stakeholders in the curriculum, and was analysed as one data set, with the analysis allowing me to generate a thematic map for the population.

6.3a Familiarising with the Data

All data was transcribed in full by the lead researcher. This detailed process aided familiarisation with the data and was an important first stage of the analytic process (see *6.2a Thematic analysis*). The transcription requires a rigorous and thorough "orthographic" transcript – a "verbatim" account of all verbal (and sometimes nonverbal [e.g. Coughs]) utterances (23). The close attention needed to transcribe data has been said to facilitate the close reading and interpretative skills needed to analyse

the data (73), with some researchers arguing it should be seen as "a key phase of data analysis within interpretative qualitative methodology" (74).

6.3b Generating initial codes

The interviews and focus groups were coded as one data set, using the NVivo computer package. The entire data set was approached systematically, with 118 codes initially identified and then matched with data extracts to demonstrate those codes. The initial codes were validated by a second researcher (Paul Leighton) and the initial codes refined, with some initial codes merged as appropriate, and other expanded as necessary. The List of open codes can be seen in Appendix Five.

6.4 Handling and Organising Raw Data

The initial coding here was inductive – i.e. a reflection of the range of topics, ideas and issues that were discussed in the interviews and focus groups. My initial analysis of the data focused on addressing our initial broad question:
What are the barriers and facilitators affecting the engagement of Orthopaedic Trainees from the East Midlands Healthcare Workforce Deanery in the Orthopaedic Virtual Learning Environment?

This broad question demonstrates the concerns which structured and informed the reassessment and model generation. I was able to organise and rationalise the data, in the form of 3 models each looking at "facilitators", "barriers" and "evolution" proposed by the trainees respectively. This next stage sees a reassessment of the initial coding to generate models and themes which organise the data/codes in a way which addressed the research question. The models were developed by formulating a hierarchy amidst the original codes. Codes which related to similar or connected topics were grouped together, and then ordered with regard to the level of abstraction. For example, the code "relevance" is an abstract construct which influences whether or not people engage in the site (so we may think of this as a

"facilitator"), but relevance is constructed with real concerns about "assessment" and "exam preparation". Quotes from the sources are attributed to either a Trainee Focus Group (FG), or a Consultant Interview (INT) and number.

6.4a Facilitators to the use of the VLE

Throughout the focus group and interviews the VLE was only mentioned in a positive light in a total of 31 references (in comparison with the total 2,062 references for the total dataset).

6.4a (i) Relevance

In discussing the use of the VLE in a positive light, one aspect that was manifest from both trainees and consultants was that information should be relevant to them in order that they would participate. The relevance of a topic was most commonly discussed in relation to speciality examinations (in this case the FRCS Tr. & Orth examination), or how it might facilitate mandatory assessments. This can be seen in the following extracts from the data:

> *I think there's definitely a role for that kind of discussion type forum that happens on the VLE. I think most people who've done the exam will say they benefited from sitting down and talking about topics with other people.* (INT 005)

> *I think the VLE is a very very useful tool, and I think it will become increasingly so once especially in trauma and orthopaedics the curriculum is published and we will all be expected to have done 10 case based discussions which are mandatory.* (FG 003)

> *We've always said that the journal clubs summaries are very useful to us, because especially in revision times you've got so many journals to look at it; it'd be useful to have the key journals to go through and so forth…* (FG 001)

> *Researcher: Do you get involved in the discussion? Answer: I will get involved in the discussion if it's something relevant.* (INT 001)

> *And I suppose the ones that I comment on are the ones, that are one's that you've obviously got an interest and knowledge with it. Which is probably the way though, they're the ones that, you know, that's most useful for your trainees point of view to actually comment on.* (INT 013)

6.4a (ii) Benefit

In addition to the relevance of the material, it was also noted that individuals would participate if there was a direct benefit for them, in particular, if it formed part of their on-going professional development. In particular on-going professional development was mentioned by Consultants. This is of course, closely related to the discussion by trainees regarding the need for help completing mandatory assessments or in revising for the specialty exams:

> *I have responded to some posts, even though they're not in my field, because it's just interesting to see what, I mean, if anything, if nothing else it gives me some CPD business.* (INT 005)
> *I mean as I say, some of the ones I looked at I'm doing as much for my own education as for in terms of actual providing instruction or tuition.* (INT 010)

> *I use it for my own professional development. It's always targeted at trainees, but the professional group that miss out are those that are already trained, and that's a group that I really think that they have an on-going educational need that's not met.* (INT 006)

It appeared therefore that a direct benefit had to be available for both groups to participate. In addition to this it was manifest in a number of references that both groups found interaction with others a facilitator to use of the VLE. This was primarily in relation to the case based discussions. Inversely, when discussing barriers to the use of the VLE (section 6.4b) it appears that lack of interaction from others was a clear barrier to the use of the VLE.

> *…it's quite nice when you're, you've submitted something, you know, you then get e-mailed everyone else's responses and once you're start, once you've started the case based discussion I think people interact quite well.* (FG 003)

> *And obviously I suppose the more, the case based discussions are probably the most stimulating and practical things to have.* (INT 010)

> *Well, I was looking at a lot of the interactions. You know but it was, it was the case, the cases that I, I mean I saw that there was you know sort of journal stuff going on, and I did, I dabbled in that a bit, but the cases I think drew my attention most.* (INT 010)

In discussing the cases and the interaction with other users, it was also clear that there are links to *all* of the factors discussed above: relevance, assessments, on-going

professional development and a benefit to the individuals involved in the form of interactions.

6.4b Barriers to the use of the VLE

6.4b (i) Time

In creating the model for the barriers associated with individual use of the VLE it was clear that "time" was manifest in all interviews and focus groups. The following are a small sample of extracts from the data:

> *Probably lack of time, I mean even my Friday afternoons now I end up having to do theatre lists, which is a bit irritating. Where I used to in between going to various teaching session go and do things like this, but essentially is lack of time, and any time we have I have to do things like appraisals and things which take up loads of time with mandatory training and all this sort of stuff, you know, so there is; it's a time issue.* (INT 007)

> *I've got so much other stuff and so many hundreds of emails to plough through that I'm not engaged with it just because I'm pushed for time is the honest answer.* (INT 009)

> *The biggest problem is, is just time to actually log on and actually remember that it, that it's there, and actually to go and regularly look at it and it's like anything else, there are so many pressures on your time.* (INT 013)

6.4b (ii) Credibility

Very closely related to the issue of "time" was the fact that trainees in particular perceived that, due to a lack of time, there was very little trainer interaction:

> *…if you say to that consultant, "right for 3 weeks" (or however many sessions you have to do, because the consultants will come back and say "look guys, we are busy, you know we sit there checking 50 emails a day, doing this, doing whatever, when are we going to devote our time to VLE?"* (FG 001)

> *Absolutely, I mean it's hard, even within their speciality interest it's difficult to get them to engage. Less so if it's completely outside their remit.* (FG 001)

> *Involving the trainers more is going to be extremely difficult. You will always have the small select group of trainers who actually have an interest in education that is above and beyond them wanting to be AESs or clinical supervisors. Because it is in your own time, there is no recognition for it. And most trainers, they do a full job, and on top of that they have meetings and things they have to go to. A lot of them are involved in various committees, like for instance the BOA or the SAC or whatever it is, and most of them also do private practice, so there is, it is easy for them to train or teach when they are in an environment where they are with the trainee, but to do them*

on their own, it is going to be pretty hard, and you will always have the usual suspects who do it, but others who will not. (INT 003)

Closely related to the lack of interaction by trainers, was the perception by both trainees and trainers, that the resource was not "credible". It was mentioned in both the interviews by trainers and the focus groups by trainees, that the case based discussions displayed a lack of knowledge by trainees.

I did go on the case based discussions once. I was a bit disappointed with the level of quality of the comments if you like, comments that were being made. I didn't really feel, it, I didn't feel it educated people as much as I think it could be. (INT 008)

So I think that's the problem, so you set out this scenario, give out some information, you get some feedback and then it sort of stagnates there, and it doesn't take you any further, and you almost sort of get feedback from say [mentions a colleague by name] and I'm not saying you don't have information, but it's sort of like having a chat over the table, and like "oh, ok, this could be the answer", and then I'll wait another week for the next answer, you know, that's the point. I don't think you can learn anything when you want to. (FG 001)

Some of the things that they were responding they were, was incorrect, was factually incorrect. Since that, because before that you would read it, and because your peers, and people more senior than you had written it, you'd think "oh, they know what they're talking about", but since that, and at that stage where consultants went on and went "uh uh", since that, it's made me, doubt what people are saying, and go and check up on what people have said. (FG 002)

This lack of knowledge and lack of credibility meant that the discussion was limited amongst those who were interacting and could not be taken to a higher level. This often meant that trainees felt that the information in the cases was not relevant to their private study, and that they were not able to learn from the encounter:

Well it comes back to the question of higher level learning right? Because if you just have the registrars involved in that sort of scenario, I know we are focusing on the case based discussions, but if you keep on focusing, the junior registrars will get up to a certain point, based on their experience and what they've read, the exam going registrars will get a bit further with literatures searches, evidence base from current literature, because that's what they've been reading, and then it stops there. You might have some questions about, to progress that further, but you don't have someone with that knowledge to interact with you, to give you that, so you don't get that closure necessarily. (FG 001)

> *The other thing that you were saying about the VLE really is that if I were to learn, with all due respect, why should I trust somebody who's written, or somebody who's copied it from somewhere? I don't know the source, whereas if I'm reading from a book, or I'm reading from a known website like orthobullets, orthoteers, I know where I'm reading from.* (FG 002)

In many cases trainees felt that this contributed to the feeling that they were too intimidated to post on the site, and felt unable to join in the discussion, as they would be judged on the poor quality of their responses:

> *And I think that sometimes there's apprehension to put comments down, because even though we're professional mature adults, people still wonder, well "what are the other people thinking", "what's going on with their training?", and whether there's coercion, and ridicule, and they do worry about that. So I think that plays on their minds occasionally.* (FG 001)

> *So there is an inherent sort of fear that if I write wrong, I won't be looked upon as a good person or, because people who write on it, they will research it, give their best on it, if they were to write anything on it. That's one main aspect, the fear.* (FG 002)

> *I think so, because we're all very competitive, we don't like looking like fools in front of our peers, so that's one of the things. If you know what you put on is you know, suddenly going to get criticised from all sides because "oh my god, this is nonsense" yes, you probably wouldn't say it.* (FG 003)

> *Because more than anything, because you wouldn't want to say something silly, you wouldn't want to perhaps misinterpreted the meaning of the discussion and you don't want to waste other people's time, because that's a discussion that's over your head.* (FG 003)

Closely linked to the lack of interaction by trainees and trainers, is the fact that there is no clear mechanism for feedback for the case based discussions. The lack of feedback was manifest in all the trainee focus groups, as well as a lack of moderator for the discussions being reference in many of the semi-structured interviews. This closely links to the fact that the trainees do not appear to see the site as a credible resource – that there are no mechanisms by which the lack of knowledge can be addressed or that the discussion could be taken to a higher level:

> *I mean I suppose that again is another point about not having a moderator, because there isn't anybody to say "actually that's not right". Yeah, and I think that, and*

that's the problem, because then you can get either things go down the wrong route or myths get perpetuated and that is the problem. And unless you've got somebody that can say "hang on a minute that is not, that isn't right" or "actually what they said is a perfectly valid point, it's just that you know there are 10 ways of skinning a cat". (INT 013)

There isn't really anyone driving the discussion forward. There's no-one kind of answering the points as you raise them, and asking new questions, really, and at the end of your fortnight, there's no-one kind of bringing it all together, and giving you a summary, and maybe suggesting some further reading. (FG 001)

I think the problem is that there isn't any feedback. What you, whatever you've entered, whatever input you've had into the VLE, you don't get a, you might get at the beginning of someone's post "OK, well that's interesting", or a, something like that, but it's not genuine feedback, you haven't resolved either your contribution or the topic as a whole, you can't, you feel you've necessarily learnt something. (FG 003)

6.4b (iii) Technical Issues

As expected when discussing any online resource, a number of technical issues were cited as barriers to use of the VLE. These included a lack of access to computers in the workplace, problems with navigation of the site, and issues with user's passwords (most commonly that they used the resource so infrequently that they were unable to remember their log-in details). There were a number of references to the fact that some trainers were not aware of the existence of the site. This suggests that one problem is a lack of communication with trainers, and possibly a lack of inclusion, which corresponds to a lack of trainer engagement:

I think perhaps, I mean the first thing is that perhaps it's probably not as publicised as it could be. (INT 007)

OK, now obviously we said briefly before the tape went on, that you haven't had a chance to look at the VLE that we've got here. No. And that's, you think an information issue? Because we've not made you aware? Or..? I think it's just a communication issue. OK. It's the sort of thing where if I had been sent something with a link I'm pretty sure I would have clicked on that link. (INT 006)

I don't know what's happening with it now, but at one point, it doesn't seem to have told me there's been a new one [CBD] *for a long time, and there is a new one* [CBD] *on there I saw the other day, but if nobody tells me there's a new one, I probably won't go on there to look.* (INT 002)

6.4c Suggestions for Evolution of the VLE

When developing models to describe the "facilitators" and the "barriers" to the use of the VLE, I felt it was also important to consider a model which recognised the solutions that were proposed by both trainers and trainees for the evolution of the VLE. There were a number of suggestions put forward for improving the use/improving engagement with the resource, which all link back to the factors which were cited as barriers to its use.

Although "time" was manifest in all interviews and focus groups, it was referenced slightly differently when thinking of suggestions to improve the engagement with the VLE. When considering "time", it was often discussed in reference to ways in which time could be maximised. There were obvious technical aspects to this: improve navigation of the site to improve speed of usage; consider development of a mobile app to allow users to maximise the time. In relation to both the technical aspects of the site, and also to maximise time, many suggested that the site become the home page for all Orthopaedic surgeons in the region. This is also closely linked to the fact that the existence of the site has not been well communicated to all the users, in particular the trainers. Trainees in particular felt that having links to other resources, and effectively making the site a "one-stop-shop" for all their training needs would improve the efficiency of the time that they spent on the site.

> *I don't even know if it's possible, ways of incorporating those different resources, or some way where you can, complete all those requirements through one website, then makes it more likely that you're going to use the other one. So you're not doing all these various log-ins the whole time.* (FG 003)

> *And I think, I absolutely agree, I think a one stop shop would make life a lot easier where you can incorporate everything you've done without having to double your efforts needlessly.* (FG 003)

As well as links on the site itself, both groups felt that the site could be more closely linked to existing resources within the training programme. In particular trainees are required to attend a mandatory teaching programme on a weekly basis, and it

was referenced in all focus groups that the VLE should be linked to the teaching programme, to maximise time that they are required to spend on the resource.

> *Because we've already said that having patients for clinical examination and teaching helps break up the format of teaching, and this might be another good way to say "well electronic learning breaks up teaching into one third, patients another third, and lectures another third".* (FG 001)

> *I think that sort of what we're trying to do, but the VLE I think would be useful as an adjunct to our curriculum and training, which is what you're trying to do. Maybe when the new curriculum comes out, or if it is out, but somehow if we can try and put sort of signposts, oh this is your curriculum, this is how the teaching follows it, go here, help here, and just sign posts really. I know we have to do work, but that might help as well.* (FG 001)

> *I mean if you want to have a quiz, every Friday, or every so many Fridays of the month, based on the topic that we've just been doing, and you run the quiz via the VLE, boom, everybody has to log in, it's part of teaching, they're not taking it out of their own personal time at home.* (FG 002)

> *So therefore you incorporate it into teaching, or you put some of the mandatory stuff we already have to do, on there, so we could do the mandatory stuff through there.* (FG 002)

It is important to note that linking the site to the current teaching programme and to the Trauma and Orthopaedic curriculum also improves both the relevance and the credibility of the site. The theme of credibility was again referenced widely in all groups. The need for a credible moderator and timely feedback was manifest in all focus groups and interviews. This links closely to the fact that trainees may be willing to invest the time if they feel that the resource is credible, relevant and enables them to learn, as well as to achieve other mandatory competences required of them to progress through their orthopaedic training programme.

> *I think if you want it to have, it has to be senior led to just to give it some credibility. Because if I was a, thinking back to when I was an ST3, if another ST3 was the one trying to bring the discussion to a close, I might not necessarily be sure that they'd got the right end of the stick. I think at least a senior registrar, if not a consultant.* (FG 001)

> *I think it can either, it should either be a consultant or a senior trainee to summarise what is the way forward. Otherwise to have a year one trainee, or a year two trainee, or a year three trainee, saying this is what we should do, it's not realistic.* (FG 002)

The person that's put the case would need to be willing to ask questions, you know answer questions, so if somebody said "Oh what's the", I don't know, "what's the white cell count?" or something that they'd be willing to provide more clinical information as needed, as you would if you were having a discussion, and there probably needs to be a lot lot better moderation, and more feedback, so when somebody says, when somebody answers they need to be, er, you know, needs to be better moderated, and probably, I would have thought ideally by a consultant, but either that or a post fellowship trainee. (INT 002)

I think it would be much better if you had somebody moderating, somebody senior preferably moderating it, because you know, they've been treating that condition or you know, they've been involved in the care of those patients for a long time and they, their contribution and experience is invaluable in that matter. (INT 012)

6.5 Defining and interpreting themes

According to the stages described by Braun and Clark (23), when interpreting a large and complex dataset such as this, on-going refinement of the themes and interpretation of those themes is required. Reviewing the dataset takes two forms; checking that the coded data fits the coding attached, and considering whether the models describe the whole data set and address the research question. When reviewing the data extracts from individual codes, we felt that the description of the raw data above does not fully capture the complexity of the whole data set and does not fully answer the research question. Refinement, in the form of defining and naming themes, as described by Braun and Clark (23), will take a descriptive, inductive approach, focusing on latent themes, and aim to fully explore the analytic narrative emerging from the data.

The organised description of the dataset has produced a number of aspects on which to concentrate, in the more active interpretation of the data. Time, engagement and credibility are all themes that would benefit from further exploration.

Within the focus group early lines of questioning exposed participants' broader conceptions of education, training and their views on what constitutes a positive

training experience. Reconsidering the raw data with stronger regard for this contextual material might provide a deeper insight into why individuals engage (or otherwise) with the VLE, and may inform our future development of the site.

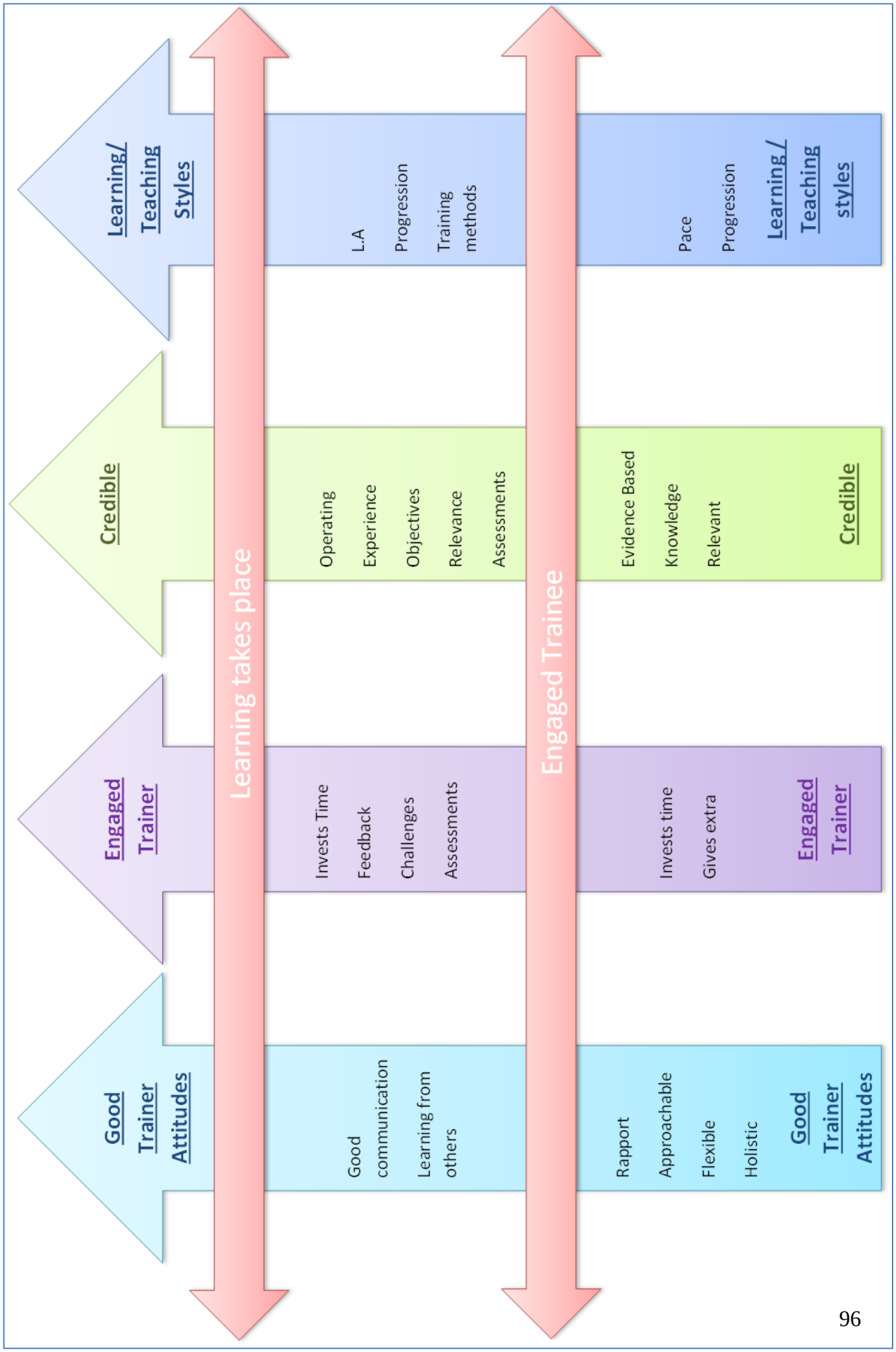
Initially incorporated into the topic guide as an opening "ice-breaker" question, the idea of what makes a good trainer, and what makes a good training experience became a large part of the discussion in both the focus groups and the interviews. We would suggest that the way in which Orthopaedic surgeons engage with their training and the expectations they have of any training experience is key to understanding why they may or may not engage with a new training resource. How does it fit into their existing understanding of good training? How does the VLE as a resource interact with other aspects of their training? We have suggested above that the participants themselves may not be able to articulate the reasons for engaging or not engaging with the resource; and we might feel that the culture of apprenticeship in the orthopaedic profession is so ingrained and normalised that they may not be able to perceive or articulate about it. In refining the data we aim to generate a form of understanding that the participants themselves cannot experience because it involves unpicking what they take for granted, and consider normal, natural and unavoidable.

6.6 Training needs – How do trainees engage with training?

When considering the way in which trainees engage with existing methods of training, we speculate that four broad factors influence trainees' engagement with existing methods of training; Good Trainer Attitudes; Engaged Trainer; Credible and Learning/Teaching Styles. These themes are refined from the initial description of the raw data (early models can be seen in Appendices Six to Ten), and are situated in a more complex and sophisticated model which we feel more adequately addresses the research question.

The first model is shown on the following page and described in terms of thresholds for trainee engagement and trainee learning. Each arrow represents a factor in the education process. At the bottom of the arrow are those characteristics which lead to trainee engagement. If trainees are engaged with any training tool, it would appear the same four factors become equally relevant for learning to take place; Good Trainer Attitudes, Engaged Trainers, Credibility and a resource must suit a trainees learning and teaching style. Therefore higher up the arrow above the engagement threshold are those factors which lead to learning taking place.

Figure 7: Model 6, How do trainees engage with training?



6.6a Good Trainer Attitudes

As mentioned, "good trainer attitude" which was manifest in all focus groups and a number of the trainer interviews. A trainer needed to be able to build a rapport with a trainee, and to be seen as approachable.

> *Just simple things like they do need to be available and approachable. Some people; they're just so busy or whatever that you don't see them really and then they might be a brilliant trainer but if you don't see them then that's, you're not going to get much benefit from them.* (FG 003)

> *I think there are a lot of things that make a good trainer, I think one of the things is being approachable, and somebody that is willing to put the time in to spend with a trainee.* (INT 002)

It was also manifest that trainers who were able to adopt a holistic approach to the training process allowed trainees to develop more fully and progress through the training programme in a more productive way. Trainees wish to be considered as a whole, taking into account any factors outside the workplace that may affect their ability to achieve the required competencies. Trainers who were able to appreciate this holistic approach also felt that they were able to get the best from their trainees in this way.

> *I think the other thing you need to understand is the trainee who's with you, what they are, other problems they may have, they maybe bring to the table for that 6 months, may possibly be having. Not everybody will be working towards an exam, some people may have family problems, may have children on the way, may have other distractions with them for that period of time that they're going to be with you. And it's really very important to try and work that out early on, although it may be difficult to broach these subjects early on, it's very important to work out what they are, so that you can understand how they are behaving during the period of time with you better rather than just discovering something later in the day and then trying to be reactive to that situation.* (INT 004)

> *So to recap there's being aware of what they need to achieve, and their assessment structure, but also being aware of where they're at at that point in time and any distracting issues that they may have.* (INT 004)

> *I think you know it's, I think being a trainee is a very difficult phase of life, because you're multi-tasking several things you know. Most people are multi-tasking their work, because it pays the bills, most people are multi-tasking the fact that they need to pass an exam, so they need to accumulate the knowledge, most people not have to multi-task in the sense that they have to plan for their, for a competitive career, so they are planning their research and their audits, and thinking about an MD maybe. And that's a huge number of plates to keep spinning you know, and then on top of that*

we expect you to have sorted your family life out, maybe get married, maybe have kids… (INT 005)

In discussing Good trainer attitudes, the idea that a trainer must be able to communicate well in order for the trainee to learn from the experience was manifest in all focus groups. In addition to being a good communicator, trainees also felt that the best trainers were those who were willing to "go the extra mile". Those trainers who were willing to devote time to extra training activity were described most positively, with particular reference to the FRCS Tr. & Orth. speciality examination. Trainers who were able to be flexible in that regard were also commented on in a positive light.

So for you to be a good trainer I think you have to be, err there's lots of things, you have to have clearly and obviously, knowledge, but you have to be approachable, enthusiastic, and you have to have time given over to be able to provide that training, and I think you have to be able to be flexible with how you provide that training as well. (FG 003)

6.6b Engaged Trainer

It was clear that the trainees felt they gained most from a training experience if they felt that the trainer was engaged in the process. The need for a "good trainer attitude" has been discussed, but this also clearly links to the idea that the trainer should engage in the training experience.

Obviously knowledge and experience are very important. Enthusiasm. You know I don't think you necessarily need to be a consultant for a long time to have enthusiasm and to drive things on. (INT 014)

One who can listen to their trainees, as well as then be able to break down what they're doing into coherent thought, someone who is patient, and well, the best trainers are the ones that are inspirational in their own way in a sense because they are enthused by their subject and therefore instil enthusiasm in their trainees. (INT 013)

Ok, um it's going to have to be, when you're, when both sides of it are involved in the training experience; both the trainer and the trainee are both take a part in it, both are engaged in it, and to some extent, both gain from it, but obviously the trainee gains more in terms of knowledge and learning from it. (INT 009)

As well as giving time for training, and devoting time to extra activities, trainees require regular and timely feedback from trainers in order to feel that learning has taken place. The idea that they need to be challenged, both in knowledge and operative skills was also manifest throughout the focus groups.

> *Similarly I think a structured layout with defined goals that you want to achieve, and feedback to make sure you're getting the training experiences that you need.* (FG 003)

> *I think a good training experience is something that's got direction, and that exposes you to whatever it is you're learning, be it knowledge or technique, and gives good or appropriate feedback. Useful feedback.* (FG 002)

> *And also I think has to have an element of reflection, so what you would potentially do different next time, to improve that training experience.* (FG 003)

> *You need to give people feedback. And that feedback really has to be timely feedback, and it has to be relevant to the event which has just occurred, and it, the more closely those two things are linked; the timing of the feedback to the event, the better the whole learning experience will be for the particular trainee. And I think that's important. A lot of the feedback that we give is probably just collated three to six months at a time; it's not related to feedback to people at that time. It has to be timely, and it has to be specific with some targeted goals really.* (INT 004)

6.6c Credible

The theme of "credibility" is also manifest throughout the dataset. This has previously emerged when discussing both barriers to use of the VLE and solutions to improve engagement with the resource. In order for trainees and trainers to engage in the training experience it must be seen as credible. While the phrase "credible" is seen in relation to assigning a credible person (usually designated as a senior post-exam trainee or consultant) to act as a moderator for the VLE in reference to the case based discussions, the theme of "credibility" is manifest indirectly throughout. In order for a trainer to be seen as credible, both by trainees and trainers, they must also take part in research and practice "evidence-based-medicine".

> *You obviously have to be up to date, and you have to keep your own knowledge and skills up to date, and I think it's very important to portray to your trainees that you do that. For otherwise I feel they won't believe that what you're trying to impart to them is indeed credible. What you're teaching should be based on evidence. It's shouldn't be, for the vast majority of the time, based on personal opinion. I think it's important*

that if you are going to, to attempt to deliver information which is personal opinion, you should be making it clear that that indeed is the case. (INT 004)

So that's what I would consider somebody…er and also, somebody who does a bit of research on the side as well as audit as well as teaches in various courses, and particularly the local teaching programme, and also possibly some national ones so that they know what other trainees are doing around the country and has contact with other trainers in the country so that has a level of standard from a national basis alright? (INT 007)

There is a clear expectation that a trainer will be well versed in the trainee curriculum and what is required of the trainee to progress through training. This is linked to the idea that a good trainer must be a person who holds knowledge, but linking back to the factors which facilitate using the VLE, this knowledge must be "relevant", linking both to the curriculum, the trainees' expectations, and the objectives set at the start of the relationship. This is most clearly defined in the need to develop a "learning agreement" where a contract is drawn up between trainer and trainee, and should be met in order for a trainee to be satisfied that they have progressed at an appropriate pace.

And that will involve obviously being familiar with their curriculum, but also being very familiar with the way in which they're going to be assessed at the end of the day. Because no matter how hard someone works, if they aren't prepared for the examination process they're about to go through, they may ultimately fail, anyway, to succeed in their aims. So I think you need to understand that. (INT 004)

Being aware of the trainees learning needs and then sort of coming to an agreement with the trainee as to what the learning package should be and how it will be assessed at the end of the training programme, er, not the training programme, the training slot. (INT 003)

Well I think there'll be a number of facets really to what makes a good trainer, and I think the most important thing initially is to understand what it is your trainee needs to achieve during the period of time that they're going to be with you. So that would be the first thing. (INT 004)

The need to be up to date with the latest evidence is closely linked to the need to have not just knowledge, but *relevant* knowledge. Again this is manifest in trainees discussion in relation to speciality examinations, or how it might facilitate mandatory assessments.

I think the best trainers are the people who try and work out what level you're at before they start teaching you or training you. I know some people who are excellent teachers but they just, they'll give the same level of teaching to anyone, and they'll never consider kind of, who they're teaching. (FG 003)

Part of the teaching that we do is actually training people to do, to prepare for what our examinations will be at the end of the day. And therefore part of the experience that we need to get to you is the experience of an exam because you won't be used to be able to perform in that environment if we really don't help them, so I think the more creation of that sort of environment for them, is indeed a positive thing, and we can't get that on a virtual learning environment. (INT 004)

You know people have to think about trainees being competent, but you also have to think about trainees passing an exam, and you cannot get that over on a learning environment experience, or not easily. (INT 004)

6.6d Learning / Teaching Styles

Trainer engagement is closely linked to the ability of a trainer to adapt to a trainees' individual learning style, and to adapt their own personal teaching style to the environment and level of training achieved by each trainee. The idea that a trainer should be aware of a trainees' level of competency, where they had reached in their progression through the training programme was manifest in much of the dataset. Trainees' expectation of a trainer was that they would be aware of this, and adjust the training experience appropriately, at a pace that was then suitable for that individual trainee. This is closely linked to the idea that trainees expect their trainers to be fully conversant with their curriculum, the objectives set for their training, and the competencies they are required to achieve in order to progress through training, and adjust the training experience in order to address any unmet needs.

Well I think a good training experience needs to start off first of all with whether or not you've met your objectives of that particular training experience, so whether that's written formally or informally, I think that if you meet the objective you are hoping to achieve then that's a successful experience. (FG 003)

Well I think a good trainer primarily has to have the trainee's objectives at the heart of it. (FG 003)

And so you can't be a good trainer unless you actually can be adaptable, listen to your trainee and know where they're at, and then pitch at the right level, for that trainee, what you can then teach them instead of just assuming they know nothing or assuming they know everything. (FG 003)

> *Similarly I think a structured layout with defined goals that you want to achieve, and feedback to make sure you're getting the training experiences that you need.* (FG 001)

Training and the training experience was often described as a very structured concept. Both trainees and trainers most often mentioned that they prefer a training structure which has clearly defined objectives, and a clear path designed for progression such that they are able to meet those objectives.

> *A structure within the organisation, that takes you from point A to point B in a systematic manner. Sort of definable objectives at every stage of your training, and good feedback to show that you are progressing at the right rate.* (FG 001)

> *Same thing, so the structured system, where it's supervised and also provides support, and ideally is uniform throughout all the hospitals, which would help.* (FG 001)

> *I think when we talk about structure and flexibility working together I think we want the education process to be quite flexible, but we want each individual learning* element *to be relatively structured. We want to have a beginning, middle and an end, we want to know that "Ok, well this is what I've now learnt, this is what I'm going to go away with and learnt about, and then the next time I'm going to be doing an approach to this, and this is how we're going to do it" But then the* opportunities *to have each of those experiences*, that's *what needs to be a little bit flexible.* (FG 003)

This seems at odds with what we might expect of adult learners. As noted above, Knowles (71, 72) principles of adult learning states that adults are independent and self-directing, more motivated to learn by internal drives than by external ones. Here the discussion has primarily been about the *external* drives for learning; competencies set by external bodies (The Royal College of Surgeons as an example); the need to pass specialty examinations. While Knowles suggests that adult learners should be involved in planning and curricular content, and in formulating their own learning objectives, the group here expresses a wish for that curriculum and objectives to be clearly defined, and the pathway to reach those objectives equally clearly defined, with a structure that can be followed in an almost uniform manner.

6.7 What makes Trainees willing to invest in a training tool?

I would suggest that the themes emerging above give a much clearer idea of what trainees require from a training experience, and use this to extrapolate what they expect from a new training tool such as the VLE, and therefore what they would require from a new training tool in order to engage with the resource. The model below is used to illustrate the point, in that we must make decisions all the time about where to invest our time.

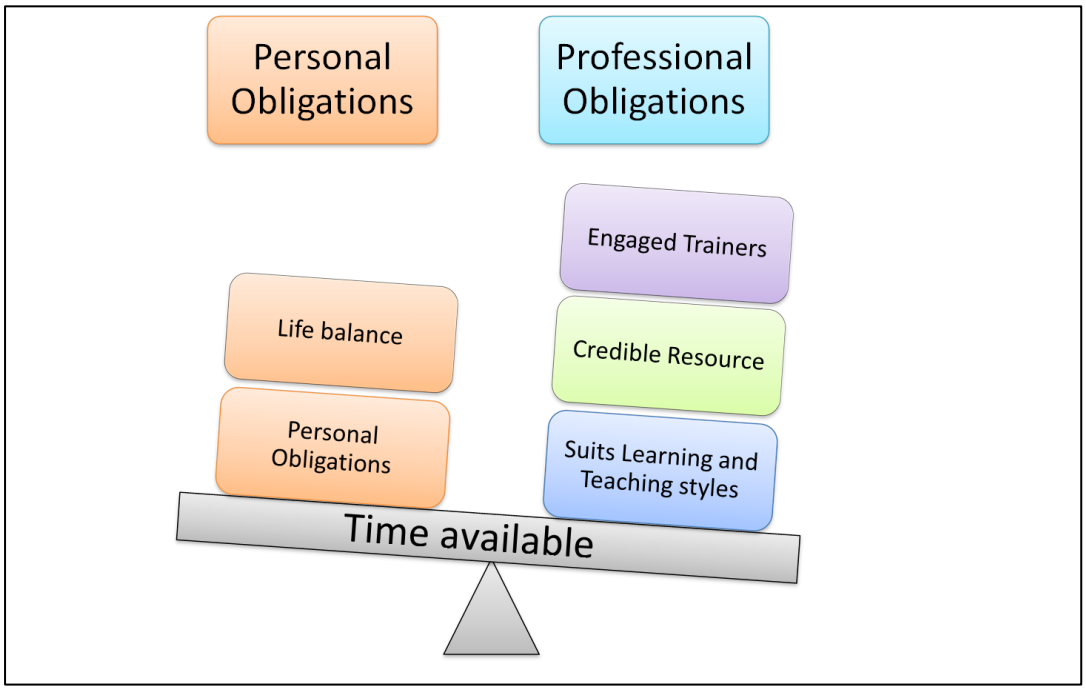


Figure 8: Model 7, Balance of factors that allow trainees to engage in a training tool?

It is clear that the existing requirements of the orthopaedic training programme and the demands of a consultant post leave little extra time to spend on new ideas. But as we have discussed above, trainees seem to be willing to devote the time to the resource if the cost: benefit ratio is perceived to be in their favour. Trainees will spend the time on a resource (or any training experience) if they feel they will gain something from it. Time is thus identified as a key factor in trainees' willingness to utilise the new VLE environment.

The whole point about VLE is, this is a resource which has to be used in your own personal time. So it has to be attractive enough to be used in your own personal time, whether I do my study, whether I am at my, with my family, doing my jobs, going to Tesco. Why would I do VLE and not go to Tesco, that's what I have to think. (FG 002)

Well, as I said at the beginning, what can it offer me that I can't get easily somewhere else? And I don't think you've answered that question really look, but I don't know. What can it offer me? (FG 002)

I think it's that the VLE requires an investment of time, whereas other websites that we use, you can just go on for 5 minutes here and there, and get something out of it, and get an immediate response, instant gratification from it. (FG 001)

So it's a question of, you know, you all work hard here, and then you get home, and you're thinking "Right, shall I watch coronation street or shall I do this?" And that I think is the main thing, because it's not an activity where you have to engage because you're in an environment where you're supposed to, it is a voluntary thing. (INT 003)

The themes that are identified from this are again similar to those we have already seen – trainees will spend time on a resource *if* it is; credible, trainers are engaged and it suits their learning style.

I don't interact very well with the VLE. My way of studying doesn't usually involve computers and I like to do stuff and actually draw or physically see a book, whereas on this I find, yes, the presentations are there, but I'm unlikely to go and look for them, so for some people I think it works, for others it doesn't. (FG 001)

Yeah, I think we've got to, I think with something like a learning method, it's not even, this is not a syllabus, this is not part of our curriculum, it's the learning method, or learning portal, then you've got to be big enough to not take it personally if something thinks it's not their method. (FG 002)

6.7a Credible

As we have discussed above, the idea that the resource must be credible is key to the trainees perception that they can learn from the resource. The knowledge gained must be relevant, and link to their curriculum, objectives and mandatory assessments. It must also be evidence-based.

So sometime people reference, or will put in an article that they've referenced in there, and I think that's good. (FG 002)

Where knowledge links to mandatory assessments, the idea that the knowledge must also be applied in the form of higher order thinking was manifest in all focus groups and a number of consultant interviews. The FRCS Tr. & Orth. Examination *viva voce* requires trainees to extend their knowledge in what has been termed "higher order thinking". This is derived from Blooms taxonomy (75), who described a classification of levels of intellectual behaviour important in learning. Rather than simply remembering and recalling information, students undertaking the FRCS Tr.& Orth. Examination are expected to show progression to the stage where they are able to use that knowledge to appraise evidence, formulate an argument for their choice of treatment and be able to defend that choice. An illustration of Blooms Taxonomy is shown below (new version).

Trainees therefore feel strongly that in order for the case based discussions to be relevant they must develop to the level where they are required to demonstrate higher order thinking.

> *But this is what I, I think the focus is wrong, because that, a CBD, is not designed to test knowledge, and were using it in the wrong way. So a CBD is meant to test judgement, and what we should be doing is checking judgement skills, and it should not be about "you need to go and research this entire topic", it should be "based on your knowledge, tell me how you would do this, and justify your answer". Based on your knowledge, not go and learn something, because that's the question.* (FG 002)

> *I suppose it depends, like you say, it does depend on what, as a case based discussion at the moment it is, I suspect more black and white. "What are the reasons for so and so and so?" It's either "These are the reasons or not". So in a way the discussion is limited because it's a bit like an MCQ – it's either right or wrong. What you're trying*

to move on to I guess is how do you open it up? To actually facilitate, it's a discussion amongst peers, rather than just testing knowledge. (FG 003)

*That's I think how you start discussing, getting people to think and not just cut and paste from you know, a journal or a review article "what would you do? You are the person in charge" (*FG 003)

I mean you don't just want to see a list of factual answers, and if you want people to be thinking about, about what the problem might be, but how to, how to investigate it, how to find out more about it, and coming up with probably a differential diagnosis, but also a list of different options you might be able to do, not just "Oh, this is, you know this patient's got arthritis, they need a total hip, here's the evidence", you need to be thinking "what are the pros and cons of different approaches" and "what's the evidence behind those", I mean like you would in a real case, but you need to have good cases, where there was, there's no point giving somebody a very straight forward case, it needs to be a case where you need to look at the evidence and I think there needs to be some research there, or at least come back with some questions about how you could look into it further. (INT 002)

6.7b Engaged Trainer

Again, linked to the idea that the resource must be credible, the idea that the trainers must be engaged with the resource for it to be successful was manifest throughout the dataset. This is seen in the idea that the resource requires a moderator, but also for timely feedback in order for trainees to progress.

And you get closure, and also all the ones that interacted on that forum get a CBD at the end of it as part of their work based assessment. And you get the closure of the topic, and you can be assessed on your higher order understanding. (FG 001)

I think you want when it's closed it to be like a nice summary as well, so you can then look back at it as like an educational resource for that case, which hopefully if everyone's answered it should be. (FG 003)

I mean if you were going to do that then you should close it properly then, and ask probably ask one of the consultants, who you would consider to be either an expert, or at least have a special interest in that, to maybe look through, look through the whole discussion, and maybe write a paragraph summary or say, "oh so and so's answer was a very good summary, I agree that that would be good" because otherwise you could just, you could really have written a load of rubbish on there and nobody's really checking it. (INT 002)

You've got to get something out of it, um, and I think what you get out of it either has to be, you must either feel that you've learnt something from it, and I think if somebody, maybe if somebody gave you some feedback about it at the end, you might feel that you had learnt something. (INT 002)

6.7c Learning and Teaching Styles

Finally the resource must suit learning styles. While I have suggested that the group have displayed some ideas which conflict with the idea of adult learners, it is clear that they prefer to make their own choices about the resource and that its use should be voluntary. They prefer to work at their own pace, and the flexibility of the resource should allow them to do this.

And they, an environment which is, in which you are distanced from the trainee i.e. you are not engaged face to face and not engaged also in real time, because there is always a lag with the virtual learning environment interface, may not suit everybody's teaching style well, and people may feel as a result that they prefer to spend time teaching trainees in other environments other than investing that time to engage in the virtual learning environment. (INT 004)

…which is a point that I think is important in learning, that we are all adult learners, and therefore we shouldn't force people to do it, and we shouldn't force people, or entice them to do it either, because everybody's got their own learning pattern, there'll be things, there'll be ways you could learn or I could learn, that other people won't be able to learn by. (FG 002)

No, but it's not, you know what I mean? I'm not going out to cause trouble, but if you tell me I have to do something, it's about learning, it's not like, you know we're adults, we're not kids, and we're always treated like kids and it's really annoying. I don't know, I'm coming close to the end and it's getting really annoying when you're treated like a child all the time. You should be able to make a decision; "actually I think this is good for me". (FG 002)

6.8 Summary

In summary, the data suggests that trainees and trainers would be willing to invest the time if the resource provides them with a clear benefit. Others should be engaged, and in doing so provide a credible resource for all to learn from.

Well I think it's a great concept and you know, it's great that we have that resource with us, so we shouldn't let it go, or we should just, I think you're doing the right thing of hopefully *at the end of all this you will come up with something that changes the whole face of it.* (INT 012)

CHAPTER SEVEN:

DEVELOPING ETOOL: FRAMEWORK, THEORIES AND IMPLEMENTATION

In this chapter I describe the development of the new Virtual Learning Environment (VLE), including the underpinning educational theories and the impact of medical culture, the content designed and developed, and the process of evaluation. This is presented in relation to the research objective three:

Objective three:

To critically design and develop eLearning and simulation-based learning tasks using:

d. A Virtual Learning Environment (VLE) platform populated with
    i. Case-based discussions
    ii. Online Journal club discussion

This chapter is sub-divided into three sections:

7.1 Links between practical design and the theoretical underpinnings

7.2 Developing the Intervention: Consideration of available models

7.3 Implementation of improvements including the learning design workshop.

The quantitative and qualitative work performed and described in chapters five and six, informed new developments to the existing orthopaedic VLE / Training resource. The comprehensive analysis allowed us to determine how to move forward in the evolution of the resource.

7.1a Links between practice and theoretical underpinnings

It is important in designing an educational intervention to improve and develop the VLE that good practice in teaching and e-learning was always underpinned by sound educational theory.

The current Virtual learning environment structure is utilized by trainees in two broad areas; as a knowledge repository, and for discussion of cases and problem solving of difficult or interesting cases. This is seen in the Quantitative learner analytics (chapter 5). As the most utilized area of the VLE, we felt it was important to consider the Case discussions in detail.

The learning with regard to the Case Based Discussions is necessarily based on clinical experience. Kolb (76) theory suggested that learners must be able to immerse in new experiences which require reflective skills and multiple views of observation. Learners conceptualize the observations and the experiences by integrating them into theories, and must use these theories for making decisions and solving problems. Kolb described effective learners with these four abilities; Concrete Experience, Reflective Observation, Abstract Conceptualization and Active Experimentation. Taken as a whole, these four processes constitute his learning cycle (see Figure £). Kolb describes a continuous process of responding to diverse personal and environmental demands that arise from the interaction between experience, concepts, reflection and action in a cyclical fashion. The optimal learning takes place when an adequate balance of these four characters is carried out.

Svnicki and Dixon (69) added instructional methods for each of the phases of the cycle:

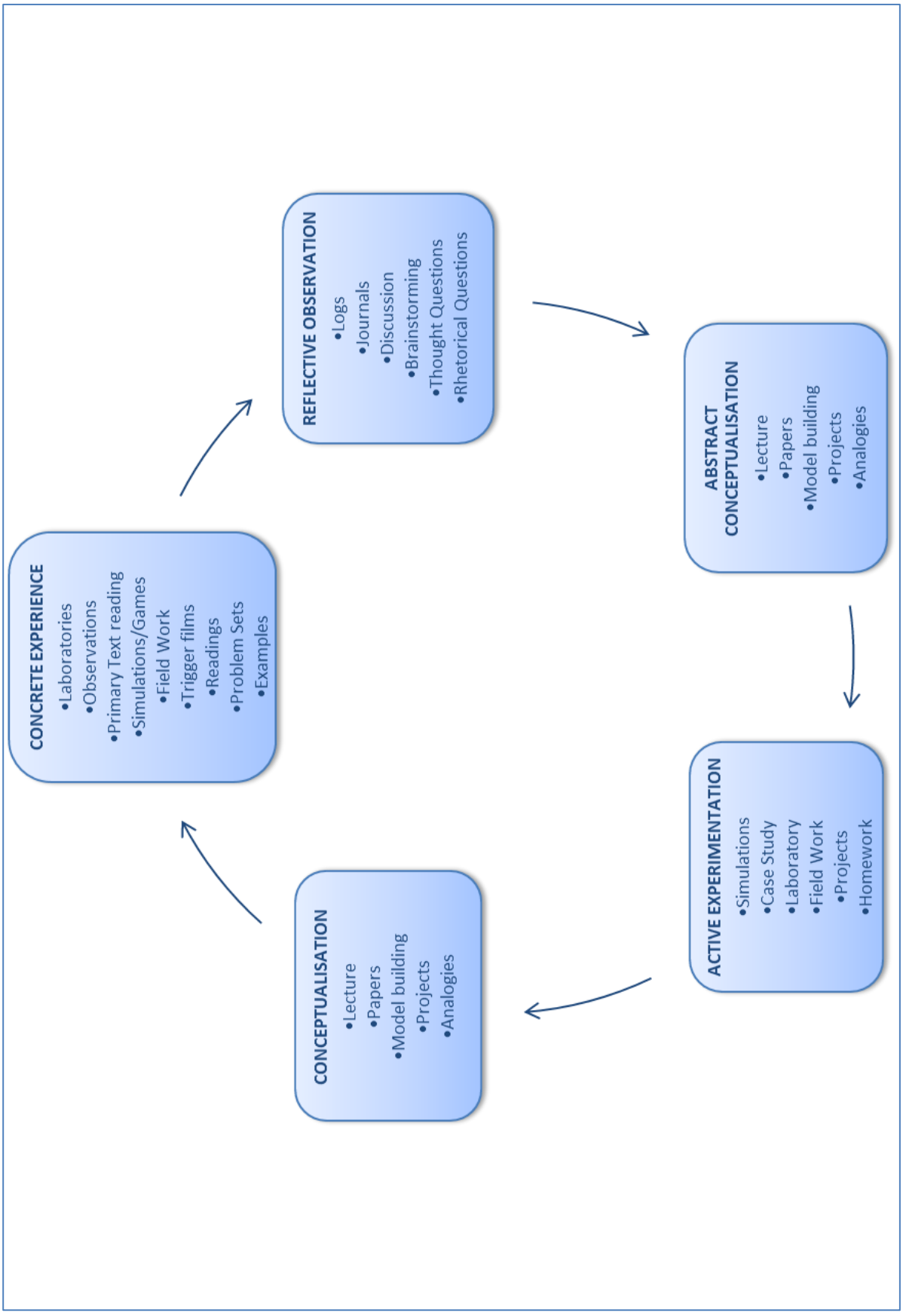


Figure 9 Kolb's learning cycle with instructional methods added by Svnicki and Dixon (1987)

When teaching clinical and surgical skills, the experiential model of learning is a useful one, and in fact Kolb's theory is based on research measuring the non-conscious development of psycho-motor skills. The Kolb model is not without criticism however. Such criticisms generally argue that Kolb provides only a limited account of the many factors that influence learning. Vince (77) feels in particular that the theory does not adequately consider the context of power relations such as social status, gender and cultural dominance, and their influence on learning. Other writers also criticize Kolb for being too narrow in his outlook; in particular the simplistic linear nature of the model.

Kolb went on to suggest that learners develop different learning styles that display preference for some models of learning over others, leading to particular characteristics. Later explored by Honey and Mumford (78) these styles of learning may help planning, as a variety of strategies to promote learning should be considered. In the qualitative work (see chapter 6), it emerged that one of the barriers to use of the VLE was that users felt the activities did not match their learning style. As teachers, the most effective application of the model would be to use it to ensure that teaching activities give full value to each of the activities available on the VLE. For example:

Planning (Pragmatist): Students try brainstorming for relevant symptoms and signs. This helps students to activate prior knowledge, orientates them and provides a framework and structure for the session.

Experience (Activist): Students interview a patient in pairs under supervision, and perform a focused physical examination. This gives them the opportunity to implement and practice skills.

Reflection (Reflector): Feedback and discussion away from the patient gives the opportunity to increase their knowledge and elaborate on the case.

Theory (Theorist): Providing the basic facts about the patient diagnosis, investigation and management helps students to link the practice with theory.

In order to complete Kolb's learning cycle, it is important to return to the planning stage. To allow learners to prepare for the next clinical encounter, and evaluate their progress, a debriefing, with questions such "What have I learnt?", and "How will I approach a patient like this next time?" can help learners articulate areas where they may be having difficulty, or which they wish to know more about. Structuring the online Case based Discussions in this way is very much student centered in its approach, and links back to the requests for adequate feedback and a "summary" of the case discussions seen in the qualitative research (see chapter 6). Kolb also draws on both the constructivist theories and theories of adult learning. It is also designed to foster "deep" learning, one of the concepts introduced by Entwistle (69). Both the student and teacher must be opportunistic in identifying learning opportunities that are appropriate, and teachers in providing timely, targeted feedback. When discussing learning styles in this context we must understand that there are recognised limitations in both the reliability and validity of *all* the learning styles questionnaires, and it is therefore important that learning styles should not be regarded as fixed; a particular learning style may only apply to a particular context. As educators, we should encourage our students to use a range of styles and approaches on different occasions.

Considering the theories above in our development of the case discussion area, it was critical to ensure that each case moves forward in a timely manner, allowing users to ask relevant questions as the case progresses. A variety of sources will be utilized (including x-rays, MRI, CT etc.) to stimulate discussion. Each case must be summarized at the end of the discussion by the moderator, and timely feedback must be provided throughout the case, encouraging students to prepare for the next clinical encounter.

The qualitative work (chapter 6) also emphasized that the postgraduate trainees are adult learners and want resources that reflect this. The problem based learning seen in the case based discussion is student centered in its approach, and draws on both the constructivist theories and theories of adult learning, based primarily on the work by Piaget, Vygotsky and Bruner (79-81). Here the teacher should not be viewed as a transmitter of knowledge, but as a guide who facilitates learning. The problem based learning approach demands that students activate prior knowledge, and build on existing conceptual knowledge frameworks. Problem based learning uses prompts from a scenario to define learning objectives. Students subsequently do independent, self-directed study before returning to the group to discuss and refine their acquired knowledge. The scenario is not therefore about problem solving *per se*, but uses appropriate patient problems to increase knowledge and understanding. However, it is important for teachers to expose the inconsistencies between the students existing knowledge and their new experiences to allow *accommodation* to occur. In order to actively acquire new knowledge, sufficient time must be provided for in-depth examination of new experiences, allowing a change in existing *schema* to occur.

While some constructivists argue that "learning by doing" enhances learning, critics of constructivism have argued that little evidence exists to support this statement with novice learners. Sweller *et al.* (82) argue that novices do not possess the underlying mental models or "schemas" necessary for "learning by doing". Kirschner, *et al.* (83) describe constructivist teaching methods as "unguided methods of instruction". They suggest more structured learning activities for learners with little or no prior knowledge. We need to take this into account based on what we have seen of the learner analytics (chapter 5). The more senior trainees (ST6, 7 and 8) may only need a trainer in the case based discussion scenario to act as a guide to facilitate discussions as they may be more able to activate prior knowledge, and build on existing conceptual knowledge frameworks. The more junior trainees (ST3

and 4) can be seen to use the resource to acquire knowledge and therefore may need more structured learning activities.

One of the drivers behind the qualitative research (see chapter 6) was to allow trainers and trainees using the resource to be involved in the process of development of the site. Knowles principles of adult learning suggest we try to motivate the students, encourage them to set their own learning goals, and to participate in decisions that affect their own learning. We must therefore involve them in planning and curricular content, and in formulating their own learning objectives. Knowles states that adult learners are more motivated to learn by internal drives than by external ones. We should therefore involve adult learners in diagnosing their own needs, which will help to trigger internal motivation. Critics of Knowles' approach to adult learning suggest that it does not adequately reflect that while adult learning is often self-motivated it is not devoid of a student's need for an instructor who can provide guidance to learning and provide the framework for students to succeed. Kerka (84) also addressed some concepts of self-directed learning. The first is that adults are naturally self-directed, when, in reality, their capability for self-directed learning may vary widely. The second is that self-direction is an all-or-nothing concept - it is apparent a continuum exists. Adults have varying degrees of willingness or ability to assume personal responsibility for learning. These may include the degree of choice over goals, objectives, type of participation, content, method, and assessment. Lesser motivated learners may profit from a more teacher-directed approach. Students can develop meaning on the grounding of the factual information, and internalise their learning. Prosser and Trigwell (70) state that this deep approach to learning is more likely to be associated with higher quality learning outcomes.

7.1b Assessment in practice

Brown *et al* (85) state that assessment tends to shape much of the learning that students do. We know that students may focus strongly on what they believe will be in the examinations, and prepare strategically. This is reflected in the emphasis that trainees have placed on the FRCS Tr. & Orth. Examination (see chapter 6). In developing the VLE we must therefore consider the 4 criteria that allow us to evaluate the advantages and disadvantages of assessment. These are validity, reliability, discrimination and practicality. Gipps (86) described *Reliability* as the 'accuracy' with which an assessment measures the skill or attainment it is designed to measure, and *Discrimination* as the extent to which an assignment allows for differences in achievement to be recognised.

In order to engage with this, it is clear that we do not just need to find any task for the students to do, but tasks that are *authentic* and *relevant*. Again, "relevant" is a concept that was prevalent throughout the trainee focus groups (chapter 6) when talking about the VLE as a whole, and in particular the case based discussions. In practical terms, this means focusing on the intended learning outcomes. Prosser and Trigwell (70) use the term 'high quality learning outcomes', which they define as 'an understanding that can be drawn upon in other and new contexts'. As discussed above, this forms part of Entwistle's deep approach to learning, where the intention is to understand through an active constructivist engagement with knowledge. Like Brown however, Ramsden (87) argues that student will adopt a surface approach to learning *or* a deep approach, depending on how they perceive the learning context, and most crucially, how they perceive the assessment task.

Biggs (88, 89) applies these ideas to the curriculum in the form of constructive alignment. Constructive alignment involves intended learning outcomes being made consistent with other elements of the curriculum, so that teaching exercises and resources, and assessment processes all support students learning. This

dynamic process involves both student and teacher. The student is required to construct meaning through relevant learning activities, while the teacher is required to set up a learning environment that supplies the learning activities to allow the student to achieve those intended learning outcomes. Although seen as a circular process, constructive alignment involves 4 key steps. Firstly, defining the intended learning outcomes (ILOs); Secondly, choosing the teaching/learning activities that are likely to lead to attaining those ILOs; Thirdly, assessing students learning to see how well it matches what was intended, and then finally arriving at a final consideration of the student achievement. This allows us to examine whether we have applied the standards of validity to our teaching - have we achieved what we set out to achieve? A reflective approach to these activities can help this become a cycle of performance and learning. We must ask whether the online case based discussion problems are authentic and relevant to the curriculum, and if they assess the skills that have been taught - do they match our ILOs? There are limitations; an online case based discussion often requires trainees to perform isolated aspects of the clinical encounter, which can be said to 'deconstruct' the doctor-patient encounter. There are also limitations on what can be simulated, and constraints on the type of patient problems that can be used.

7.1c Considering potential challenges

At this point it may be important to note my own perspectives on educational theory: we know that the site development cannot occur in a vacuum and it is important to consider my own theoretical standpoint. As clarified in chapter six, it must be understood that the lead researcher is embedded in the process beyond that of the average researcher; both a trainee using the Virtual Learning Environment and known to all of the site users, both professionally and personally. We must consider that they will be constructing activities which evoke understanding experientially. The lead researcher has a background and knowledge coming into this project that we must acknowledge is personal and subjective. Is objectivity

possible? It may even be that the participants themselves may not be able to articulate the reasons for engaging with the resource; the culture of apprenticeship in the orthopaedic profession is so ingrained and normalised that they may not be able to perceive or articulate about it. Can anyone?

Although the trauma and orthopaedic VLE is already one of the tools available for postgraduate trainees to use, we have seen from the qualitative and quantitative data that it is often used only as a repository for lecture materials with only the more senior trainees using the discussion aspect of the site. This could be described as a largely *teacher-centred* use of the technology. It has been suggested that those introducing online learning in this format have proved very reluctant to adopt more *learner-centred* ideas (90), Becher and Trowler (91) describe "tribe and territory" as a strong disciplinary identity and focus, arising from epistemological and social factors, that can inhibit acceptance of change (91, 92). Many practitioners seeking development will only respond to peers in their discipline and are often antipathetic to staff development, advice, theory or research which is not wholly discipline-based (93). Staff development approaches are often driven by policy and compliance requirements, as well as the staff developers' agenda, rather than the academics' actual needs (94).

Given the challenges described above, including potential sources of bias, it was clear that any intervention must be multi-disciplinary in its approach, with input from researchers, learning technologists, orthopaedic surgeons and academics in order to produce the most appropriate interventions for the resource.

7.2 Developing the Intervention: Consideration of Available Models

7.2a A Framework for Designing the Intervention

7.2a (i) Developing and evaluating complex interventions: the new Medical Research Council guidance

In 2000, the Medical Research Council (MRC) published a framework (95) to help researchers and research funders to recognise and adopt appropriate methods in designing a complex intervention. Complex interventions are usually described as those that contain several interacting components, but the number of components and range of effects may vary widely. The 2000 framework characterises the process of development through to implementation of a complex intervention in terms of the phases of drug development. Although it is useful to think in terms of phases, in practice these may not follow a linear or even a cyclical sequence.

The MRC framework defines "best practice" as developing interventions systematically, using the best available evidence and appropriate theory. They must then be tested using a carefully phased approach, starting with a series of pilot studies targeted at each of the key uncertainties in the design, and moving on to an exploratory and then a definitive evaluation. The results should be disseminated as widely and persuasively as possible, with further research to assist and monitor the process of implementation.

Whilst the entire framework may not be wholly applicable in this situation, it can act as a guide for development. In particular:

> *Identifying existing evidence*— The first step is to identify what is already known about similar interventions and the methods that have been used to evaluate them. If there is no recent, high quality systematic review of the relevant evidence, one should be conducted and updated as the evaluation proceeds.
>
> *Identifying and developing theory*— A key early task is to develop a theoretical understanding of the likely process of change by drawing on existing

evidence and theory, supplemented if necessary by new primary research. This should be done whether the researcher is developing the intervention or evaluating one that has already been developed.

Modelling process and outcomes— Modelling a complex intervention before a full scale evaluation can provide important information about the design of both the intervention and the evaluation. This may identify weaknesses and lead to refinements, or even show that a full scale evaluation is unwarranted. The process of presenting to an expert panel and wider audiences within the orthopaedic community has allowed us to discuss theoretical models and work through the process and possible outcomes.

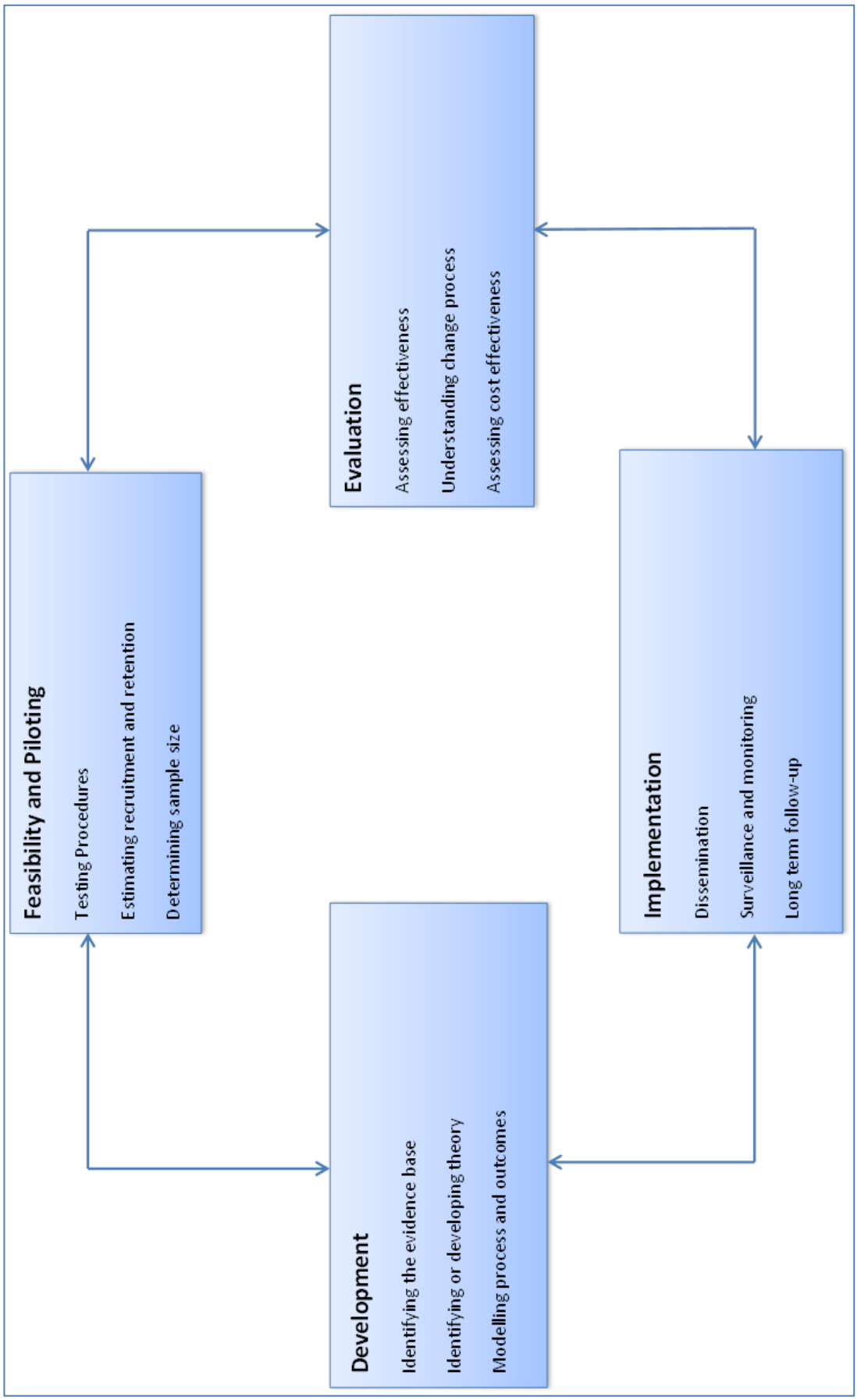


Fig 10: Key elements of the development and evaluation process

As we have discussed earlier in the chapter, good theoretical understanding is needed of how our intervention may cause change. If we utilize the framework to develop our interventions, a thorough process of evaluation is also needed to identify implementation problems. In the case of the VLE in particular a single primary outcome may not make best use of the data; a range of measures will be needed and unintended consequences picked up where possible. The MRC framework and guidance is not intended to be prescriptive but to help make appropriate methodological and practical choices.

7.3 Implementation of improvements including the learning design workshop.

A more simplified framework than the MRC framework is seen in the following diagram from "Carpe Diem: seizing each day to foster change in e-learning design" (96) which describes the process of the Carpe Diem course (see section 7.3b Learning design workshop).

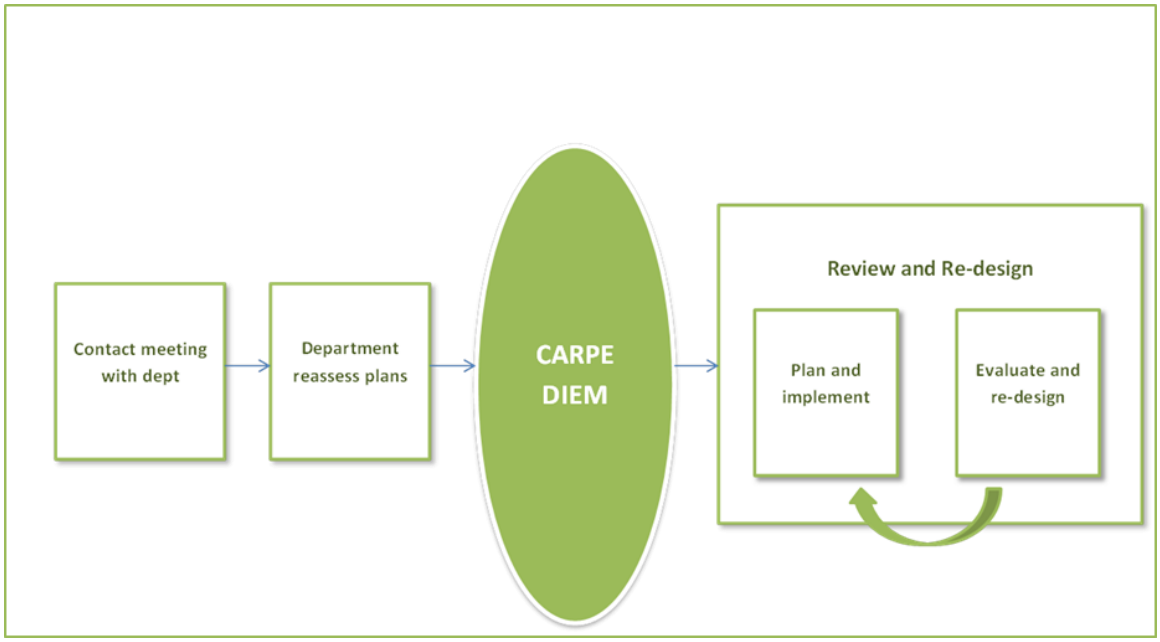


Fig 11: "Carpe Diem" framework

I have adapted this to demonstrate the approach taken in designing the interventions for the evolution and implementation of improvements to the virtual learning environment:

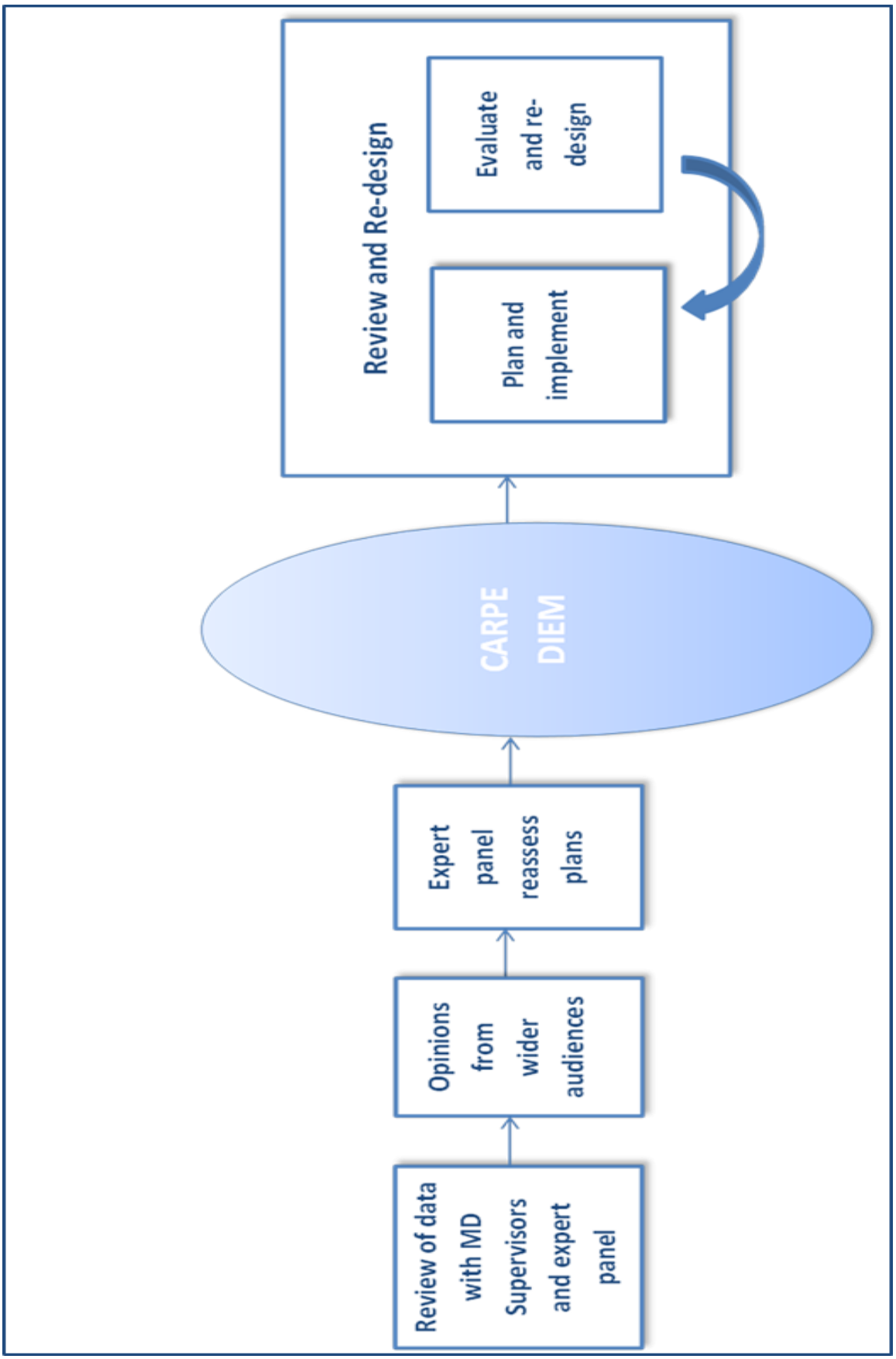


Figure 12: Adapted "Carpe Diem" framework

7.3a Presentation of data

The first step in the evolution of the resource was to present the data to a panel of experts to invite opinion and discussion on the next steps for the Virtual Learning Environment for postgraduate Orthopaedic Trainees. This was done in three stages (see Figure 15 below):

7.3a (i) Stage One: Presentation to MD Supervisors:

Both supervisors are involved in education and training and have valuable insight into the use of e-learning resources, involved in postgraduate training and development. Both the qualitative and quantitative data sets were presented and discussed to formulate ideas for the next steps in the future development of the VLE.

7.3a (ii) Stage two: Presentation to expert panel:

Following the presentation of the data to my supervisors, a meeting of an expert panel of those involved in the Virtual Learning Environment was scheduled to allow presentation and discussion of the data. The panel consisted of:

- Miss Veronica Roberts; Webmaster for the site and trainee representative
- Miss Lucy Cutler; Consultant Lead for the VLE
- Mr. Bhaskar Bhowal; Training Programme Director for Trauma and Orthopaedics (East Midlands South)
- Mr. Jose Blanco; Trainee representative
- Mr. Robert Ashford; Lead for Trauma and Orthopaedic Post graduate teaching programme

This panel then formed the core committee to attend the learning design workshop (see section 8.5).

7.3a (iii) Stage three: Presentation to wider audiences;

I was invited by the Royal College of Surgeons to present at the Trauma and Orthopaedic Training and Education day in April 2013, and at the Simulation and

Technology Enhanced learning day as part of the National BOA Congress in October 2013. Both gave opportunities to present aspects of the qualitative and quantitative data sets and to invite discussion among experts from other regions as to how the resource can be developed, as well as how the resource might be used to assist other Trauma and Orthopaedic training programmes, and how collaboration with other centers might be achieved.

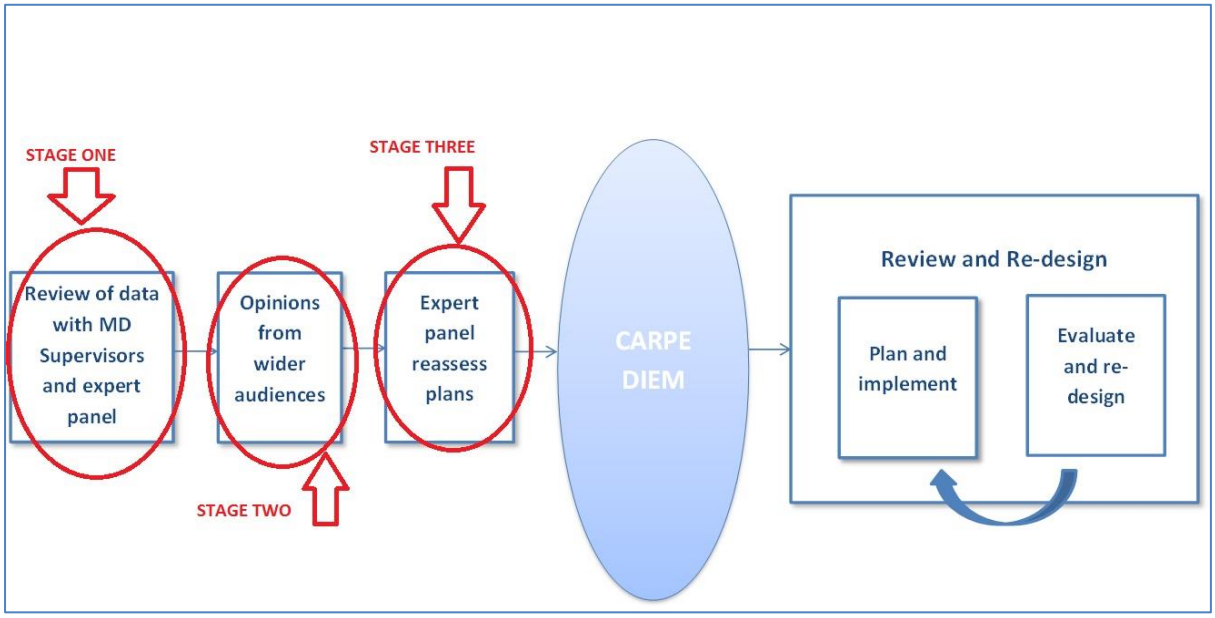


Figure 13: Adapted "Carpe Diem" framework with stages highlighted.

The Trauma and Orthopaedic Training and Education (TOTE) day was held at the Royal College of Surgeons of England in April 2013. The aim of the day was to focus on the training and curriculum of Specialist Registrars and consultants within Trauma and Orthopaedics and to consider further development of the Training Programme, particularly with respect to what is expected of T&O in terms of delivering a simulation curriculum and to formulate a plan for how simulation can be integrated at a local and national level in the short, medium and long term. The use of technology enhanced learning, and how to use such tools to maximise opportunities was also discussed, and I was able to present both the quantitative user analytics and the qualitative data to invite feedback on my work so far.

The TOTE meeting was attended by members of the BOA Education and Revalidation committee, as well as the Training Standards Committee, and regional Training programme directors from across the country. Feedback was also received from Ms. Lisa Hadfield-Law, the BOA Educational advisor.

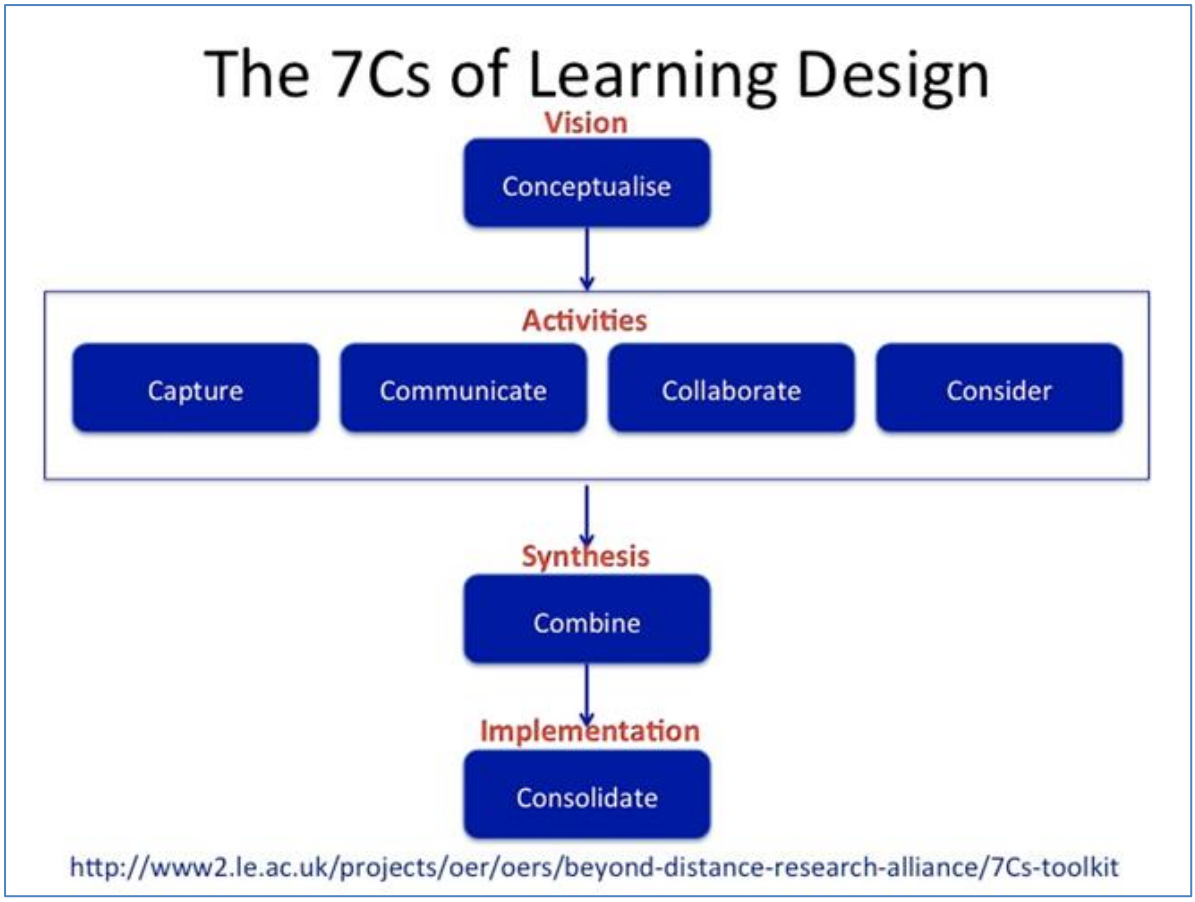
7.3b Learning Design Workshop

The course team were then able to attend a learning design workshop held at the University of Leicester. The workshop was awarded as a prize for my poster presentation at the East Midlands VLE Development Day, and was therefore provided free of charge. The *7Cs of Learning Design* workshop is an interactive two-day workshop that enabled the course team to design effectively for learning. The hands-on workshop is based on a well-rehearsed, well researched team approach to learning design using learning technologies from the Institute of Learning Innovation. This workshop forms one element of the new "7Cs of Design and Delivery" programme which integrates the findings and lessons learned from Leicester's "Carpe Diem" research and the Open University Learning Design Initiative into a suite of creative workshops for academic course teams and learning technologists, run by Professor Gráinne Conole. Professor Conole is Director of the Institute of Learning Innovation at the University of Leicester. Prior to this, she was Chair of E-Learning at the Institute of Educational Technology, The Open University. Also facilitating the course was Terese Bird, a Learning Technologist and SCORE Research Fellow with 15 years of experience in harnessing technologies appropriately for learning and in assisting educational practitioners.

The 7Cs of Learning Design are grouped into four categories:

- **Vision**
    - **Conceptualise** (i.e what are you designing and why, who are you designing for?)
- **Activities**
    - **Capture** (in terms of capturing resources to be used and activities around Learner Generated Content)
    - **Communicate** (mechanisms to foster communication)
    - **Collaborate** (mechanisms to foster collaboration)
    - **Consider** (activities to promote reflection and enable assessment)
- **Synthesis**
    - **Combine** (combining the activities to give a holistic overview of the design and associated learning pathways)
- **Implementation**
    - **Consolidate** (in terms of running the design in a real learning context, evaluating, refining and sharing the design).

Each C has a set of Conceptual Learning Designs (CLDs) associated with it.



As mentioned above, the course team consisted of:

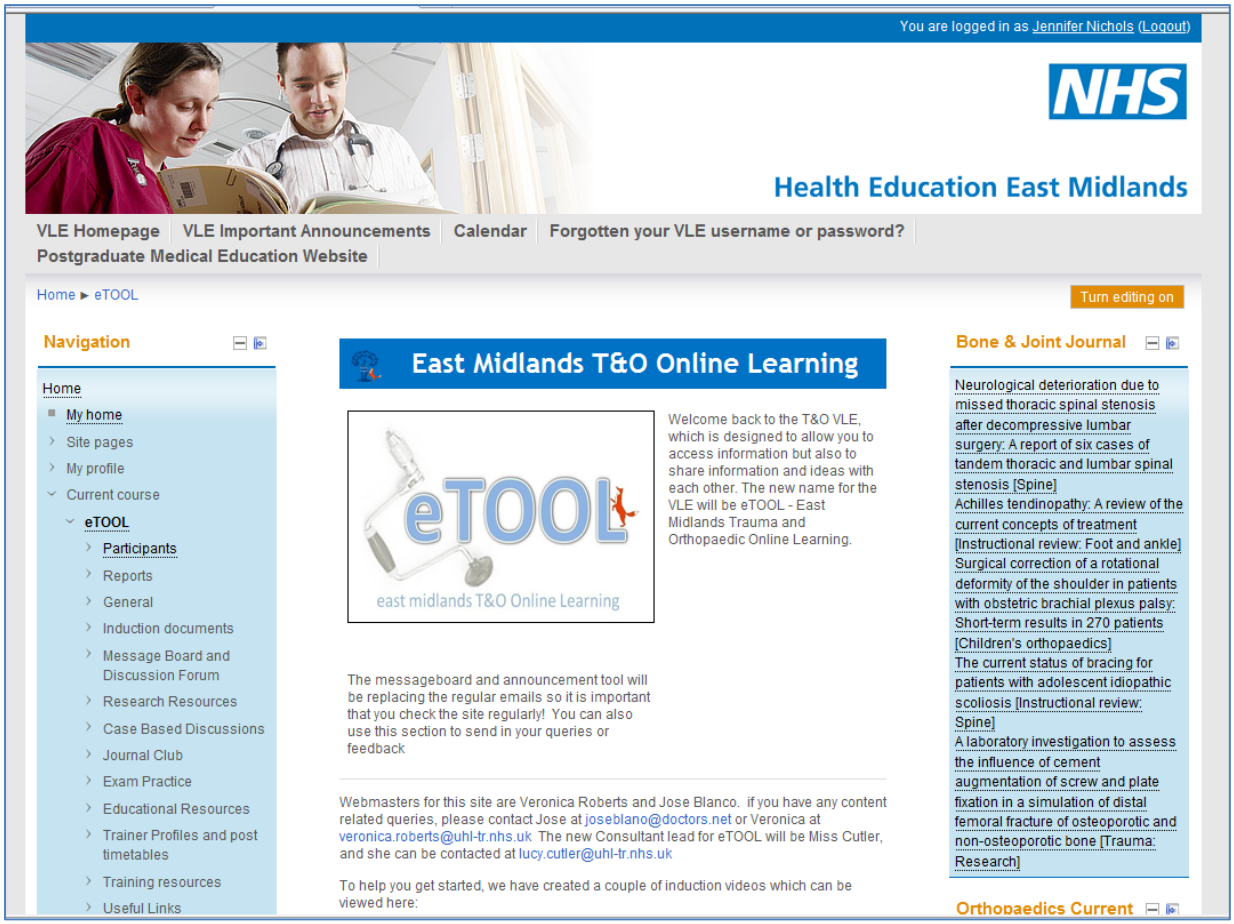
- Miss Jennifer Nichols
- Miss Veronica Roberts; Webmaster for the site and trainee representative
- Miss Lucy Cutler; Consultant Lead for the VLE
- Mr. Bhaskar Bhowal; Training Programme Director for Trauma and Orthopaedics (East Midlands South)
- Mr. Jose Blanco; Trainee representative

The course described above allowed us as a team to gain awareness of the range of resources, tools and methods which are available to support learning design, including learning design tools/methods and open educational resource repositories, and how to apply those resources. We also considered a range of pedagogical approaches and the role played by different technologies in supporting these approaches. We were able to consider the features we want to include in our

module/course, based on the quantitative learner analytics, and also the qualitative data. The resources we choose will affect not only the look and feel of the course, but also the nature of the learners' experience. We were then able to conceptualise the design process from different perspectives and draft an action plan for next steps in the redesign process.

Activity profiles and the quantitative learner analytics allowed us to consider the balance of activity types to include in the course. This also allowed us to start mapping out the new design for the course, including plans for student support, and activities for assessment, communication and collaboration. This further encouraged the development of a storyboard for the course in which the learning outcomes are aligned with the assessment events, topics (contents) and e-tivities. This was particularly helpful in the context of the case based discussion area of the VLE. Most importantly we were able to generate a number of e-tivities (electronic activities) for the course, ensuring these were aligned with the storyboard and course map.

One of the key aspects that emerged as part of the Learning Design Workshop was the lack of ownership by the trainees regarding the Virtual Learning Environment. The site is still referred to as "The VLE" rather than by any unique name, and one of the most important e-tivities (shortened term for electronic, or online activities) was a re-branding of the VLE. The name "e-TOOL" was proposed by the committee; Electronic Trauma and Orthopaedic Online Learning, or eTOOL. A new logo and re-naming of the site was uploaded during the workshop, and has prompted some useful informal feedback already by trainees. A screenshot shows the new logo in situ below:



7.3c On-going evolution

In addition to the re-branding of the site and new logo, several other measures were instigated to continue the development and evolution of the VLE.

Multimedia and communication

Two videos were produced during the learning design workshop; these were an introductory video designed to welcome members to the site, and an instructional video to allow novice users to become familiar with navigating the site. The introductory video involved all members of the eTOOL team, and was designed simply to re-introduce all users to the site and lay out the intentions for its development.

This video was embedded on the eTOOL homepage, so that all site users logging on could view. The video was also emailed to all Orthopaedic trainers and trainees within the East Midlands, so that awareness of the site development was heightened. A second instructional video was created during the learning design workshop.

This narrated PowerPoint was designed to address some of the concerns expressed regarding a number of technical issues that were cited as barriers to use of the VLE. These included problems with navigation, issues with user's passwords, and how to log-in to the site. As mentioned in Chapter 6, there were references to the fact that some trainers were not aware of the existence of the site. The instructional video was emailed to all Orthopaedic trainers and trainees within the East Midlands to specifically address this issue.

Case Based Discussions

Both the trainees and trainers had stressed the importance of mapping the case based discussions to the curriculum. In particular the critical conditions outlined in the new syllabus, published August 2013. This extract from the new curriculum outlines the expectations for all Trauma and Orthopaedic trainees:

CBDs are designed to assess judgement and decision making. In this curriculum revision it is a requirement that all critical conditions are assessed by a CBD.
*A critical condition is defined as "**any condition where a misdiagnosis can be associated with devastating consequences for life or limb**".*
The critical conditions list is:
1. Compartment syndrome (any site).
2. Neurovascular injuries (any site).
3. Cauda equina syndrome
4. Immediate assessment, care and referral of spinal trauma.
5. Spinal infections
6. Complications of inflammatory spinal conditions.
7. Metastatic spinal compression.
8. The painful spine in the child.
9. Physiological response to trauma.
10. The painful hip.

As mentioned above, the learning design workshop encouraged storyboarding of the case discussions, in which the learning outcomes were aligned with the assessment topics (contents) and e-tivities. A named consultant has been allocated to each upcoming case based discussion, focussing in particular on our spinal surgical colleagues, as 50% of the critical cases are based around knowledge of spinal problems. The quantitative study showed that there had previously been no involvement on the site by this particular group of surgeons at all, and references from the Qualitative study suggest that this may be due to the lack discussion in their sub-specialty. There will be increased focus on feedback for the case, with podcast feedback provided, so that trainees will be able to listen to the comments made by the lead consultant moderating the case. The feedback will be timely, and we will aim to provide individualised feedback to participating trainees, allowing them to then complete a reflective CBD for the case topic. Once the case is closed with consultant feedback it will be archived, and all trainees can access the case and view all posts, allowing them to use these as a good knowledge resource.

7.4 Summary

This chapter presents the development and evolution of the Virtual Learning Environment (VLE) in relation to the research objective three a:

> **Objective three:**
>
> To critically design and develop eLearning and simulation-based learning tasks using:
>
> a. A Virtual Learning Environment (VLE) platform populated with
>
> iii. Case-based discussions
>
> iv. Online Journal club discussion

As mentioned we aim for eTOOL to be an evolving set of rich online resources to help trainees with their study, therefore I anticipate changes will continue into the future, and after the completion of this project.

CHAPTER EIGHT:

ASSESSING THE IMPACT OF VIRTUAL REALITY SIMULATION FOR TRAINING IN ARTHROSCOPIC KNEE SURGERY

In this chapter we describe a discrete, Randomised Control Trial to evaluate the use of a virtual reality arthroscopy simulator in postgraduate trauma and orthopaedic trainees within the region. This is presented in relation to the research objectives two, three and four:

Objective Two

To evaluate the level of engagement among orthopaedic trainees with existing resources, in particular ***simulation-based learning activities***

Objective Three

To critically design and develop simulation-based learning tasks using:

An Arthroscopy simulator

Objective Four

To assess the effectiveness of the simulation-based learning activities in facilitating trainees to achieve these outcomes

This chapter is presented according to the CONSORT statement, an evidence-based, minimum set of recommendations for reporting randomized trials. It offers a standard way for authors to prepare reports of trial findings, facilitating their complete and transparent reporting, and aiding their critical appraisal and interpretation (56).

8.1 Structured summary of trial design, methods, results, and conclusions

Item	Description
Trial design	This was a single centre randomised control trial, with balanced randomisation (1:1). This single-blind, parallel-group study was conducted at the University Hospitals of Leicester, United Kingdom.
Methods:	
Participants	Eligible participants were all postgraduate Trauma and Orthopaedic Trainees of CT1 grade or over, employed in the East Midlands (South) training rotation. The study took place within the University Hospitals of Leicester NHS Trust, United Kingdom.
Interventions	The intervention group received a fixed protocol of simulator training. The simulation training consisted of 9 hours of simulated knee arthroscopies during a six month period. The ArthroVR GMV knee simulator was used in all cases in a designated bio skills laboratory.
Objective	To assess the effectiveness of the simulation-based learning activities in facilitating trainees to achieve improved performance in educational outcomes, specifically the procedural based assessment (PBA).
Outcome	The primary outcome measure with respect to efficacy in simulated arthroscopy training was the improvement in score achieved on the Procedural Based Assessment (PBA) in Knee arthroscopy performed in the operating theatre.
Randomisation	Participants were randomly assigned following simple randomization procedures (computerized random numbers) to either the intervention or the control group.
Blinding (masking)	Trainees allocated to the intervention group were aware of the allocated arm, outcome assessors were kept blinded to the allocation.

Item	Description
Results:	
Numbers randomised	12 participants were randomised to the control group and 14 participants were randomised to the intervention group
Numbers analysed	6 participants were analysed in the control group and 10 participants were analysed in the intervention group
Outcome	The simulator group were seen to show a significant increase in the PBA score in comparison to the control group ($p<0.0001$)
Harms	None
Conclusions	We would suggest that in designing the curricula for Orthopaedic training the use of simulation based training should be considered.

8.2a Scientific background and explanation of rationale

The aim of this study was to investigate the effect of virtual reality simulator training on the ability of surgical trainees to perform diagnostic arthroscopy of the knee. Effective use of simulation can help to lessen the impact of reduced hours and shift working by accelerating the acquisition of technical skills and transferring learning away from the patient. There are numerous examples of successful use of simulation equipment ranging from simple procedural skills such as suturing to high fidelity team-based training. These technologies allow trainees to develop a level of competency in operational skills. While the VLE project aims to assess how we can utilise technology assisted learning to improve clinical reasoning and knowledge, this looks specifically at the other key aspect of surgical training: technical skill.

There are broadly two types of arthroscopy simulator available: one is a computerised simulator, the other a training stack. Training stacks offer more traditional simulation, where trainees can carry out arthroscopic procedures on bone and plastic models using the familiar equipment they will see within the operating theatre, although in a scaled down version of the traditional arthroscopic stack. This allows them to perform instrumented procedures, such as menisectomy (with multiple tear configurations available) and retrieval of loose bodies within the knee joint. Shoulder and ankle joints are also available that allow the trainees to perform simple procedures including debridement, cuff repair with anchor fixation and other similar techniques.

Picture 1: Traditional knee arthroscopy simulator

Picture 2: Traditional plastic insert for model

Whilst these offer a useful alternative to allow all grades to practice skills there are certain disadvantages. The models have an upkeep cost, and there is a cost for the consumables such as replacement menisci. Unlike a computerised simulator, the models do not have an inbuilt mechanism to record of the trainee's progress and time spent in the acquisition of these new skills.

Arthroscopic computerised simulators are now available that allow users to learn and improve minimally invasive surgical techniques. Virtual reality techniques constitute a supporting tool to enable learning of the arthroscopic environment as well as manual coordination with an arthroscopic instrument. The simulator focuses on the maximisation and evaluation aspects of the educational process through the appropriate categorisation of exercises, skill evaluation techniques and multimedia tools. The systems typically use two haptic devices that allow the user to mimic surgical procedures using such tools as a probe and a burr. While surgeons follow training modules on a computer screen, the haptic devices they hold literally "push back" on their hands as they perform virtual surgery on physical 3D knee and

shoulder models. In addition, the system generates realistic sounds and can assess skills.

Picture 3: GMV Arthro VR simulator - picture courtesy of GMV

8.2b Specific objectives and hypotheses

The objectives of this RCT are to critically design and develop simulation-based learning tasks using an Arthroscopy simulator, and to use the simulator to assess the effectiveness of the simulation-based learning activities in facilitating trainees to achieve improved performance in educational outcomes, specifically the procedural based assessment (PBA).

The hypothesis states that the use of an arthroscopy simulator will lead to improved educational outcomes for Orthopaedic Trainees in the form of improved scores in the procedural based assessment (PBA).

Methods

8.3a Trial design

This was a single centre randomised control trial, with balanced randomisation (1:1). This single-blind, parallel-group study was conducted at the University Hospitals of Leicester, United Kingdom.

8.3a Changes to Trial design

No changes to the trial design were made during the study.

8.4a Participants

Eligible participants were all postgraduate Trauma and Orthopaedic Trainees of CT1 grade or over, employed in the East Midlands (South) training rotation.

Exclusion criteria were trainees who were ST8 or over (as they were deemed too senior to benefit from additional simulation training), any trainee employed in a post that provided large numbers of arthroscopy training in addition to normal daily activities, and any trainee also part of another training rotation, as the experience of training posts in other regions could not be controlled for.

8.4b Study Settings

The study took place within the University Hospitals of Leicester NHS Trust, United Kingdom. The control group received traditional training within the hospital operating theatre environment. The intervention group received an additional fixed protocol of simulator training. The ArthroVR GMV knee simulator was used in all cases in a designated bio skills laboratory at Leicester Royal Infirmary.

8.5 Interventions

Control Group/Comparison

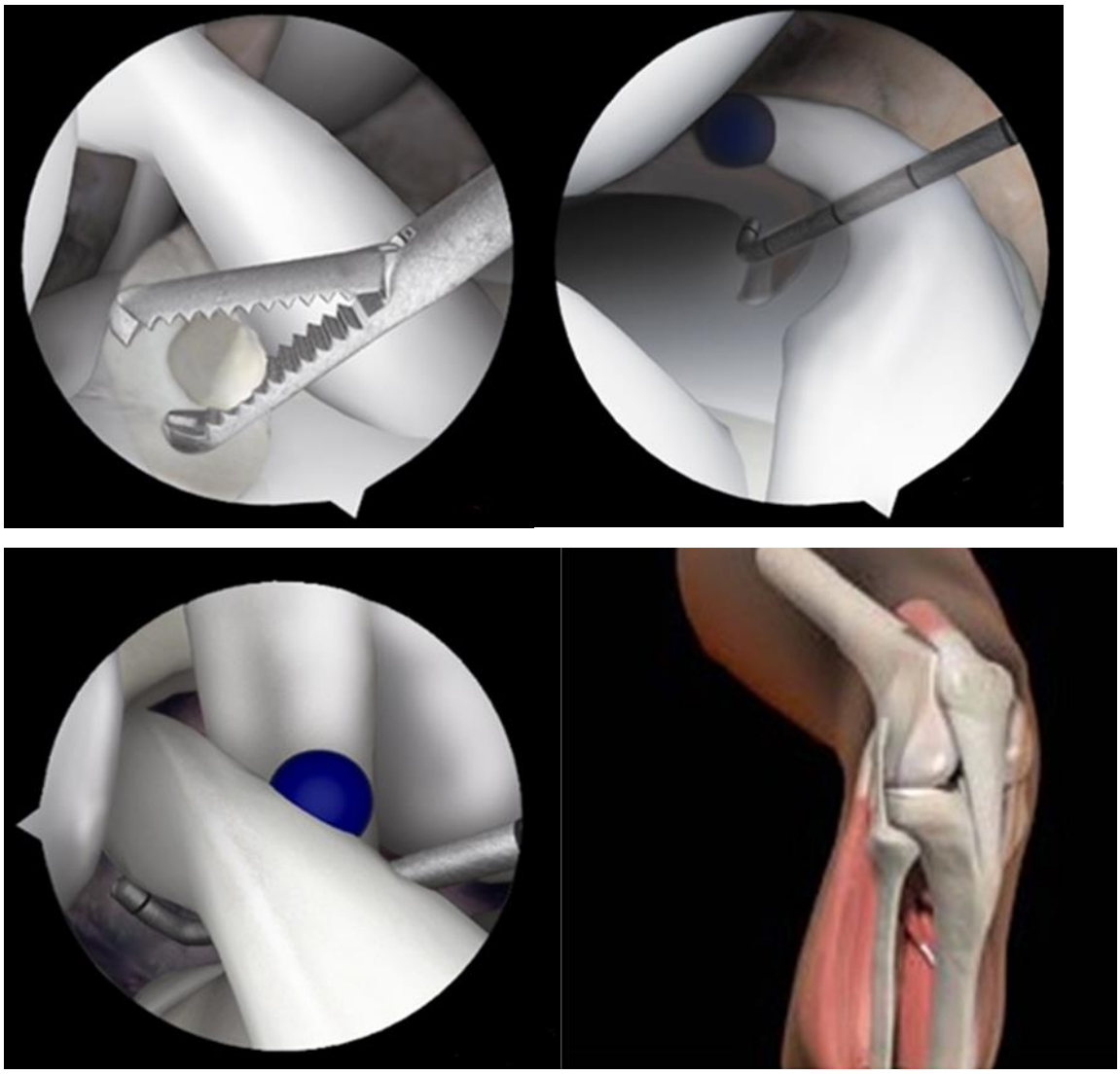
The control group received traditional training in theatres only. Guidelines for training in Trauma and Orthopaedics are provided by the JCST (Joint Committee on Surgical Training). Trainees of ST3 level and above must provide evidence of participation in annual scheduled (i.e. timetabled) minimum of three operating lists per week and two outpatient clinics per week (including fracture clinic). Trainees must also demonstrate consolidated logbook evidence of the breadth of operative experience defined in the specialty syllabus. Trainees should have a minimum 1800 cases recorded in their logbooks over 6 years of training from ST3 to ST8 (average 300 cases / year or 150 in the 6 months of the study period). In addition to this, minimum specific operation groups are expected as a requirement for CCT (Certificates of Completion of Training) in 72 months of training. These procedures must be supported by evidence from PBAs (Procedural Based Assessment – see chapter one) over a range of trainers and periods of time.

In the case of Knee Arthroscopy they are required to demonstrate a total of 40 procedures in the 6 years of training from ST3 to ST8. A CCT confirms that a doctor has completed a training programme approved by the GMC (General Medical Council) and is eligible for entry onto the GP Register or the Specialist Register.

Intervention Group

The intervention group received an additional fixed protocol of simulator training. The additional simulation training consisted of 9 hours of simulated knee arthroscopies during a six month period. The simulated arthroscopies were supervised by the lead researcher until competent with the simulator and followed a fixed protocol for diagnostic arthroscopy of the knee as agreed by surgeons experienced in this area. The ArthroVR GMV knee simulator was used in all cases in

a designated bio skills laboratory. A standard 30 degree arthroscopic camera and display system was used for all cases.



Picture 4: Screen capture from simulator (courtesy of GMV)

8.6a Outcomes

The primary outcome measure with respect to efficacy in simulated arthroscopy training was the improvement in score achieved on the Procedural Based Assessment (PBA) in Knee arthroscopy performed in the operating theatre.

Each trainee was assessed at the beginning and end of the study period. Each trainee was allocated a theatre session with an experienced consultant knee surgeon who was blinded to their training status. They were then assessed as each trainee performed a diagnostic arthroscopy. Assessment was made using the Procedural Based Assessment (PBA) tool for diagnostic knee arthroscopy. This tool gives a maximum score of 60 points. The score can be seen in Appendix Thirteen. Use of the PBA has been incorporated into the competency based surgical training structure implemented by the surgical royal colleges in the United Kingdom and is a familiar training tool to all Orthopaedic Trainers and trainees. The primary outcome measure was the difference in performance between the simulator group of trainees and the non-simulator group.

Additional analyses were performed on the improvement shown over the six month period of simulator training between the first and second assessed arthroscopies. The difference in improvement was also compared between the two groups.

8.6b Changes to Outcomes

There were no changes to the initial study protocol.

8.7a Sample size

Calculations were performed to determine the minimum number of subjects required for enrolment in the study in order to have sufficient power to detect an effect. By enrolling too few subjects, the study may not have sufficient statistical power to detect a difference (Type II error). Enrolling too many subjects in this study would be unnecessarily costly and time-consuming.

For this study, we have two independent study groups – with only one group participating in the use of the simulator (as the intervention). The end point is determined as the mean PBA score. Anticipated means for group one were

determined as 30 +/- 3, i.e. 50% of a possible total +/- 10%. We anticipated a 15% increase in the PBA score for the intervention group (group two) receiving simulator training based on effect sizes previously seen in the literature (18, 62). The Alpha (i.e. probability of a Type I error) was set at 0.05. Beta (i.e. probability of a Type II error) was set at 20% (0.2) giving Power of 80%. These figures are universally acceptable throughout the medical literature.

Sample size calculations suggest each group requires 9 participants to provide Power of 80% (see calculation below). We are aware that this may result in differences to the baseline characteristics. Imbalanced groups may occur particularly when there are relatively few participants (e.g. 15 to 20 participants per group) enrolled in a trial (97).

$$k = \frac{n_2}{n_1} = 1$$

$$n_1 = \frac{(\sigma_1^2 + \sigma_2^2/K)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$$

$$n_1 = \frac{(3^2 + 3^2/1)(1.96 + 0.84)^2}{4^2}$$

$$n_1 = 9$$

$$n_2 = K * n_1 = 9$$

$\Delta = |\mu_2 - \mu_1|$ = absolute difference between two means

σ_1, σ_2 = variance of mean #1 and #2

n_1 = sample size for group #1

n_2 = sample size for group #2

α = probability of type I error (usually 0.05)

β = probability of type II error (usually 0.2)

z = critical Z value for a given α or β

k = ratio of sample size for group #1 to group #2

8.7b Interim analyses

No interim analyses were performed.

8.8a Randomisation: sequence generation

For allocation of the participants, a computer-generated list of random numbers was used.

8.8b Randomisation: type

Due to the small number of participants in the trial, participants were randomly assigned following simple randomization procedures (computerized random numbers) to either the intervention or the control group.

8.9 Randomisation: allocation concealment mechanism

The allocation sequence was concealed from the researcher enrolling and assessing participants using opaque, sealed envelopes. Envelopes were opened only after the enrolled participants completed the baseline assessments and it was time to allocate the intervention. Participants were asked not to reveal their allocation to the assessor completing the final assessments until after the scoring was completed.

8.10 Randomisation: implementation

The lead researcher generated the allocation sequence, enrolled participants, and assigned participants to interventions using opaque, sealed envelopes.

8.11 Blinding

Whereas trainees allocated to the intervention group were aware of the allocated arm, outcome assessors were kept blinded to the allocation. Each trainee was assessed at the beginning and end of the study period. Each trainee was allocated a theatre session with an experienced Consultant Orthopaedic Surgeon who was blinded to their training status and allocated arm of the study. They were then assessed as each trainee performed a diagnostic arthroscopy (see above).

8.12a Statistical methods

The primary outcome measure with respect to efficacy in simulated arthroscopy training was the improvement in score achieved on the Procedural Based Assessment (PBA) in Knee arthroscopy performed in the operating theatre**.** Secondary efficacy endpoints included the change in score in the intervention group between initial and final assessments and change in score in the control group between initial and final assessments. We used a Paired t-test for the primary endpoint and Ordinary One way analysis of variance (ANOVA) with multiple comparisons (Sidak's multiple comparisons test) for the secondary endpoints.

8.12b Additional analyses

Further sub-analysis of the simulator-trained group was undertaken to demonstrate objective improvement in simulator performance with training for the movement analysis variables, time taken in seconds, total path travelled in millimetres and roughness in Newtons.

Results

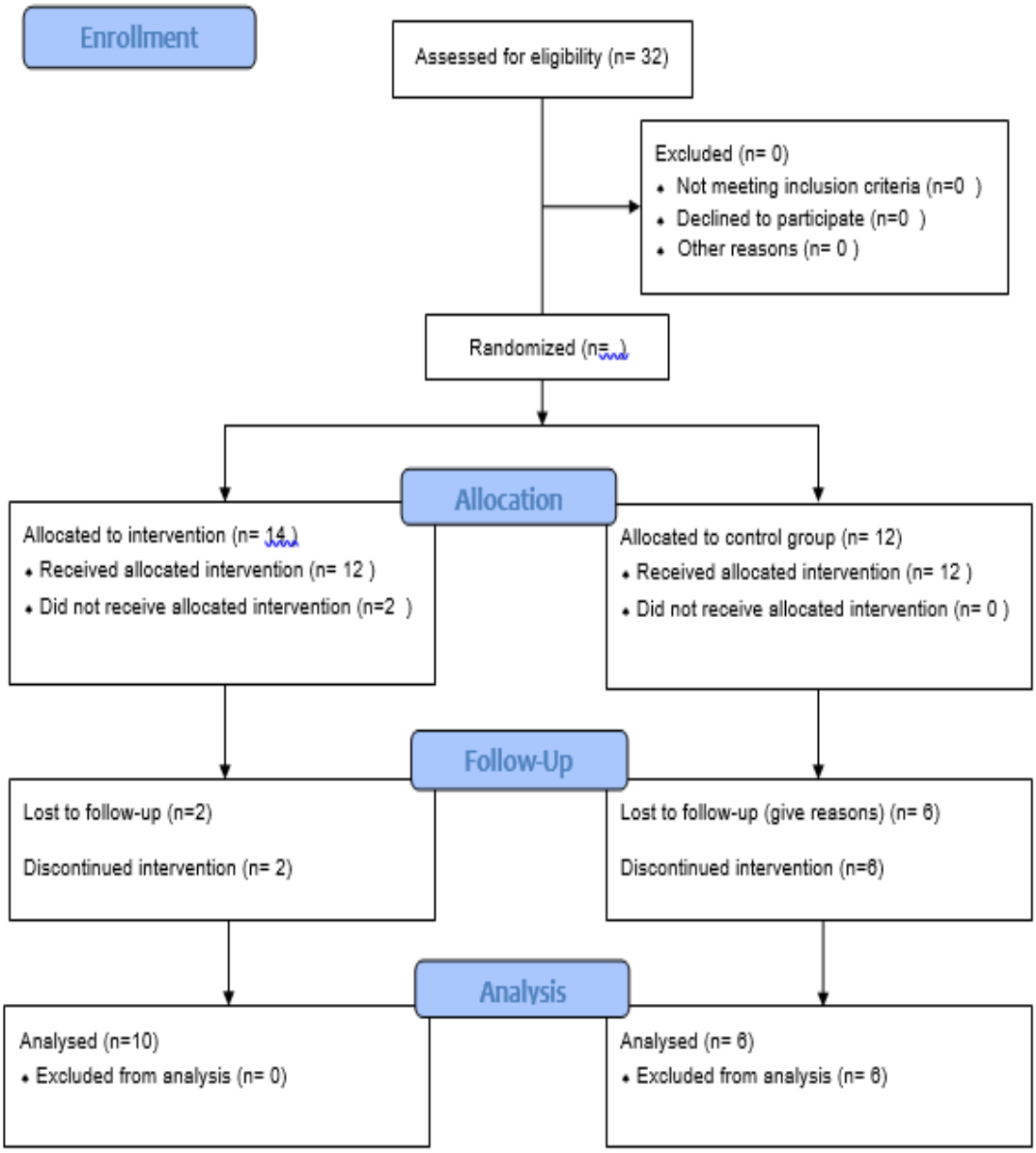
8.13a Participant Flow

See participant flow chart below as per the CONSORT guidelines.

CONSORT

TRANSPARENT REPORTING of TRIALS

CONSORT 2010 Flow Diagram



8.13b Losses and Exclusions

No participants were excluded from the study. There were no deviations from protocol during the study. All participants in the control group received traditional training. Six trainees were lost to follow up from the control group. They declined to return for the second assessment at the end of the study period, citing reasons including "being too busy" and "not being able to accommodate the assessment in their timetable".

There were two losses from the intervention group after randomisation, and therefore did not receive the allocated intervention. One trainee was removed from the training rotation, and the second trainee declined to participate after the initial assessment. Two trainees received the allocated intervention and participated in a period of 9 hours simulator training, but were lost to follow up and declined to return for the second assessment at the end of the study period, citing similar reasons as in the control group including "being too busy" and "not being able to accommodate the assessment in their timetable".

8.14 Recruitment

Eligible participants were recruited from August 2012 to March 2013. Assessments were performed in the operating theatres. Participants then attended the Bio skills laboratory at Leicester Royal Infirmary at the time of randomisation. The intervention group also attended the Bio skills laboratory to complete the additional simulation training consisting of 9 hours of simulated knee arthroscopies during a six month period. Participants then attended the Bio skills laboratory at the end of the study period to report their final assessment scores.

8.15 Baseline Demographic data

	Intervention (Simulator Training)	Control Group
Age (mean)	**32.5**	**35.4**
Sex (male)	**92%**	**94%**
Grade of training		
CT	(2/12) **17%**	(2/14) **14%**
ST3	(5/12) **41%**	(2/14) **14%**
ST4	(2/12) **17%**	(6/14) **44%**
ST5	(2/12) **17%**	(1/14) **7%**
ST6	(1/12) **8%**	(1/14) **7%**
ST7	(0/12) **0%**	(2/14) **14%**

Small sample size in each group may have resulted in differences to the baseline characteristics. Imbalanced groups may occur particularly when there are relatively few participants (e.g. 15 to 20 participants per group) enrolled in a trial (97). The fact that there are more ST7 trainees in the control group must make us wary of a ceiling effect.

8.16 Numbers analysed

The primary analysis involved all participants who were randomly assigned.

8.17 Outcomes and Estimation

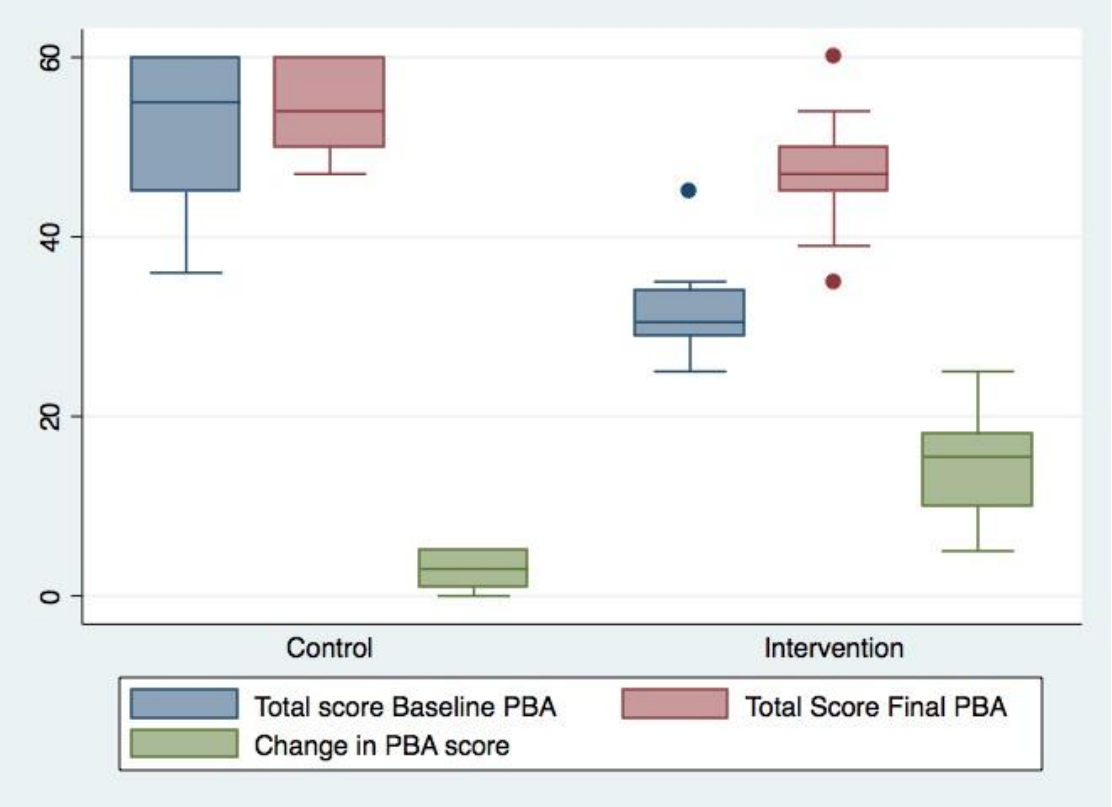
Primary Outcome Measure Results

The primary outcome measure was the difference in performance in the operating theatre between the simulator-trained intervention group and the control group. Assessment was made using the Procedural Based Assessment (PBA) tool for diagnostic knee arthroscopy. This tool gives a maximum score of 60 points.

Analysis of the performance in the operating theatre of both groups using the Procedural Based Assessment (PBA) tool for diagnostic knee arthroscopy showed that the performance of the simulator-trained intervention group improved significantly. The simulator group were seen to show a significant increase in the PBA score in comparison to the control group ($p<0.0001$).

	PBA score (60 point scale)			
	Initial	Final	Mean Difference (95% CI)	P value
Intervention group	32.1	47.1	15 (10.87 – 19.13)	<0.0001
Control group	51.14	54.14	3 (1.075 – 4.925)	0.0088

Box plots are seen below:



On analysis, there are differences in the seniority of the two groups, but these differences are not significant. There is also a significant difference between groups on the baseline assessment between controls and intervention. The initial control group scores were higher than the simulator-trained intervention group. This is a confounding factor, and may impact upon the original power calculation which assumed that the groups would be the same at baseline assessment. It is difficult to explain why the control group scores were significantly higher although may represent a ceiling effect. However, the trainees were randomised to ensure that there were equal numbers in each group, rather than by seniority or operative experience. There was no significant difference in the levels of experience between the control and intervention groups however.

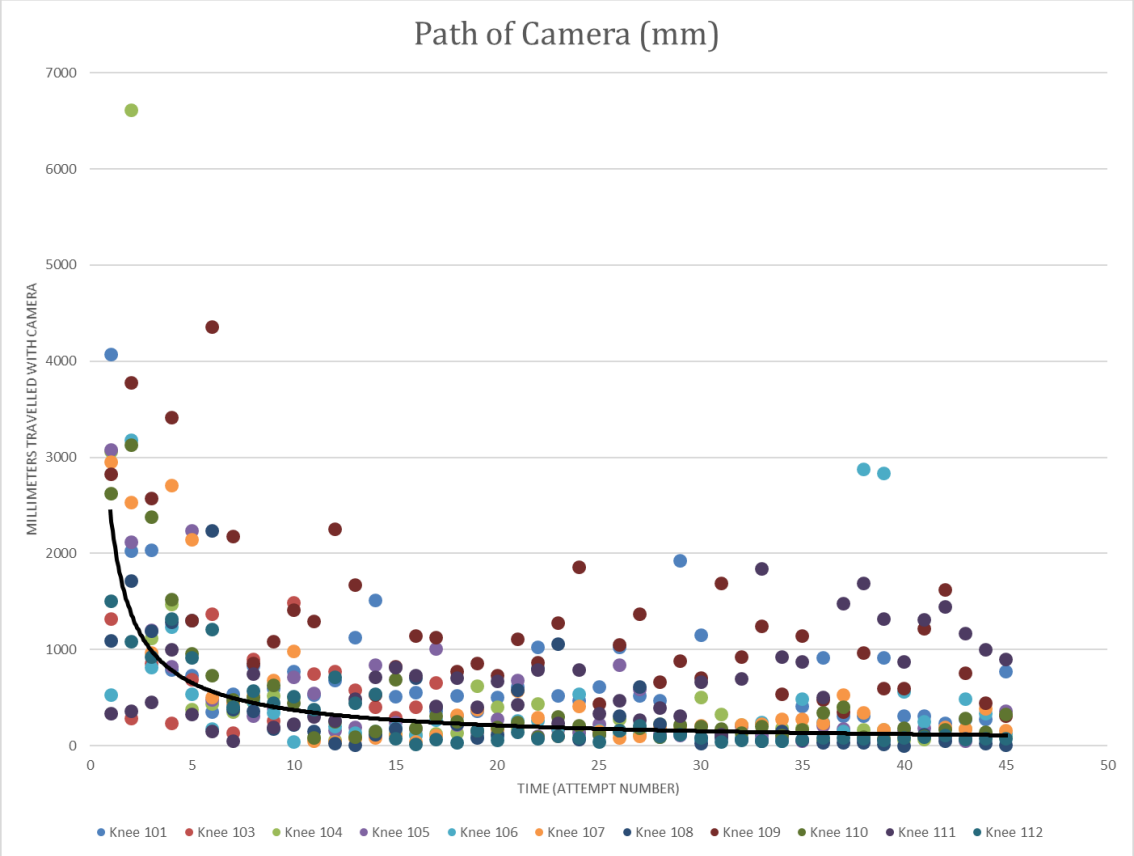
8.18 Ancillary analyses

Secondary Outcome Measure Results

Further sub-analysis of the simulator-trained group was undertaken to demonstrate objective improvement in simulator performance with training for the movement analysis variables, time taken, total path travelled and roughness. Time taken is measured in seconds, and is the time elapsed from the start of the exercise until it ends. Covered distance is measured in millimetres, and is the distance covered by the tip of the instrument used during the exercise. This is the main metric to measure economy of movement during the exercise. An additional covered distance is computed for grasper instruments when their jaws are open, due to the increased risk of injuring cartilages when the sharp parts of the grasping instrument are exposed. Roughness is measured in Newtons when colliding with anatomical structures.

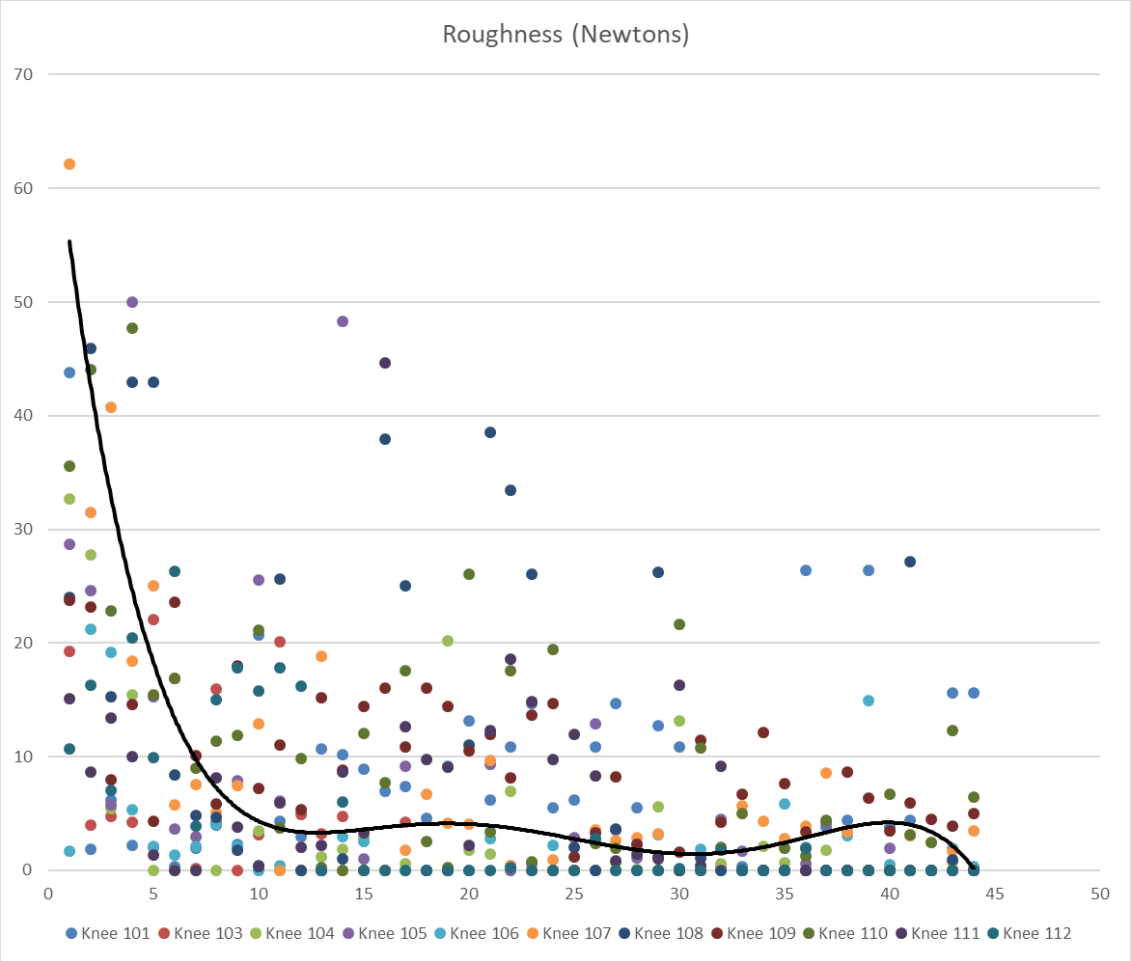
Path of Camera

The primary metric to assess economy of movement is the path travelled by the camera during the exercise measured in millimetres. Analysis of the data in all users appears to show an improvement in simulator performance during training.



Roughness of Instruments

The roughness of the instruments when colliding with anatomical structures is also measured. The value is recorded in Newtons (with a value of Zero for an exercise indication that no inadvertent collisions with anatomical structures occurred). An improvement in performance is seen in all users, with roughness decreasing with the number of exercises performed during the training period.



8.19 Harms

None identified

Discussion

8.20 Limitations

There are a number of limitations to this study which should be considered. One limitation of the study is the high initial scores for the PBA assessment shown by the control group. This is difficult to explain, as approximately 75% of each group was formed of trainees who were ST4 or below, and therefore in the early years of their surgical training. It does however raise the question regarding the capacity to improve when initial scores are high. As mentioned the trainees were randomised

to ensure that there were equal numbers in each group, rather than by seniority or operative experience. Reviewing operative experience of trainees prior to randomisation to determine equal skill mix in each group may be appropriate in additional work moving forward.

Limitations also include the high dropout rate among trainees in the control group. This differential drop out between the two groups may result in bias in interpreting the results. However we would argue that unequal dropout rates do not imply that estimates are biased, but we should consider the analysis method carefully. It is interesting that lower dropout rates were seen in the simulator training group, which might be seen as more demanding for the trainees, requiring a substantial commitment of time in addition to traditional training. The control group did not receive any additional training with the simulator, and may have had higher dropout rates due to lack of interest in the study, apathy or frustration at not being able to access a resource that might be perceived as being helpful to their training. When asked, trainees usually cited "not being able to accommodate the assessment in their timetable", but may have felt that the additional commitments required to complete the final assessment was of little benefit, and the study itself had provided them with little reward for their efforts. Future studies may achieve lower dropout rates if the control group were offered access to the simulator after the study period has ended.

8.21 and 8.22 Generalisability and Interpretation

Simulation based training has been used for years in the aviation industry, and to train military personnel in difficult or hazardous situations. Simulation based training is considered to be a crucial factor in the high degrees of safety achieved in commercial aviation. As can be seen in the literature review (Chapter 4) preliminary studies show simulation technology is beneficial in Orthopaedic training, to increase the total acquisition of surgical skills without risk to patients and without the time

and financial constraints of traditional surgical education (18, 59). There is also some evidence that there is transfer validity to in-vivo operating, and an improvement in performance when using a simulator model for training (62, 63).

In designing the study, the additional simulation based training was embedded within the trainees' teaching, and the Bioskills laboratory used for training was located between two ward areas, close to clinical areas to allow trainees unrestricted access to the simulator. It has been well documented that concern regarding simulation based methods of training among both trainees and trainers, is that lack of access to such equipment is an ongoing barrier to its use in everyday practice. Locating the equipment within a clinical area, and allowing trainees flexible access to the simulator during the six-month trial period may have contributed to the low numbers of withdrawals from the intervention arm of the study.

The decision to use the Procedural Based Assessment (PBA) score as the primary outcome measure is validated by the literature (18). The arthroscopy procedure-based assessment is now compulsory in orthopaedic training in the United Kingdom, and this type of global rating scale has been previously shown to be objective, valid, and to correlate well with movement analysis assessment. Adapting the score to provide a global rating scale for each procedure based-assessment comprises a more objective means of appraisal than the Orthopaedic Competence Assessment Project procedure-based assessment alone. The study by Howells *et al* (18) does appear to offer some evidence that it can also differentiate between trainees of differing ability.

This study has shown that Orthopaedic surgical trainees who have undertaken additional simulator based training alongside their traditional training demonstrate improved performance in the operating theatre in comparison with a trainees who did not have access to the additional training. We must be aware of the limitations

mentioned above, and the study is small, with some confounding factors. We would argue however that the results are significant and may in fact underestimate the benefits of this type of simulator training provided "in-situ" as part of Orthopaedic surgical training. We would suggest that in designing the curricula for Orthopaedic training the use of simulation based training should be considered. The type and duration of training may vary, as those who are already experienced in arthroscopic techniques may only have limited capacity to improve. In these cases simulation could be used to develop new or complex techniques before transferring to the operating theatre. This data should be considered in the form of a pilot study to encourage future work on this important topic.

CHAPTER NINE:

VIRTUAL LEARNING ENVIRONMENT QUANTITATIVE DATA ANALYSIS POST INTERVENTION

This chapter presents the findings from the analysis of the quantitative usage statistics from the Virtual Learning Environment in relation to the research objective four:

> **Objective Four**
>
> To ***assess the effectiveness*** of the eLearning activities in facilitating trainees to achieve the required outcomes

This chapter describes the quantitative data analysis of the use of the East Midlands Deanery (LETB) Virtual Learning Environments for Orthopaedic Postgraduate trainees following the interventions outlined in Chapter Seven. The quantitative and qualitative work performed and described in Chapters Five and Six, were designed to inform the development of the existing orthopaedic VLE / Training resource. A comprehensive analysis of both sets of data was also planned to determine how to move forward in the evolution of the resource. As described in Chapter Seven, user activity profiles and the quantitative learner analytics allowed us to consider the balance of activity types to include in the evolution of the eTOOL site.

As described in Chapter Five, participation and usage statistics were examined for the website by the lead researcher. Statistics for their usage were examined for the purposes of this project. Usage data was provided by the Moodle Website, and anonymised. Data on participant training grade, sex and age were available in an anonymised format. The usage is examined from September 2012 to September 2013, when the quantitative and qualitative work commenced and was ongoing by the lead researcher. Usage data was also examined from September 2013 to March

2014, the period immediately after the intervention and development of the website was introduced.

The following outcomes were assessed:

- Total number of posts by individual participant
- Total number of views by individual participant
- Domains visited and posted upon by individual participants
- Postings over time, including monthly and annual usage data.

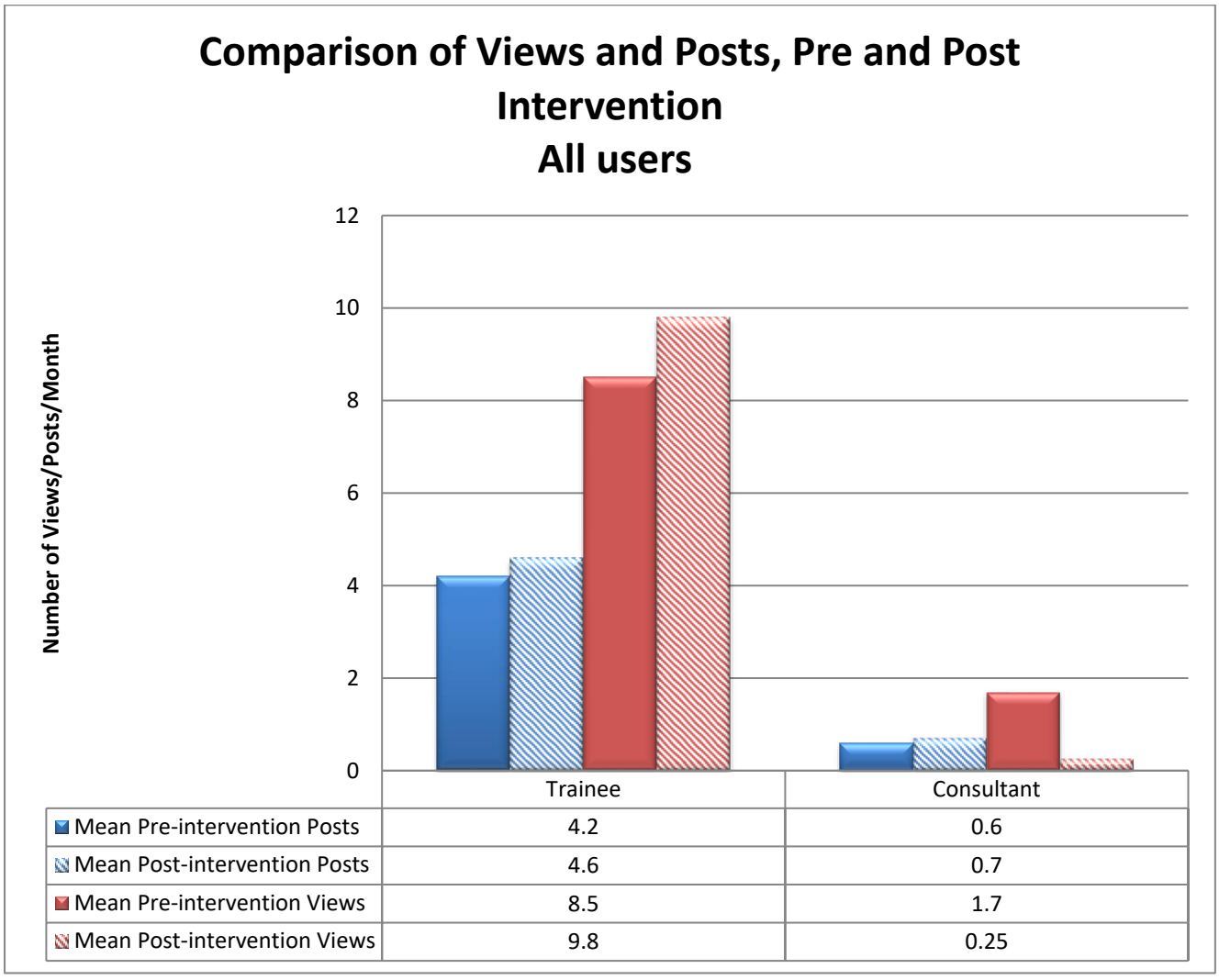
9.1 Total eTOOL activity

Usage statistics were examined from the website to determine the total number of views and posts across all users. At the initial evaluation, 43 Orthopaedic postgraduate trainees (including both core and specialist training grades), 62 Consultant Orthopaedic surgeons and 4 course leaders (a combination of three specialist trainees within the Orthopaedic department and the Orthopaedic Training Programme Director) had access to the website. In March 2014, at the final quantitative analysis, 62 Orthopaedic specialist trainees and 68 Consultant Orthopaedic surgeons now have access to the website. The additional number of specialist trainees includes a number of trainees who had completed their training within the region, but were still given access to the resource during their period of fellowship training. An additional Course Leader had been appointed, meaning there were now 5 course leaders (a combination of three specialist trainees within the Orthopaedic department, the Orthopaedic Training Programme Director, and a Consultant Orthopaedic Surgeon with a special interest in Education).

Overall usage remains low in the two largest groups; trainees and trainers. Course administrators are showing increased activity in comparison to the other two groups. Number of views is seen to exceed the number of posts in the trainee group and Course Administrators as before, but the number of posts now exceeds the

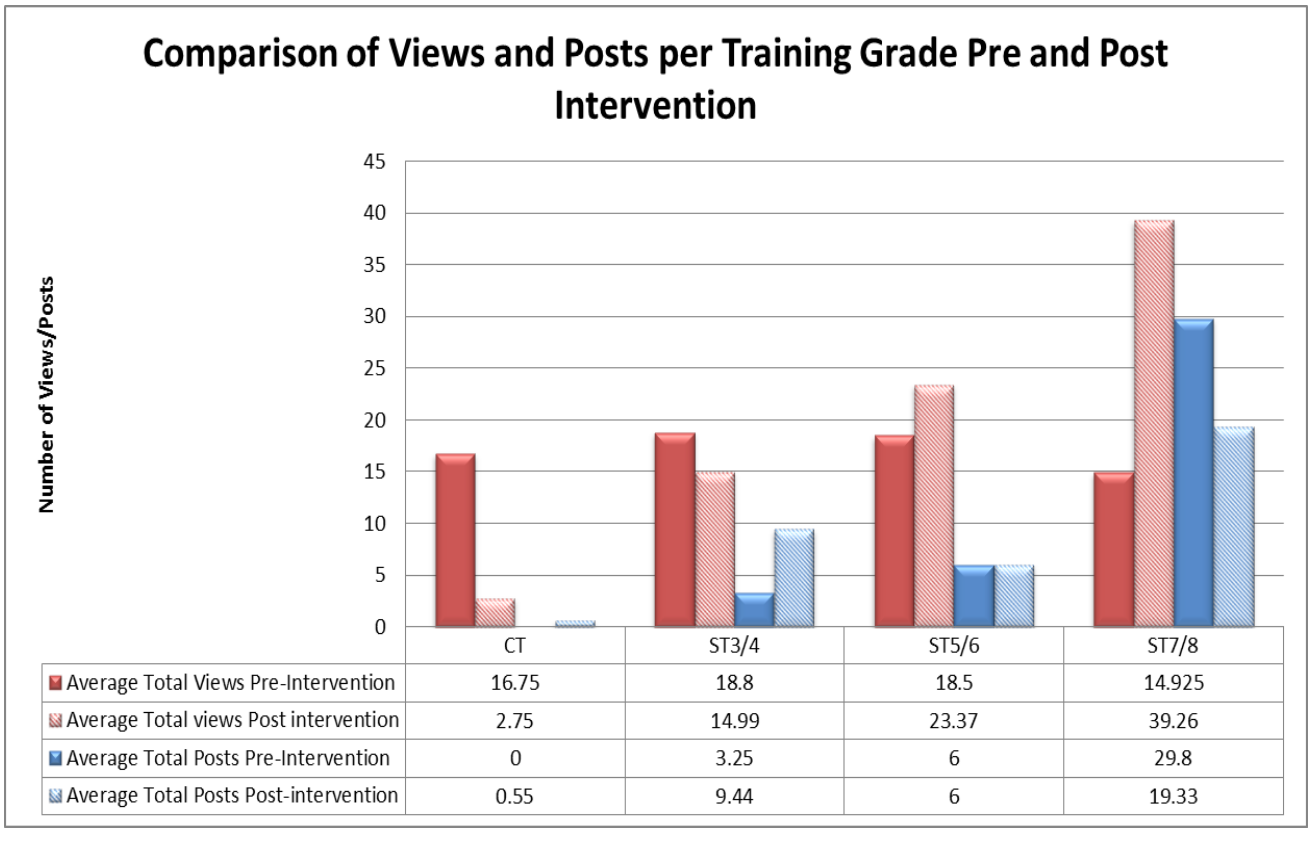
number of views in the Consultant group. Average number of views was 2.12 times the average number of posts in trainees, while average number of views was 2.26 times the average number of posts in the Course leaders, in comparison with 3.9 times the average number of posts prior to the intervention. Average number of posts in the Consultant group was 2.72 times the number of views. Prior to the intervention the number of *views* was 3.2 times the average number of *posts* in Consultants. Despite this, Consultant activity remains the lowest of the three groups overall.

The Graph below demonstrates the comparison of Total usage of the eTOOL site pre and post-intervention in Trainees and Consultant:



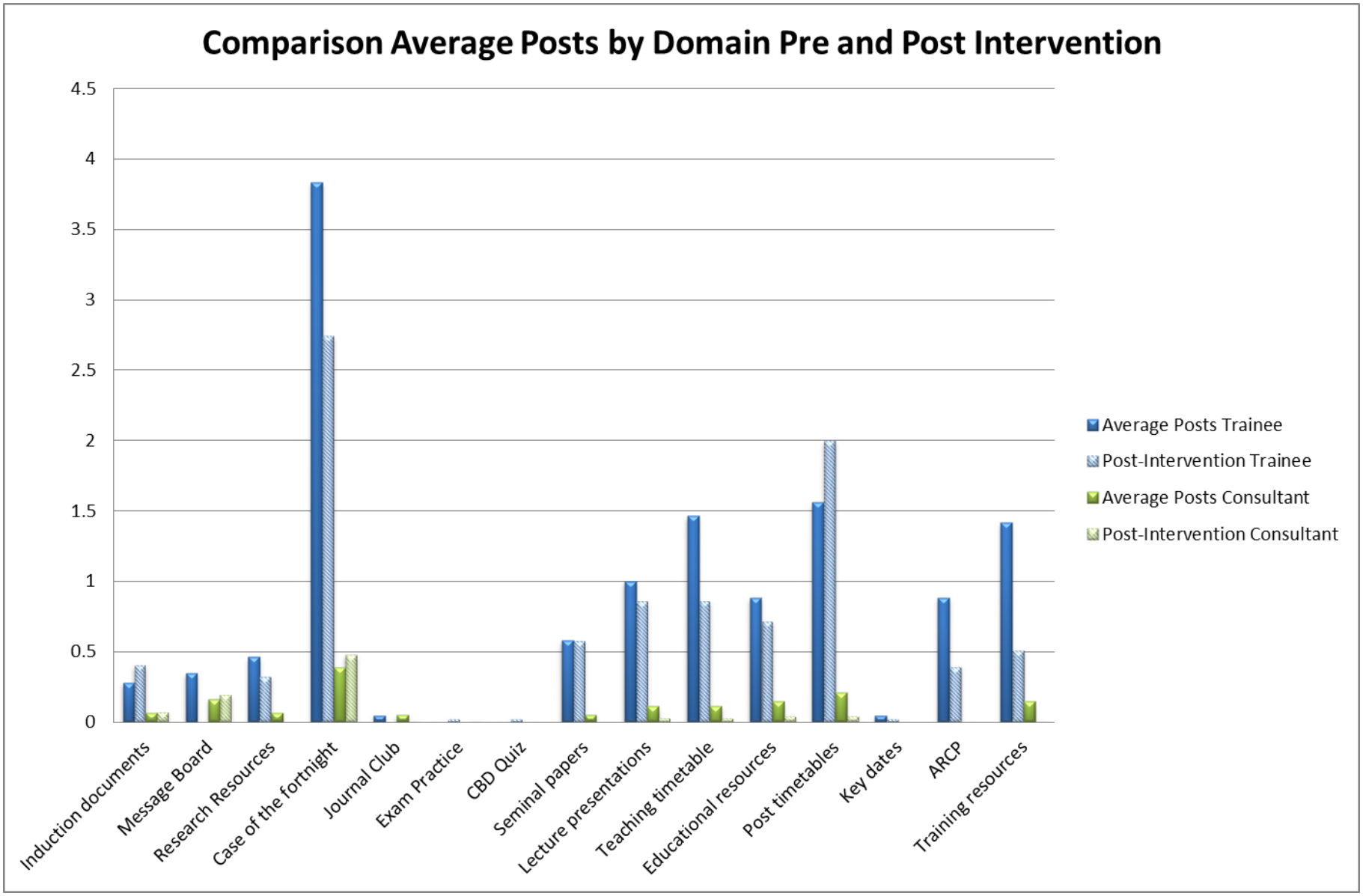
Overall usage has increased post-intervention. We can see that the number of Posts has increased in every group: trainees, trainers and the course administrators. The number of posts is 1.09 times greater than pre-intervention in the trainee group, 1.15 times greater in the consultant group, and 1.63 times greater in the course moderator group. The number of Views has increased in the trainee group: post-intervention the number of views is 1.15 times greater than pre-intervention. The number of Views has decreased in the Consultant group and the Course Moderator group. This may mean that these two groups are using the site more actively in comparison to the more passive role they played prior to the intervention.

A comparison of the Average number of views and posts seen pre and post intervention has been further examined by grade of training. Trainees have been grouped into junior trainees (ST3 and ST4), pre FRCS examination (ST5/6) and post FRCS examination (ST7/8). Views and posts seen pre and post intervention is shown in the Graph below:



	CT	ST3/4	ST5/6	ST7/8
Average Total Views Pre-Intervention	16.75	18.8	18.5	14.925
Average Total views Post intervention	2.75	14.99	23.37	39.26
Average Total Posts Pre-Intervention	0	3.25	6	29.8
Average Total Posts Post-intervention	0.55	9.44	6	19.33

We can see that in the same way as prior to the intervention, the number of views is higher than the number of posts in the more junior training grades. There is great variation in the number of views across each training grade, but as before, we see an increase in the number of posts as the grade of training increases. Post-intervention we are also seeing an increase in the number of posts made by the more junior training grades.


Comparison Average Posts by Domain Pre and Post Intervention
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Induction documents
Message Board
Research Resources
Case of the fortnight
Journal Club
Exam Practice
CBD Quiz
Seminal papers
Lecture presentations
Teaching timetable
Educational resources
Post timetables
Key dates
ARCP
Training resources
Average Posts Trainee
Post-Intervention Trainee
Average Posts Consultant
Post-Intervention Consultant

9.2 Domain usage across eTOOL

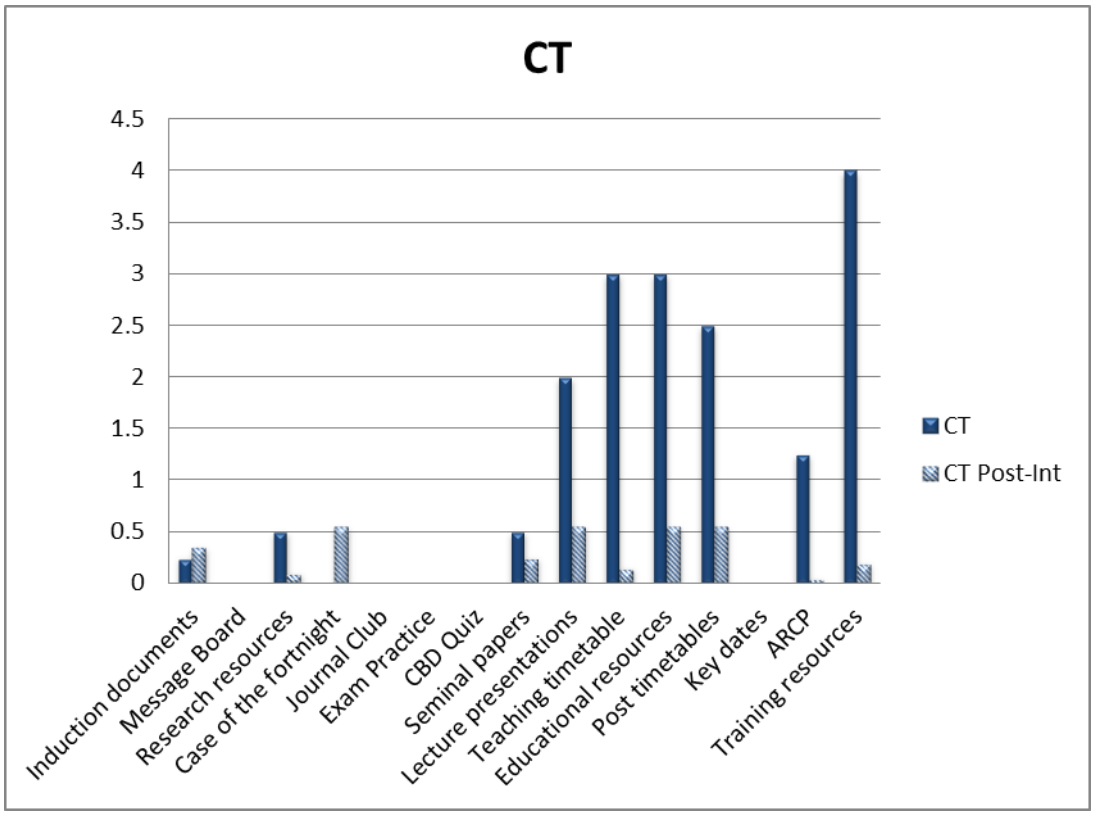
The domains visited on the site have been examined and are seen in the graph above. The area of the site most visited by trainees pre and post-intervention is the area "Case Based Discussions". Following the development of the site as described in chapter seven, two additional domains have been added to eTOOL: Exam practice (including revision tips and notes from senior trainees, and multiple-choice quizzes), and a quiz directly related to the Case Based Discussion to assess learning following the completion of the case discussion. There has been moderate activity in these new domains. The next most visited domains for trainees are the post timetables (i.e. job plans and rota details). Almost all other domains show activity by trainees including the teaching timetable, training resources, lecture presentations and other educational resources. There is no activity by trainees on the message board or in the journal club domains.

Prior to the intervention, there was very little activity by the consultant group in the majority of the domains. Post intervention there is increased activity seen in the Case Based discussions and on the message board by the Consultants. Consultant usage of other domains remains universally low.

9.2a Domain usage by Training Grade

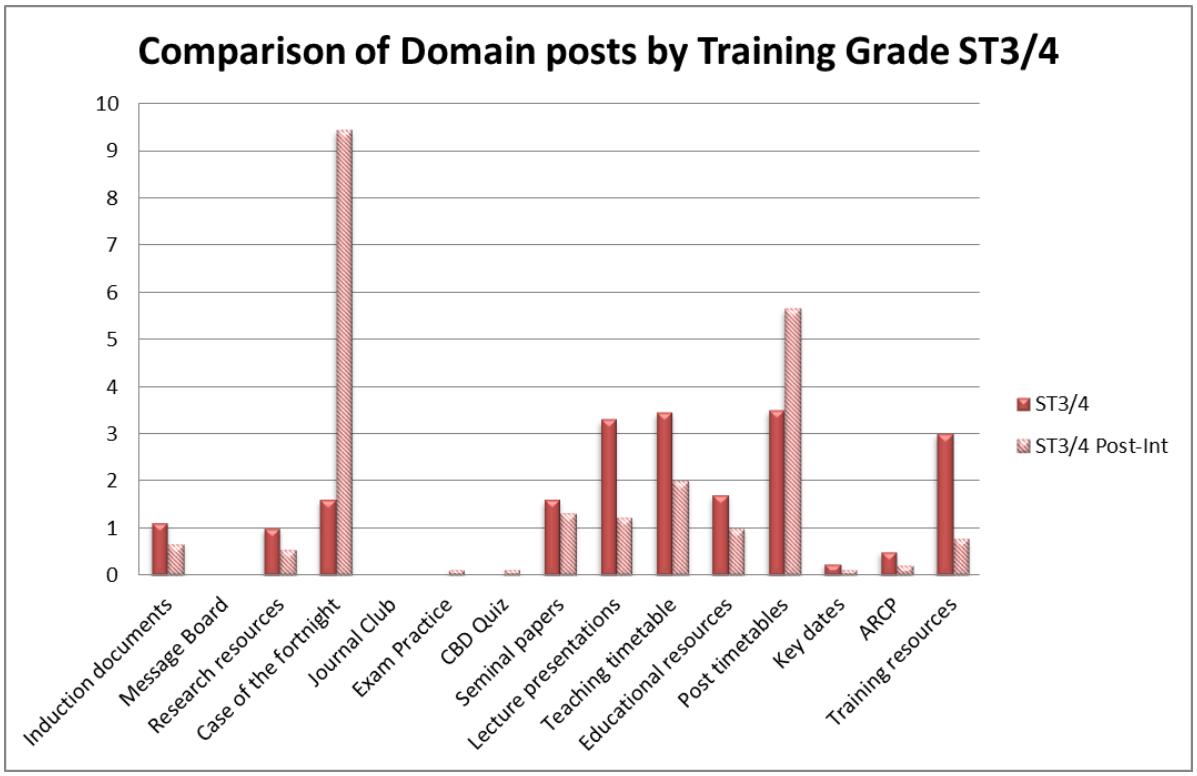
Domain usage by Training Grade is broken down for clarity into graphs representing the domain usage for trainees grouped into; junior trainees (ST3 and ST4), pre FRCS examination (ST5/6) and post FRCS examination (ST7/8), so that usage by these training grades can be examined and comparison can be made pre and post-intervention.

Core Trainees



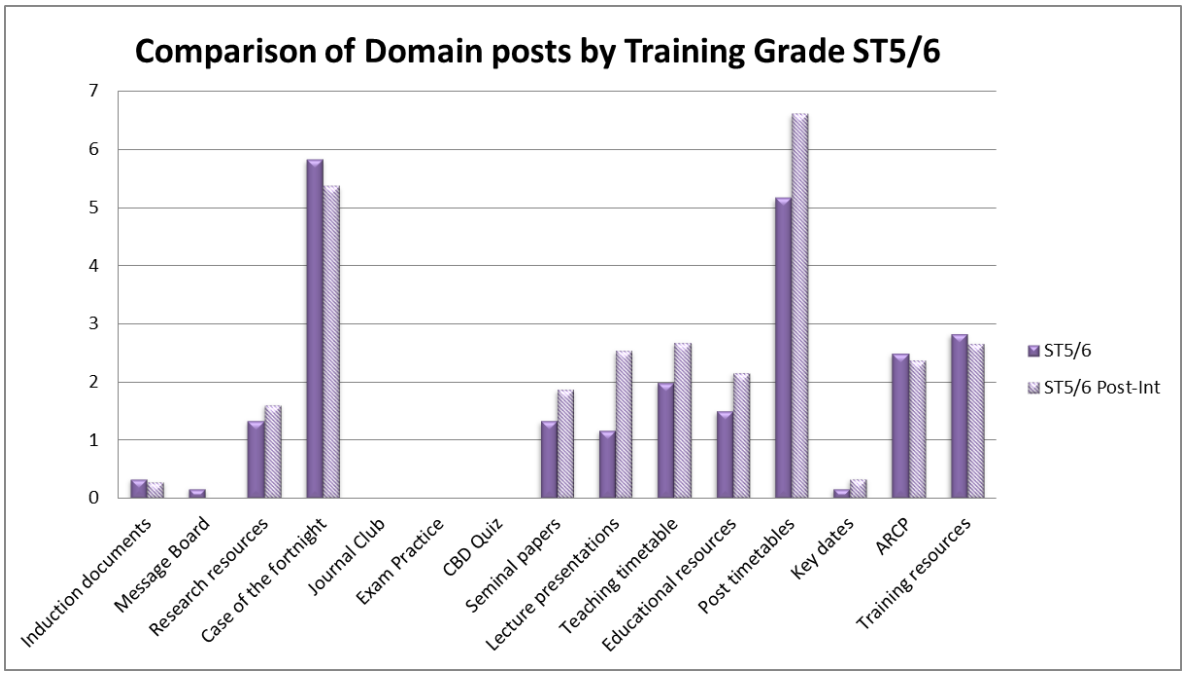
Core Trainees do not yet have a speciality training number, but work within the Orthopaedic department. Prior to the intervention we saw that the CTs access knowledge based resources (lecture presentations and educational resources) as well as administration based resources (e.g. teaching timetables) but did not participate in the case based discussions. Whilst their usage is primarily knowledge and administration based, we have seen that the CT trainees were able to participate in the case based discussion following the interventions and development of the site.

ST3/4 Trainees



Prior to the intervention there is very little activity by the ST3/4 trainees. Activity is seen primarily in the domains acting as a knowledge repository; lecture presentations and review of seminal papers. There was also activity in the administrative areas of post-timetables and Training resources. It was postulated that the new trainees starting at the ST3 grade may not yet feel confident to post on the site, or may not be adequately aware of what the site can offer. More structured learning activities were therefore targeted at the more junior trainees (ST3 and 4) to encourage them to use the resource to participate in discussions, activate prior knowledge, and build on existing conceptual knowledge frameworks. Post intervention significant increases are seen in the number of posts in the case based discussion by the junior trainees. Only the most senior ST8 trainees showed a greater number of posts in the CBD domain.

ST5/6 Trainees

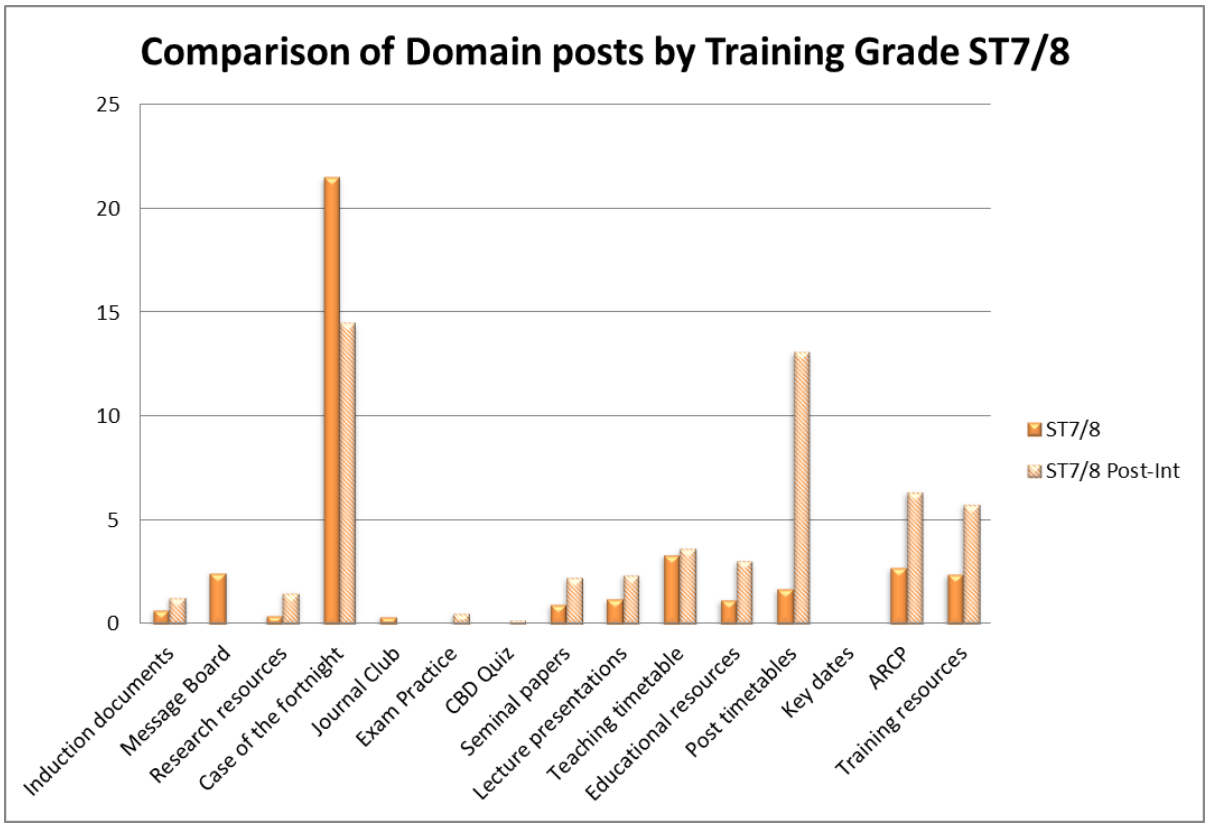


Pre intervention ST5/6 trainees show participation in the majority of the domains. Post intervention increased activity is seen in many domains. This group of trainees show increased activity in the knowledge based resources. They show widespread usage of almost all other domains, in particular the post timetables, training resources and documentation required for the ARCP (Annual Review of Competence Progression). There is a decrease in participation in the Case Based discussions, but their activity in this domain remains high overall.

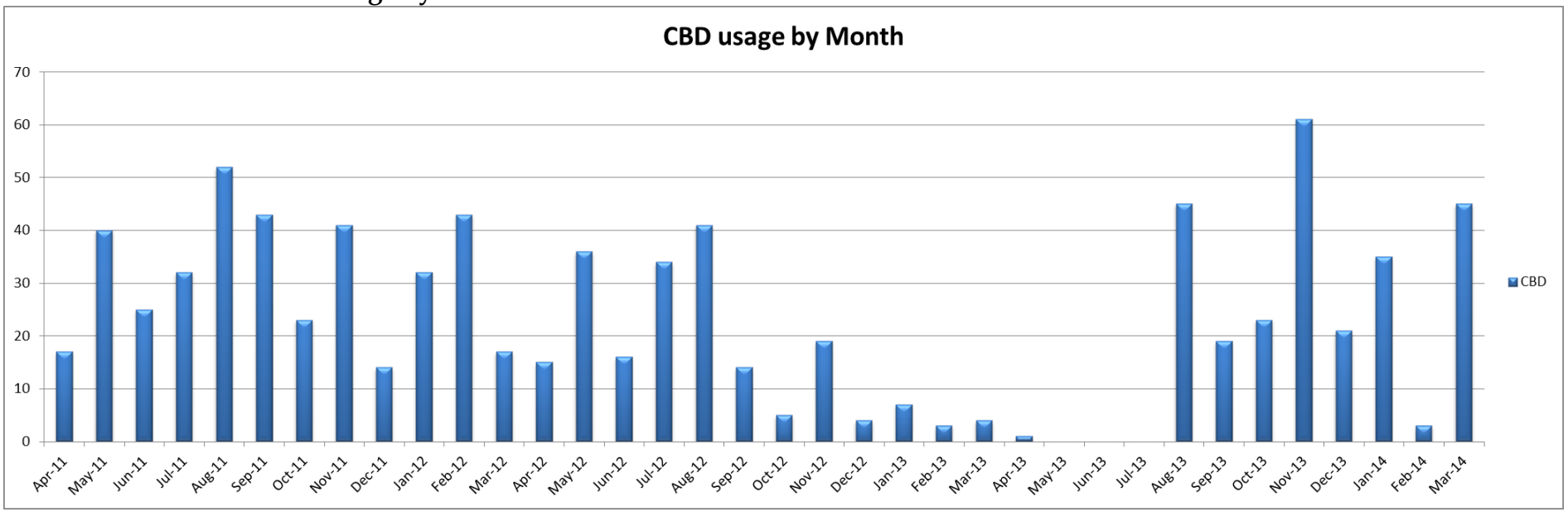
ST7/8 Trainees

Pre-intervention there is limited usage of all domains except the Case Based Discussions by the more senior trainees. Overall they have the highest activity of all the training groups. One suggestion is that the more senior trainees (ST7 and 8) may only need a trainer in the case based discussion scenarios to act as a guide to facilitate discussions as they may be more able to activate prior knowledge, and build on existing conceptual knowledge frameworks. Post intervention, the ST7/8 trainees show the greatest increase in usage of all training grades. Post intervention increased activity is seen in the majority of domains, including the lecture

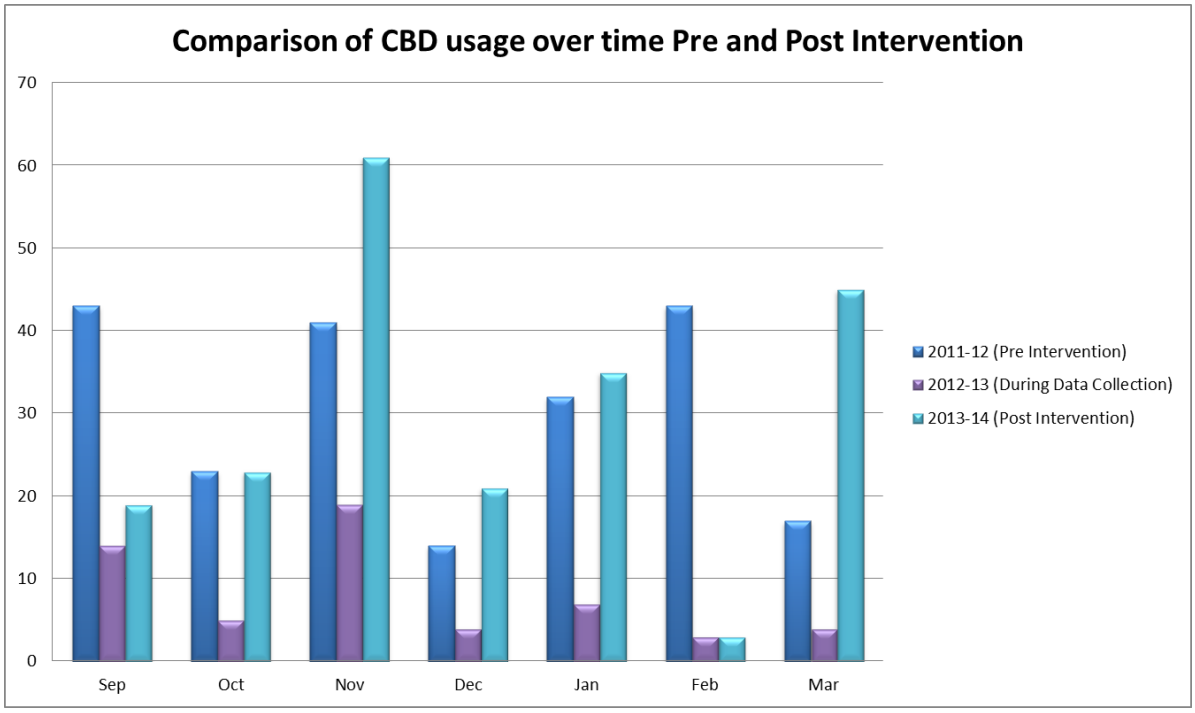
presentations, educational resources and the administrative areas, in particular post timetables. Post intervention there is a decrease in activity in the case based discussions, but their activity in this domain remains high overall.



9.3 Case Based Discussion usage by month



The Case Based Discussion domain has already been shown to be the most used domain across the VLE, with the greatest number of posts and views. Comparison of monthly activity is seen in the graph below. The six-month period after the development of eTOOL and intervention to the site is shown in comparison to the corresponding time period prior to any intervention in 2011/2012, and also the corresponding period in 2012/2013 while data collection was ongoing by the lead researcher.



Peaks of usage are seen in November 2013, January 2014 and March 2014. Increased usage is also seen in December 2013. Activity overall is slightly lower in the six-month period following the intervention with 213 total posts pre-intervention, and 2017 total posts in the CBD domain post-intervention. Minimal activity is seen in February 2014.

There is no activity in the months May to July 2013. During this time period the qualitative investigation was complete, and data analysis was ongoing by the lead researcher. This may correspond with this period of low activity on

the site perhaps due to limited online presence by the one of the primary course administrators. Usage then increases significantly in August 2013.

9.4 Additional Quantitative data review

During the writing up period additional data on site usage was collected to add to determine if meaningful activity remains in place for this group of trainees and trainers. This data is not presented graphically due to the small numbers obtained.

The site only stores activity logs and site usage for the preceding 12 month period. Therefore data on course participation is only available from the 19th May 2017, up to the 15th May 2018 when the author conducted a review of the resource. No additional data is available from the period March 2014 to May 2017.

In the 12 months from May 2017 to May 2018, there were a total of 22 visits to the site. One visit to the site from a trainee, two from a course leader, and 19 from a single consultant. No other trainees or teachers visited the site. The trainee logged on to the resource only, and viewed the home page, but did not access any of the resources. The course leader (not the author) logged into the resource once, and then accessed documents required for the annual appraisal process (ARCP). No other activity was seen by course leaders in the 12 month period.

The consultant who accessed the site, did so on three separate occasions. Initially in July 2017, to access the message board, where they announced the creation of a new "case based discussion" and associated resources in the form of a video created and stored in the Educational resources domain. The

consultant then accessed the site a month later in August 2017, to view the videos and case based discussion. There is no activity by trainees in response to the creation of the case based discussion.

The last activity on the site was Feb 2018, until the site was accessed by the author in May 2018 to view the course participation and activity logs.

9.5 Summary

This chapter presents the findings from the analysis of the quantitative usage statistics from the Virtual Learning Environment in relation to the research objective four:

> **Objective Four**
>
> To ***assess the effectiveness*** of the eLearning activities in facilitating trainees to achieve the required outcomes

Overall usage has increased post-intervention. The number of Posts has increased in every group: trainees, trainers and the course administrators. The number of views is much higher than the number of postings across all groups except the Consultant group, where the number of posts is higher post intervention. This may mean that the consultant group is using the site more actively in comparison to the more passive role they played prior to the intervention.

The Case Based Discussion area remains the most active domain on the site; however the ST4 and ST8 trainees are now the most active group on the site, with significantly more posts than all the other training grades. Decreased usage is seen particularly in the ST7 trainees. The site is used across the year, but with peaks in November 2013 and March 2014. Increased usage is also

seen in October 2013. Unlike the period prior to the intervention, these peaks cannot be said to correspond with the dates for the Orthopaedic Speciality examination (FRCS Tr. & Orth.) or with the start of a new training post, which occurs every August and February.

We have not been able to correlate the increase in engagement on the site with ISCP based learning outcomes, so although we can state that the engagement has increased following the intervention, but we do not know whether this has increased their output of the intended learning outcomes with, for example, increased output of CBDs on their ISCP portfolio.

There have obviously been significant developments in available resources and the usage by trainees of online resources and applications for study outside the clinical working environment. The 2017/2018 review of the activity logs suggest that there has been a sharp decline in the usage of the VLE resource. Repeat qualitative analysis would be useful to identify causative factors in decline in participation within the groups, and whether additional or alternative resources may be preferable to existing trainees and consultants. From the literature review (Chapter 3) we know that facilitation is an important factor in student participation. In the study by Nathoo *et al* (37) students reported that online interaction was most effective when the faculty tutor actively facilitated discussion. But in the case based discussion initiated by a consultant on the site in July 2017, there remained no student participation. Why? The paper by Munoz *et al* (28) suggests current e-Learning systems are inadequate to support the level of interaction, personalization and engagement demanded by the users. Again, this is supported by studies by Halbert *et al* (32) and De Leng *et al* (33). Halbert's study found that of the students who utilized the online materials, 57% responded that the online material ''rarely'' or ''never'' replaced the course

materials, while De Leng's study also found that students gave a significantly negative judgement of the stimulation of interaction during self-study. They found that the discussion board did not stimulate distance discussions in between face-to-face group meetings. Do the trainees prefer the face to face interaction of the weekly teaching sessions provided by the training programme? It may that the VLE is already being replaced by newer forms of online interaction, including social media, Twitter, Whatsapp and MOOCs as the preferred form of online interaction by the current trainees. Further reflection on this will be undertaken in the discussion chapter.

CHAPTER TEN:

DISCUSSION

In this chapter, I will critically examine the research findings in the light of the previous chapters, and determine what has been learnt. I will consider the role and context of technology enhanced learning and simulation, the limitations of the work, and important areas for future work which have emerged from the research.

We must consider the Primary research question and aims of the study:

The Primary Research Hypothesis states:

To what extent can eLearning and simulation-based learning tasks actively engage orthopaedic trainees to achieve their educational outcomes?

The aim of the study

The aim of this project was to *investigate the use of eLearning and simulation-based training to facilitate the achievement of improved learning outcomes for orthopaedic trainees.*

The objectives of the study are:

5. To critically explore the use of existing technology enhanced learning resources, in particular, Virtual Learning Environments and simulation based technologies. This has two sub- objectives:
    a. To determine where we are now in the availability and scope of technology enhanced learning resources.
    b. To investigate methods of using these resources that have been successful in facilitating surgical trainees to improve learning outcomes

6. To evaluate the level of engagement among orthopaedic trainees with existing resources, as well as the newly developed eLearning and simulation-based learning activities.
7. To critically design and develop eLearning and simulation-based learning tasks using:
    a. A Virtual Learning Environment (VLE) platform
    b. An Arthroscopy simulator

8. To assess the effectiveness of the eLearning and simulation-based learning activities in facilitating trainees to achieve required outcomes.

I will consider the results of the quantitative and qualitative research into the Virtual Learning Environment, and the randomised controlled trial into the use of Virtual Reality arthroscopy simulation.

10.1 Technology Enhanced learning in context

As mentioned in Chapter 1, trainees receive less operative exposure and experience than prior to the introduction of the European Working Time Directive (EWTD). It is now expected that after the introduction of "Modernising Medical Careers" (MMC), specialist registrar training will be reduced to 6,000 hours over 5 – 7 years. These changes represent an 80% reduction in available training hours for specialty trainees before they are considered ready for appointment as Consultants. Although it has been said that the intensity of the work has increased when on duty, due to a decrease in the number of doctors available at any one time, it can be argued that the increase in intensity leads to further reduction in the time for experiential learning, less opportunity for reflection and interaction, and reduced

opportunities for shared learning within the medical team (14). Shift patterns have been described by many as being detrimental to training, leading to a reduction in in-service learning and attendance at formal educational sessions, as well as difficulty in obtaining study leave to attend courses (15). Trainees report that the result of this, is that Orthopaedic Trainees often have scant knowledge of some areas of the curriculum, and they may qualify for the FRCS Tr. & Orth. Examination without having witnessed multiple presentations of some key orthopaedic conditions.

E-learning has become a fixed feature within Professional Education, and has been prioritised by Universities around the world, as well as the Royal College of Surgeons, and the British Orthopaedic Association (13, 51, 53). Trainees and medical students are now familiar with virtual learning environments and expect similar provision for their postgraduate studies (98). Technology enhanced learning and the web affords a huge opportunity for training. The sharing of good (and bad) training experiences, podcasts and webinars offer the ability to discuss conditions that one may not have the opportunity to see locally. The scattering of trainees across on-call rotas, and the differing geography of training rotations within the UK make online learning more attractive (99). Technology-enhanced practice is also likely to encompass a wide spectrum of activities: from supporting traditional practice to blended learning (the combination of traditional and e-learning practices) to learning that is delivered entirely online. As a result, the application of this technology will not be focused on any one mode of delivery – for example, distance or remote learning – but will be part of the mainstream provision for all learners.

Technology adds value to learning by enabling:

- Connectivity to information and to others

- 24/7 access to learning resources
- Greater choice over the time, place and pace of study
- Knowledge-sharing and co-authoring across multiple locations
- Opportunities for reflection and planning in personal learning spaces
- Rapid feedback on formative assessments
- More active learning by means of interactive technologies and multimedia resources
- Participation in communities of knowledge, inquiry and learning

The technology-enabled lifestyles of 21st century learners ensure that learning can also be accessed via their own personal choice of tools, ranging from mobile phones, MP3 players and handheld games consoles, to free online chat and telephony, social networking and media-sharing websites. Designers of learning in a digital age must therefore recognise that personal, informal technologies are likely to play a role in learners' strategies for learning; learners with specific learning needs and disabilities may even depend on being able to access familiar software and hardware without which their ability to learn is reduced. Combining technology-enhanced options with the best of established practice and the practitioner has greater capacity to create meaningful and transformative learning experiences (48, 51).

10.2 The role of Technology Enhanced Learning in Orthopaedic Postgraduate Training

Our local Virtual Learning environment was designed using Moodle software. As described in Chapter 3 based on the findings from the literature

review, we chose to use a Moodle as our local VLA platform. The platform was also in use for other medical postgraduate specialties within the University Hospitals of Leicester NHS Trust. The literature review examined the current use of this and other platforms in current use. Whilst none of the papers examined show a significant difference in a pass/fail grade while using a VLE, all the papers show a significant improvement in knowledge when using a platform such as Moodle. We therefore felt that there would be a place within the postgraduate orthopaedic training curriculum for a Virtual Learning Environment.

The initial learner analytics (Chapter 5) showed that junior trainees (ST3 and 4) were only using the resource to acquire knowledge and for administrative purposes (meaning to access post timetables and important dates etc.) but the more senior trainees (ST6, 7 and 8) were able to participate actively in the case based discussion scenarios. This would suggest that they were behaving in accordance with the constructivist theories and theories of adult learning, based primarily on the work by Piaget, Vygotsky and Bruner. They were able to use the trainers as a guide to facilitate discussions, being able to activate prior knowledge, and build on existing conceptual knowledge frameworks.

The qualitative work allowed us to explore in detail the reasons behind the trainee usage of the site, and the role it played in their current training. In order to engage with the resource, it was clear tasks must be *credible* and *relevant*. This concept was prevalent throughout the trainee focus groups when talking about the VLE as a whole, and in particular the case based discussions. A reflective approach to the online activities would help this become a cycle of performance and learning. This is seen in the work

completed in the Qualitative work completed in Chapter 6. When considering the role of the VLE within training, we must ask whether the online case based discussion problems are authentic and relevant to the curriculum, and if they assess the skills that have been taught - do they match our Intended Learning Objectives (ILOs)? Work places based assessments, including the CBD (Case Based Discussion), PBA (Procedural Based Assessment), CEX (Clinical Examination Exercise) and Mini-PAT (Peer Assessment Tool) are tools used for continuous assessment at all levels by Orthopaedic postgraduate trainees. These allow competence and also under-performance to be documented (10). Although these tools have great versatility, from my own experience, and the comments from trainees during the focus groups (see Chapter 6), they depend on the relationship and experiences of the trainer and trainee working together to be able to use it to its best effect. Trainees are required to keep records of reflective practice in their portfolio and log book of surgical procedures, and these tools encourage that practice. It is hoped that reflection will be used to evaluate failing trainees, to extend good trainees, and to develop evaluation skills. These assessment tools are described as having no value on their own – except for giving feedback, and should therefore be thought of as "formative". *En mass* in a portfolio with other evidence however, they will have summative value. However, following the recent high profile case involving Dr Bawa-Garba, there has been increasing concern regarding the use of reflection as a tool by all specialties of the medical profession. The GMC's core guidance for doctors is contained in 'Good Medical Practice'. This stipulates, at paragraph 22: "You must take part in systems of quality assurance and quality improvement to promote patient safety. This includes…regularly reflecting on your standards of practice and the care you provide" (12). The GMC states that the focus on reflection should be on learning, but following the Dr Bawa-Garba case, some medical professionals have been left feeling less than accepting of the

reflective process and the use of the e-portfolio as a tool for learning. At the recent LMC Conference, Liverpool, March 2018, representatives of General Practitioners called on the BMA to advise GPs to "disengage from written reflection in both appraisal and revalidation". In a letter to the editor of the BMJ, medical students wrote that "it is disconcerting to think that reflective practice, a valuable tool for trainee development, could be used in a court setting. We feel uneasy about a future that impedes reflective practice and have no doubt that doctors will be more conscious about what is included in their portfolio in the future. We fear such practice may also extend into medical schools, where students are cautious about reflecting openly on mistakes. This may not only impact a student's educational development, but may further act as a negative driver against ensuring probity in light of errors in practice" (100, 101).

The GMC has attempted to allay the concerns with a factsheet released regarding the Bawa-Garba case, which states that "at no time during Dr Bawa-Garba's criminal trial was her e-portfolio reflection statement presented to the court or jury as evidence". They have also stated that "The GMC does not demand to see these in fitness to practise cases, but the doctor can choose to share them if they feel they demonstrate insight. In Dr Bawa-Garba's case, some personal reflections – though not the e-portfolio statement – was shared with the panel to show her remediation efforts" (102). It may now be difficult to encourage the students to use these to reflect and to plan further learning targets, with a continuing cycle of performance and learning, but one must be mindful not only of the GMC requirements but also that of statute under the duty of candour, which prescribes it an offence if this obligation is not discharged (10-13, 53).

Both the trainees and trainers had stressed the importance of mapping the case based discussions to the curriculum in the focus groups and one-on-one interviews (see Chapter 6). In particular the critical conditions outlined in the new syllabus, published August 2013, and therefore the activities online must map not only to the syllabus but utilise the relevant assessment tools. Trainees are becoming much more reliant on text based descriptions of many orthopaedic conditions that their predecessors may have encountered frequently in their clinical practice. The critical conditions mentioned above have been highlighted in the syllabus as they can be associated with significant risk to patients if not identified early and so require focused learning and assessment. But many of the conditions are also rare, and many trainees may not have encountered them during their training. By continually developing an evolving set of rich online resources to help trainees with their study we can provide e-learning resources that address these issues (10).

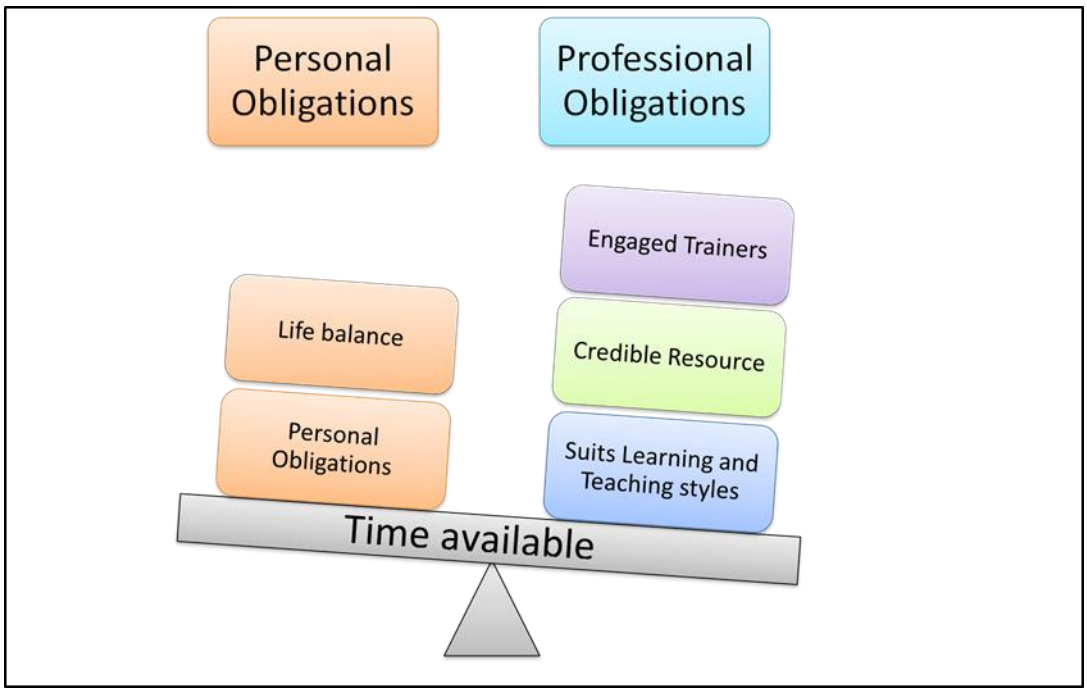
10.3 To what extent can eLearning learning tasks actively engage orthopaedic trainees to achieve their educational outcomes?

The first postings from eTOOL were considered extremely promising. The first case discussion went live on Wednesday 14th August 2013 at 9.19am and ran until Thursday 5th September, generating 63 posts by 11 trainees during that time. Anecdotally (without formal learner analytics), this far outstrips any previous case postings by over 100%, as the highest number of posts recorded for any previous case was 30. However, more detailed learner analytics (see Chapter 7) did not see this level of engagement sustained among trainees. Although the overall usage has increased post intervention, the usage by trainees and trainers remains low. Where the interventions were structured and targeted appropriately there has been some success. More learning activities were targeted at junior trainees (ST3 and 4) to encourage

them to use the resource to participate in discussions, activate prior knowledge, and build on existing conceptual knowledge frameworks. Post intervention significant increases are seen in the number of posts in the Case Based Discussion by the junior trainees. The Case Based Discussion area remains the most active domain on the site; however decreased usage is seen particularly in the ST7 trainees, who were previously the most active group of trainees within the domain.

During the writing up period additional data on site usage was collected. In the 12 months from May 2017 to May 2018, there were a total of 22 visits to the site. One visit to the site from a trainee, two from a course leader, and 19 from a single consultant. No other trainees or teachers visited the site. There have obviously been significant developments in available resources and the usage by trainees of online resources and applications for study outside the clinical working environment. This 2017/2018 review of the activity logs suggest that there has been a sharp decline in the usage of the VLE resource (Please see Chapter 9, section 9.4 Additional Quantitative data review).

So why is the trainee engagement not sustained? Why has the development not perhaps been as successful as we hoped? The diagram below represents the themes defined and interpreted from the qualitative study (Chapter 6). This may give ideas as to why the trainees might not be engaged with the resource in the way we might have expected:



As we have already explored, trainees have limited time available, and will need to prioritise the time they have for training and for personal obligations. In contrast to Knowles principles of adult learning, trainees appeared to be primarily motivated by *external* drives for learning; competencies set by external bodies (The Royal College of Surgeons as an example); the need to pass specialty examinations. While Knowles suggests that adult learners should be involved in planning and curricular content, and in formulating their own learning objectives, the trainees express a wish for that curriculum and objectives to be clearly defined, and the pathway to reach those objectives equally clearly defined, with a structure that can be followed in an almost uniform manner. Are the external drives for learning so strong, that the trainees are not able to participate in additional activities that are more motivated by the internal drives for learning? The ability to achieve competencies required in the Case Based discussion by including the critical conditions may explain why this is the most popular area. The fact that the trainers have also been more involved in the case based discussion; with more posts following the intervention may also explain the success of this area.

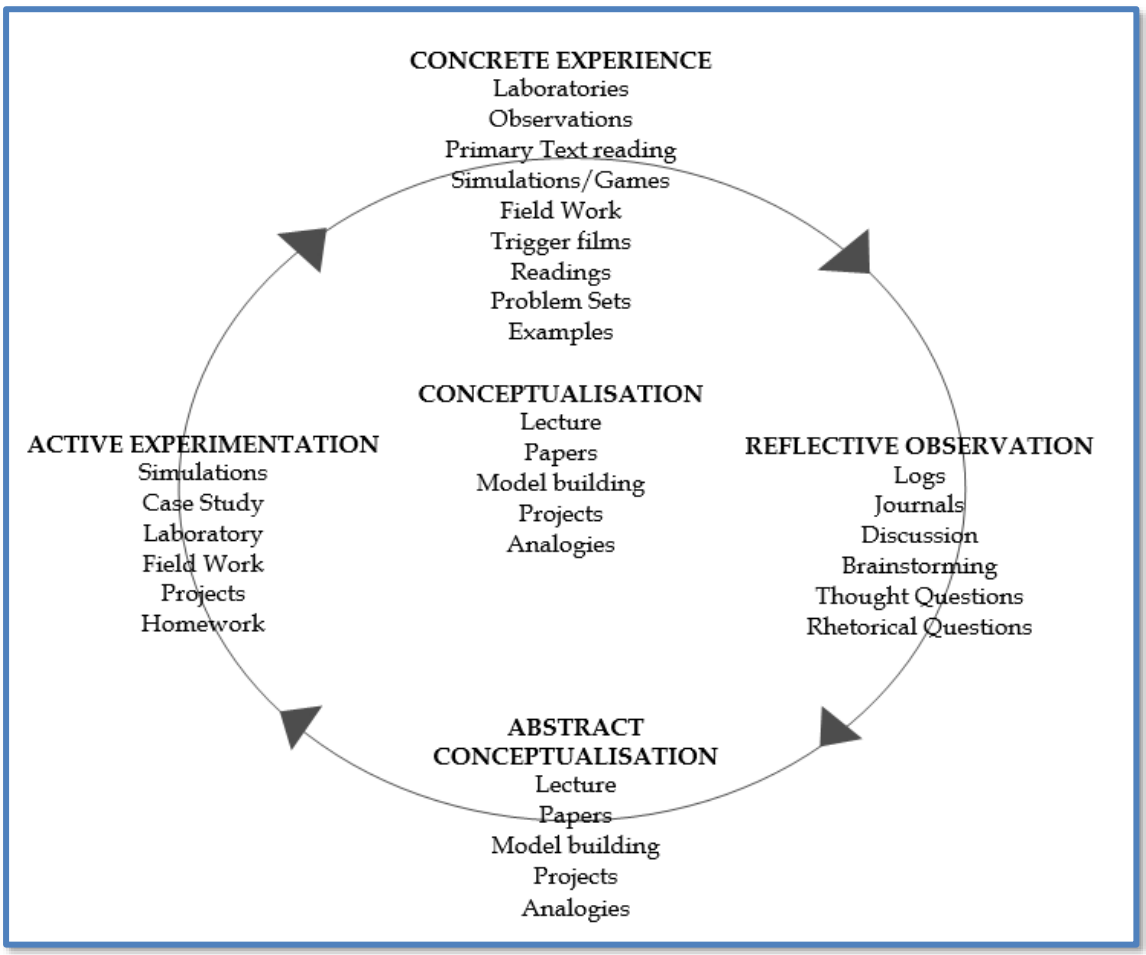
One might argue that this fulfills the criteria for *credibility* and *engaged trainer*, which were key factors in engaging trainees in the resource.

From the literature review (Chapter 3) we know that facilitation is an important factor in student participation. In the study by Nathoo *et al* (37), students reported that online interaction was most effective when the faculty tutor actively facilitated discussion. But in the case based discussion initiated by a consultant on the site in July 2017, there remained no student participation. Why? The paper by Munoz *et al* (28) suggests current e-Learning systems are inadequate to support the level of interaction, personalization and engagement demanded by the users. It may be that the VLE is already being replaced by newer forms of online interaction, including social media, Twitter, Whatsapp and MOOCs as the preferred form of online interaction by the current trainees.

As mentioned above, the credibility and relevance of the resource clearly links to the assessment tools used by trainees. We must also consider the learning styles of the trainees. Are the learning styles of trainees already established by the time they come to a postgraduate training programme? Are surgical trainees less likely to engage in an online resource as they are more active learners? The idea that a surgical trainee, whose training is primarily based on a practical skill, may therefore be an "active learner" is an interesting one.

Much of learning within the clinical setting is necessarily based on experience. The most widespread theory of learning from experience is associated with David Kolb (1984). Kolb suggested that learners must be able to immerse in new experiences which require reflective skills and multiple views of observation. Learners must then be able to conceptualize the observations and the experiences by integrating them into theories, and finally they must

be able to use these theories for making decisions and solving problems. Kolb described effective learners with these four abilities; Concrete Experience, Reflective Observation, Abstract Conceptualization and Active Experimentation.



Kolb suggested that learners must be able to immerse in new experiences which require reflective skills and multiple views of observation. Our learning style is therefore a product of these decisions:

	Active Experimentation (Doing)	Reflective Observation (Watching)
Concrete Experience (Feeling)	Accommodating (CE/AE)	Diverging (CE/RO)
Abstract Conceptualization (Thinking)	Converging (AC/AE)	Assimilating (AC/RO)

Learners must then be able to conceptualize the observations and the experiences by integrating them into theories, and finally they must be able to use these theories for making decisions and solving problems. As teachers, the most effective application of the model is to use it to ensure that teaching activities give full value to each stage of the process.

There are a number of studies in the literature that support the idea that surgeons, and in particular Orthopaedic surgeons are "active" learners. Richard *et al* (103) assessed the learning styles of orthopedic residents, faculty, and applicants at an East-coast academic program. The applicant and resident groups demonstrated a high tendency toward Active Experimentation followed by Abstract Conceptualization. Their learning style primarily involved problem solving and decision making, with the practical application of ideas and the use of hypothetical-deductive reasoning. Interestingly, learning through AE decreased with age, whereas learning through AC increased. Work by Caulley *et al* (104) also correlates with these findings. They found that Orthopaedic Residents demonstrated a high tendency toward the learning skill of abstract conceptualization combined

with active experimentation, and a transition from action-oriented to more reflective learning style with age and postgraduate education.

As we have said, the introduction of the European Working Time Directive (EWTD) may represent an 80% reduction in available training hours for specialty trainees before they are considered ready for appointment as Consultants. Although it has been said that the intensity of the work has increased when on duty, due to a decrease in the number of doctors available at any one time, it can be argued that the increase in intensity leads to further reduction in the time for experiential learning, less opportunity for reflection and interaction, and reduced opportunities for shared learning within the medical team (14). Does this have an impact on the learning styles of trainees which might make them more open to online learning resources available for surgical training? The literature suggests that this may not entirely be the case. Work from the United States by Quillin *et al* (105) following the implementation of duty hour reform suggests that prior to reforms, the predominant resident learning style was converging. A style where an individual relies on their own ideas and theories to find solutions to problems and are less concerned with interpersonal skills (see tables above). There was a significant change in resident learning styles after the reduction in working hours, with fewer residents learning via the converging style and more having the accommodating style. Although elements of these styles are similar, accommodators prefer to work in teams and rely more heavily on others for information rather than their own analysis to solve problems.

Work by Costa *et al* (98) also suggests that interactive discussion is preferred among undergraduates in Trauma and Orthopaedics. Undergraduate students preferred interactive discussion in comparison with more didactic

lectures, and those who experienced the discussion group performed better is assessment, as well showing improved retention of knowledge.

This might explain why Orthopaedic trainees studies are less engaged with a resource like eTOOL. eTOOL and other electronic learning management systems have been said to suit learners who are more visual or reflective learners. Studies show that the e-books, lecture notes, videos and tables are helpful in learning for these kinds of students, with more organized learning methods and activities such as e-books and forum conversations useful for reflective learners. A more active learning style preferred by trainees would explain why the CBD area of eTOOL was the most active domain on the site. Lack of engagement by faculty would also correlate with the decline in usage. From the literature review (Chapter 3) we know that facilitation is an important factor in student participation. In the study by Nathoo *et al* (37) students reported that online interaction was most effective when the faculty tutor actively facilitated discussion. The paper by Munoz *et al* (28) suggests current e-Learning systems are inadequate to support the level of interaction, personalization and engagement demanded by the users. Literature also suggests that the faculty may also prefer other methods of teaching. The studies by Richard *et al* (103) and Caulley *et al* (104) suggest learning through AE decreased with age, whereas learning through AC increased. There appears to be a transition from action-oriented to more reflective learning style with age and postgraduate education. The study by Jack *et al* (106) assessed residents, faculty and medical students. Surgical residents preferred active learning, whereas faculty preferred reflective learning. Faculty appeared to prefer teacher-centered, role-modeling instruction. If there is such a mis-match in learning and teaching styles, are we then doomed to fail online? In the qualitative study by Guan *et al* (34) the authors felt that online

learning "failures tend to occur at the social level far more than they do at the technical level".

10.4 To what extent can simulation-based learning tasks actively engage orthopaedic trainees to achieve their educational outcomes?

The aim of this study was to investigate the effect of virtual reality simulator training on the ability of surgical trainees to perform diagnostic arthroscopy of the knee. Effective use of simulation can help to lessen the impact of reduced hours and shift working by accelerating the acquisition of technical skills and transferring learning away from the patient. There are numerous examples of successful use of simulation equipment ranging from simple procedural skills such as suturing to high fidelity team-based training. These technologies allow trainees to develop a level of competency in operational skills. While the VLE project aims to assess how we can utilise technology assisted learning to improve clinical reasoning and knowledge, this looks specifically at the other key aspect of surgical training: technical skill. The primary outcome measure was the difference in performance in the operating theatre between the simulator-trained intervention group and the control group. Assessment was made using the Procedural Based Assessment (PBA) tool for diagnostic knee arthroscopy. This tool gives a maximum score of 60 points. The groups were matched in terms of demographics and previous surgical experience.

The simulator-trained group were seen to significantly outscore the control group. Analysis of the performance in the operating theatre of both groups using the Procedural Based Assessment (PBA) tool for diagnostic knee arthroscopy showed that the performance of the simulator-trained intervention group improved significantly. The simulator group were seen to

show a significant increase in the PBA score in comparison to the control group ($p<0.0001$).

In designing the study, the additional simulation based training was embedded within the trainees' teaching, and the Bioskills laboratory used for training was located between two ward areas, close to clinical areas to allow trainees unrestricted access to the simulator. It has been well documented that concern regarding simulation based methods of training among both trainees and trainers, is that lack of access to such equipment is an ongoing barrier to its use in everyday practice (28, 32, 35, 39). Locating the equipment within a clinical area, and allowing trainees flexible access to the simulator during the six-month trial period may have contributed to the low numbers of withdrawals from the intervention arm of the study. It is interesting that lower dropout rates were seen in the simulator training group, which might be seen as more demanding for the trainees, requiring a substantial commitment of time in addition to traditional training. The control group did not receive any additional training with the simulator, and may have had higher dropout rates due to lack of interest in the study, apathy or frustration at not being able to access a resource that might be perceived as being helpful to their training.

As discussed above, the higher level of engagement in a practical skill, rather than an online learning resource like eTOOL may be explained by a predominance for more active learning styles in Orthopaedic trainees (103-105). The qualitative work suggests that credibility and relevance are important to trainees, and as "Knee Arthroscopy & simple arthroscopic procedures" remains one of the primary PBAs, and is also one of the procedures where a minimum number is required for certification approval, and 40 procedures are expected as a requirement for certification in 72

months of training. Literature suggests simulation technology is beneficial in Orthopaedic training, to increase the total acquisition of surgical skills without risk to patients and without the time and financial constraints of traditional surgical education (18, 59). There is also some evidence that there is transfer validity to in-vivo operating, and an improvement in performance when using a simulator model for training (62, 63). It may be that trainees perceive that participating in a study involving simulation in a required skill may allow them to improve more quickly, acquire skills which can be transferred to the operating theatre, and therefore achieve goals required to complete their surgical training. Can the same be said of the online learning resources?

10.5 Summary.

Following the repeat learner analytics, particularly in comparison to the results of the arthroscopy simulator study, it would be extremely valuable to perform further qualitative work with trainees to determine causative factors for the lack of participation with eTOOL, and why practical simulation activities appear much more attractive and successful. Comparing the activity of surgeons with physicians or other sub-specialties would be interesting to see if other types of training may be more suited to a virtual learning environment. Do our learning styles and personality types influence our choice of sub-specialty? Or is it the exposure to the sub-specialty that goes on to influence our style and preferences for learning? Will changes to training in the future attract difference personalities and learning styles to surgical sub-specialties? The transition to a more team based approach to patient care required by the implementation of EWTD suggests that surgical training may become more attractive to learners who work best in teams and rely on others for information in solving clinical problems (105).

CHAPTER ELEVEN:

LIMITATIONS

In this chapter we will consider and reflect on the limitations experienced during the project.

There have been significant changes in the use of the online resources and other digital media since the onset of the study. The rapid development of technology will require higher education institutions to continually review their approaches to teaching and research methods, both for Undergraduate Medical Students, but also for Postgraduate Trainees within surgery, as my work focuses on delivery to this postgraduate group. Other drivers will be changing social attitudes in relation to the use of technology, and the rapid innovation in online technology, including mobile devices and cloud computing. In the Future Directions chapter (Chapter 12) we will also discuss the use of Twitter and WhatsApp as additional resources. These technologies will provide the ability to reach a much larger volume of students with fewer resources, and the ability to reach students over much longer distances, while maintaining a direct interaction in real time through shared online spaces.

11.1 Literature review.

There are limitations identified within the review of the literature which are applicable to both literature reviews undertaken by the lead researcher. The additional literature review performed at the time of write up, aimed to include additional and up to date work produced following the original literature review. It is possible there may have been incomplete identification of studies, however the search strategy was identical to that used in the original literature review. The possible limitations of the results due to the

quality of the included studies is also considered. It is unlikely that major studies produced in the period between the two literature studies have been missed.

11.2 Virtual Learning environment

11.2a Qualitative review:

The main limitation of the study is that the numbers of participants in the focus groups was small, and this may limit the themes generated. It is possible some new themes could have been explored with other Orthopaedic postgraduate trainees. For example, perspectives from other training rotations in the region with a broader spectrum of trainees may have generated some interesting new themes for consideration.

The presence of the lead researcher in the focus groups and conducting the interviews leading to a conflict of interest has already been raised in Chapter 6 (Chapter 6.2b Reflexivity). We know that the analysis cannot occur in a vacuum and it is important to consider my own theoretical standpoint and my own perspectives. When I am constructing an argument it must be understood that I was embedded in the process beyond that of the average researcher; I was both a trainee using the Virtual Learning Environment and knew all of the subjects of the interviews and focus groups, both professionally and personally. There is little in the literature about the effect of health professionals interviewing each other. The main *advantage* cited is the shared language and background can facilitate understanding of often complex concepts (107). It is suggested that when interviewees recognize the similar professional background, the interviews provided richer and deeper data containing more personal accounts, and data relating to attitudes and shared professional values (108). There are many variables at play however, and Coar and Sim (109) point out there may be potential disadvantages. The

perceived seniority in the professional hierarchy could influence the nature of the interviews. This may be of most relevance to the lead researcher interviewing the trainers within the region, as at the time of interviewing the lead researcher was a trainee, and therefore considered "junior" within the professional hierarchy. This can lead to an imbalance of power (107). Had time and resource constraints allowed, it might have been useful to consider assistance from focus group facilitator and experienced qualitative researcher, Paul Leighton, as had been done within the focus groups.

Would we consider repeating the Qualitative study? Essentially no. Qualitative work is designed to identify flaws, to be an exploratory process and to facilitate the development of the resource. Therefore if we can show a change in the engagement then we can be confident that we have interpreted the qualitative data correctly, and there is no natural comparison. However (as discussed in the Future Directions chapter 12), it may be useful to undertake further research to explore more current methods, and how the use of additional technology enhanced learning resources relates to the qualitative work performed within this study.

11.2b Quantitative review:

We must consider that the period post intervention to eTOOL for data analysis only covers a 6 month period, and may not be long enough to demonstrate a significant effect of the improvements implemented. There are 32 specialist trainees within the region, and this small number may not be large enough to show an effect. The additional analysis undertaken by the author during the write-up period also only covers the last 12 months, and therefore cannot take into account any additional trends or patterns that may have been evident in the intervening period between analyses. The data saved by the site only allows review of the previous 12 months. Had it been

possible, ongoing analysis of the data showing usage of the site from the time of the intervention could have been reviewed, aiming to pinpoint the trends, and associate possible causation to the downward trend of site usage seen during the write up period.

11.3 Arthroscopy simulator

There are a number of limitations to this study which should be considered. One limitation of the study is the high initial scores for the PBA assessment shown by the control group. This is difficult to explain, as approximately 75% of each group was formed of trainees who were ST4 or below, and therefore in the early years of their surgical training. It does however raise the question regarding the capacity to improve when initial scores are high. As mentioned the trainees were randomised to ensure that there were equal numbers in each group, rather than by seniority or operative experience. Reviewing operative experience of trainees prior to randomisation to determine equal skill mix in each group could have been considered and may be appropriate in additional work moving forward.

Limitations also include the high dropout rate among trainees in the control group. This differential drop out between the two groups may result in bias in interpreting the results. However unequal dropout rates do not imply that estimates are biased, but we should consider the analysis method carefully. It is interesting that lower dropout rates were seen in the simulator training group, which might be seen as more demanding for the trainees, requiring a substantial commitment of time in addition to traditional training. The control group did not receive additional training with the simulator, and may have had higher dropout rates due to lack of interest in the study, apathy or frustration at not being able to access a resource that might be perceived as being helpful to their training. When asked, trainees usually cited "not being

able to accommodate the assessment in their timetable", but may have felt that the additional commitments required to complete the final assessment was of little benefit, and the study itself had provided them with little reward for their efforts.

The use of qualitative research could have been considered regarding the use of the arthroscopy simulator. Identifying barriers and facilitators in a similar way could have helped to reduce dropout rates in both groups. It may also have helped to guide the programme of exercises used for participants in the simulator programme. The exercises were chosen by the lead researcher, and were aimed to map closely to the Orthopaedic postgraduate curriculum. A trial period for all participants at the start of the study may have provided a period of troubleshooting, and identified tasks within the simulator programme that were perceived as less relevant, and those that were perceived as more relevant, or indeed more "fun". This may have led to a more consistent dataset within the Arthroscopy simulator group, and may have helped with a more robust analysis of benefits seen within the simulator training group.

11.4 Conclusions

Despite the limitations described above, the points raised throughout the study remain valid, and can be used to inform the future direction of work within the field of Technology Enhanced learning and Simulation. This is discussed in the next chapter.

CHAPTER TWELVE:

FUTURE DIRECTIONS

In this chapter we will consider any future work that may be generated as a result of the work described in this thesis.

12.1 Virtual Learning Environment

The qualitative work (Chapter 6) allowed us to explore in detail the reasons behind the trainee usage of the eTOOL site, and the role it played in their current training. In the Limitations chapter (Chapter 11) we discussed the themes generated by the trainee focus groups. For logistical reasons, the trainers in the region were interviewed one-on-one, but had it been possible to arrange focus groups, the resulting discussion may also have generated additional themes to pursue in the analysis.

In order to engage with the resource, it was clear tasks must be *credible* and *relevant*. Both the trainees and trainers had also stressed the importance of mapping the case based discussions to the curriculum. In particular the critical conditions outlined in the new syllabus, published August 2013, and therefore the activities online must map not only to the syllabus but utilise the relevant assessment tools. By continually developing an evolving set of rich online resources to help trainees with their study we can provide e-learning resources that address these issues (10). Work continues on developing more learning modules individually, including podcasts, video and audio to enhance the eTOOL site with useful multimedia available for trainees and trainers to download. Lack of interactive content was mentioned in the qualitative research (see chapter 6) as another barrier to use of the VLE. Some work can be sourced from Open Educational Resources (OERs) but much is

being generated by trainees and trainers, which can then be made available to all via eTOOL.

We consider whether the use of the Moodle VLE remains the most *credible* and *relevant* resource to be used by the trainees. The study by Pickering *et al* (46) used screencasts to replace the live element of the anatomy lectures. 92.8% of students accessed the screencasts at least once. The authors felt that the high level of engagement was due to the ability of students to access the material via their own mobile devices and in a way that is individually suited to their own learning style. Younger users also seem to value immediacy of response in any online resource. Portable electronic devices (smartphones, tablet computers) were used for communicating via email, performing Internet searches, and using specific applications. The smartphone is one of the fastest growing sectors in the technology industry, and its impact in medicine has already been significant. Smartphones have been shown to improve communication among doctors and nurses on inpatient wards (110). The study by Ozdalga et al reported improvements in communication and decreased disruption of workflow (110). Nurses reported decreased time spent attempting to contact doctors. Doctors also reported value in the ability to receive non urgent messages via email. Apps for pharmacology, medical references, and a myriad of other categories are providing physicians with quick and practical medical information that will aid in education and patient care, and may be more relevant to the current postgraduate trainees. The VLE resource has traditionally been difficult to access and view in a mobile format. To utilise the data stored, Moodle updates to a more compatible and user friendly mobile format should be considered.

The study by O'Sullivan *et al* (111) reviewed the use of WhatsApp within clinicians. WhatsApp started as an alternative to SMS text messaging, and

now supports sending and receiving a variety of media: text, photos, videos, documents, and location, as well as voice calls. The company now claims that more than 1 billion people in over 180 countries use WhatsApp to stay in touch with friends and family (112).

The study by O'Sullivan *et al* (111) found 100% of those surveyed had a WhatsApp account and 100% had an active 'group chat' used for clinical medicine. These WhatsApp groups can vary, with approximately 10% including only interns, 70% also including senior house officers and registrars, and up to 20% of groups including consultants. 90% of respondents felt that they could not provide the best possible clinical care without using instant messaging. Thus, there may be a compelling patient safety argument for the use of instant messengers when one considers that 95% of respondents feel that it is 'safer for patients' if everyone on the team uses an instant messenger.

This is reflected in our own experiences regarding the use of WhatsApp. An online journal club was set up in September 2017 via the WhatsApp messenger, and was accessed by both trainees and trainers to review journal articles and provide a discussion forum for the articles and answers to questions. One example shows the between the 9th October 2017 and the 20th October 2017, the discussion regarding two journal articles generated a total of 118 messages, with 68 messages by registrars, and 50 responses by Consultants. This included 10 registrars and 14 Consultants, which shows a significantly higher trainer engagement than previously seen in the VLE. Trainees were given the options to generate a WBA by emailing the chain of the WhatsApp chat to themselves, which can then be saved as a document and uploaded to the ISCP website. Trainers would then be able to validate the assessments of those trainees who felt that they had made a significant

contribution to the discussion. In the study by Nathoo *et al* (37) students reported that online interaction was most effective when the faculty tutor actively facilitated discussion. The paper by Munoz *et al* (28) suggests current e-Learning systems are inadequate to support the level of interaction, personalization and engagement demanded by the users, but the engagement seen by Trainers on WhatsApp, Twitter and additional smartphone apps is at a level not previously seen, and may therefore represent the future direction of technology enhanced learning resources.

Most recently at the British Orthopaedic association Conference in Birmingham, the session on Innovation and Simulation cited the use of smartphone apps for both trainees and patients (113). Patients are being encouraged to use smartphone apps for feedback, and to encourage them to engage in appropriate health behaviours. The paper delivered by O'Dowd-Booth looked specifically at Core Trainees, but suggests that smartphone apps can be used to improve surgical training through cognitive simulation, both pre-operatively and to reinforce intra-operative learning, thus maximising learning opportunities (114).

As mentioned in the discussion (Chapter 10), the recent high profile case involving Dr Bawa-Garba may lead to some interesting discussion with trainees and trainers regarding the use of online documentation and tools for reflection and learning. In September 2018, The Academy of Medical Royal Colleges (AoMRC) released guidance for trainee doctors entering reflective notes into their e-Portfolios (115). Key points state that doctors should 'anonymise patients as far as possible in their self-reflective logs. Reflection is to be used as an educational and not a medical tool and therefore should not include patient identifiable or personal data relating to a third party. Trainees are also advised to take advice from a senior, experienced colleague when

writing reflection about cases that may be contentious or result in an investigation. Future work may assess the impact on the usage of online documentation in light of this.

12.2 Arthroscopy Simulator

For the purposes of the thesis, a decision was taken not to repeat the qualitative study. Following the repeat learner analytics, and the results of the quantitative analysis, particularly in comparison to the results of the arthroscopy simulator study, it would be extremely valuable to perform further qualitative work with trainees to determine in particular why practical simulation activities appear much more attractive and successful.

Future studies on the Arthroscopy simulator may also help to identify why the dropout rates were so high, and perhaps should also include an additional period of access to the simulator when the study period is concluded, which may help to motivate participants who would not otherwise have access to the simulator.

In light of the above, a project designed to look at the learning styles of surgeons may prove a useful insight into how and why trainees may choose to engage with technology enhanced learning. Are surgeons "Active Learners"? Comparing the activity of surgeons with physicians or other sub-specialties would be interesting to see if other types of training may be more suited to a virtual learning environment. Do our learning styles and personality types influence our choice of sub-specialty? Or is it the exposure to the sub-specialty that goes on to influence our style and preferences for learning? Further work in this area would prove interesting.

REFERENCES

1. Calman K. Hospital Doctors - Training for the future. Department of Health 1993.

2. Tooke PSJ. Aspiring to excellence: Findings and recommendations of the independent inquiry into modernising medical careers. MMC Inquiry 2007(Aldridge Press, Chiswick, London).

3. Donaldson L. Unfinished business: proposals for the reform of the senior house officer grade. Department of Health 2002 August.

4. Temple J. 'Time to Train': Review of the impact of the European Working Time Directive on the quality of training. Department of Health 2010.

5. No authors listed. Surgical Trainees worried as Training Deteriorates under European Working Time Regulations. www.asit.org/assets/documents/ASiT_BOTA_EWTD_Survey_Press_Release_November_2009 pdf 2009.

6. House of Commons Health Committee. Modernising Medical Careers: Third report of session 2007 - 08. Volume 1 report with formal minutes. House of Commons 2008 May (London: The Stationary Office Limited).

7. Department of Health. Modernising medical careers. The response of the four UK Health Ministers to the consultation on unfinished business. Department of Health 2003.

8. Greenaway D. Securing the Future of Excellent Patient Care. GMC 2013.

9. RCS Professional Standards. Improving Surgical Training: Proposal for a Pilot Surgical Training Programme. Royal College of Surgeons of England 2015 October 2015.

10. ISCP. Intercollegiate Surgical Curriculum project. www.iscp.ac.uk

11. OCAP. Orthopaedic Competence Assessment Project. www.ocap.org.uk

12. General Medical Council. Generic Standards for Training London. www.gmc-uk.org 2009.

13. The Gold Guide: A reference guide for postgraduate specialty training in the UK. 2010 June; Fourth Edition.

14. Scallen, A. A review of the literature. Education and shift working: an Oxymoron? Association for the Study of Medical Education 2002:2-6.

15. Carr S. Education of senior house officers: current challenges. Postgrad Med J 2003; 79: 622-6.

16. Jain S. Practicing medicine in the age of Facebook. New England Journal of Medicine 2009; 361 (7):649.

17. Aggarwal R, Darzi A. Technical skills training in the 21st century. New England Journal of Medicine 2006(355):2695.

18. Howells N, Gill H, Carr A, Price A, Rees J. Transferring simulated arthroscopic skills to the operating theatre. A randomised blinded study. J Bone Joint Surg [BR] 2008; 90-B:494.

19. Aggarwal R, Grantcharov TP, Eriksen JR, Blirup D, Kristiansen VB, Funch-Jensen P, et al. An evidence-based virtual reality training program for novice laparoscopic surgeons. Ann Surg 2006; 244(2):310-4.

20. Aggarwal R, Ward J, Balasundaram I. Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. Annals of Surgery 2007; 246(5):771.

21. Bokhari R, Bollman-McGregor J, Kahoi K, Smith M, Feinstein A, Ferrara J. Design, development, and validation of a take-home simulator for fundamental laparoscopic skills: using Nintendo Wii for surgical training. Am Surg 2010; 76(6):583.

22. Aggarwal R, Black SA, Hance JR, Darzi A, Cheshire NJW. Virtual Reality Simulation Training can Improve Inexperienced Surgeons' Endovascular

Skills. European Journal of Vascular and Endovascular Surgery 2006; 31(6):588-93.

23. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative research in psychology 2006; 3(2):77.

24. Boyatzis R. Transforming qualitative information: thematic analysis and code development. Sage; 1998.

25. NHS Centre for Reviews and Dissemination. Systematic Reviews: CRDs guidance for undertaking reviews in Healthcare. 3rd ed. York: CRD, University of York; 2009.

26. Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. BMJ 2009; 339: 2535.

27. Critical Appraisal Skills Programme (CASP). Critical Appraisal Skills Programme: making sense of evidence about clinical effectiveness: 11 questions to help you make sense of a trial. http://www.casp-uk.net/wp-content/uploads/2011/11/CASP_RCT_Appraisal_Checklist_14oct10 pdf 2010 14.14.10.

28. Munoz DC, Ortiz A, Gonzalez C, Lopez DM, Blobel B. Effective e-learning for health professional and medical students: The experience with SIAS-intelligent tutoring system. Stud Health Technol Inform 2010; 156: 89-102.

29. Wessa P, de A, Holliday IE. Content-based VLE designs improve learning efficiency in constructivist statistics education. PLoS ONE 2011; 6(10).

30. Mazzoleni MC, Rognoni C, Finozzi E, Gri T, Pagani M, Imbriani M. E-learning for occupational physicians' CME: a study case. Stud Health Technol Inform 2011; 165: 111-6.

31. Beddy P, Ridgway PF, Beddy D, Clarke E, Traynor O, Tierney S. Defining useful surrogates for user participation in online medical learning. Advances in Health Sciences Education 2009; 14(4):567-74.

32. Halbert C, Kriebel R, Cuzzolino R, Coughlin P, Fresa-Dillon K. Self-assessed learning style correlates to use of supplemental learning materials in an online course management system. Med Teach 2011; 33(4):331-3.

33. De BA, Dolmans DHJM, Muijtjens AMM, Van CPM,Vleuten. Student perceptions of a virtual learning environment for a problem-based learning undergraduate medical curriculum. Med Educ 2006; 40(6):568-75.

34. Guan J, Tregonning S, Keenan L. Social interaction and participation: formative evaluation of online CME modules. J Contin Educ Health Prof 2008; 28(3):172-9.

35. McHarg J, Goding L, Caldarone E, de SR, SR, McLachlan J. Availability of a virtual learning environment does not compensate for the lack of a physical facility. Med Teach 2006; 28(3):258-63.

36. Hege I, Ropp V, Adler M, Radon K, Masch G, Lyon H, et al. Experiences with different integration strategies of case-based e-learning. Med Teach 2007(29):791-7.

37. Nathoo AN, Goldhoff P, Quattrochi JJ. Evaluation of an Interactive Case-based Online Network (ICON) in a problem based learning environment. Advances in Health Sciences Education 2005; 10(3):215-30.

38. Campbell M, Gibson W, Hall A, Richards D, Callery P. Online vs. face-to-face discussion in a web-based research methods course for postgraduate nursing students: A quasi-experimental study. Int J Nurs Stud 2008; 45(5):750-9.

39. Moule P, Ward R, Lockyer L. Nursing and healthcare students' experiences and use of e-learning in higher education. J Adv Nurs 2010; 66(12):2785-95.

40. Brown M, Bullock A. Evaluating PLATO: postgraduate teaching and learning online. Clinical Teacher 2014 2014 Feb; 11(1):10-4.

41. MacDonald E, Nicol L, Ahmed I. Providing a specialty trainee teaching programme over long distances. Clinical Teacher 2013 2013 Dec; 10(6):374-378.

42. Felder RM SB. Learning styles and strategies. Available from: http://www4.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/styles htm ;September 2010.

43. Brindley LD. Collaborate to compete: Seizing the opportunity of online learning for UK higher education. Report to HEFCE by the Online Learning Task Force. HEFCE 2011 01.01.2011;2011/01.

44. Hennessy C, Kirkpatrick E, Smith C, Border S. Social Media and Anatomy Education: Using Twitter to Enhance the Student Learning Experience in Anatomy. Anatomical Sciences Education 2016 2016 Apr; 5(10):1002 - 1610.

45. Jaffar A. Exploring the use of a Facebook page in Anatomy Education. Anatomical Sciences Education 2014; 7: 199-208.

46. Pickering J. Anatomy Drawing Screencasts: Enabling Flexible Learning for Medical students. Anatomical Sciences Education 2015 2015 May-Jun; 8(3):249-57.

47. Yang D, Sinha T, Adamson D, Rosé CP. Turn on, tune in, drop out: Anticipating student dropouts in massive open online courses. Proceedings of the 2013 NIPS Data-driven education workshop; 2013.

48. Davies S. Department of Health: A Framework for Technology Enhanced Learning. www.dh.gov.uk/publications 2011 Nov.

49. Khera G, Milburn J, Hornby S, Malone P. A statement from ASiT: Simulation in Surgical Training. www.asit.org 2011 Nov.

50. Hazarika S, Baird E, Palan J. BOTA positional statement on the use of simulation in surgical training in Trauma and Orthopaedics. www.bota.org.uk 2013 April.

51. Dias J, Briggs T, Limb D, Goodwin M, Kimmons M. BOA Training and Education strategy for 2013. www.boa.ac.uk/publications 2012 Dec.

52. East Midlands Healthcare Workforce Deanery. East Midlands Simulation Strategy 2010 - 2015. www.eastmidlandsdeanery.nhs.uk 2011 Oct.

53. Pitts D, Wallace A, Clarke N, Sher L, Reed M, editors. BOA: Specialist Training in Trauma and Orthopaedics. Edinburgh: OCAP, Royal College of Surgeons of Edinburgh, ; 2009.

54. HESA. Student record. 2009/10.

55. OFCOM. 2011.

56. Schulz KF, Altman DG, Moher D, for the CONSORT Group. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. BMJ (Clinical research ed)2010(340):332.

57. Gomoll AH, Pappas G, Forsythe B, Warner JJP. Individual skill progression on a virtual reality simulator for shoulder arthroscopy: A 3-year follow-up study. Am J Sports Med 2008; 36(6):1139-42.

58. Gomoll AH, O'Toole RV, Czarnecki J, Warner JJP. Surgical experience correlates with performance on a virtual reality simulator for shoulder arthroscopy. Am J Sports Med 2007; 35(6):883-8.

59. Andersen C, Winding TN, Vesterby MS. Development of simulated arthroscopic skills: A randomized trial of virtual-reality training of 21 orthopedic surgeons. Acta Orthopaedica 2011; 82(1):90-5.

60. Howells N, Auplish S, Hand G, Gill H, Carr A, Rees J. Retention of arthroscopic shoulder skills learned with use of a simulator. Demonstration of a learning curve and loss of performance level after a time delay. J Bone Joint Surg Am 2009; 91(5):1207.

61. Dunn J, Belmont PJ, Lanzi J, Martin K, Bader J, Owens B, et al. Arthroscopic Shoulder Surgical Simulation Training Curriculum: Transfer

Reliability and Maintenance of Skill Over Time. Journal of Surgical Education 2015 Nov-Dec; 72(6):1118-23.

62. Waterman B, Martin K, Cameron K, Owens B, Belmont PJ. Simulation Training Improves Surgical Proficiency and Safety During Diagnostic Shoulder Arthroscopy Performed by Residents. Orthopaedics 2016 May; 2:1-7.

63. Martin K, Patterson D, Phisitkul P, Cameron K, Femino J, Amendola A. Ankle Arthroscopy Simulation Improves Basic Skills, Anatomic Recognition, and Proficiency During Diagnostic Examination of Residents in Training. Foot Ankle Int 2015 Jul; 36(7):827-35.

64. Lyu S, Lin Y, Huang S, Yau H. Experience-based virtual training system for Knee arthroscopic inspection. BioMedical Engineering Online 2013 Jul;4(12):63.

65. Aggarwal R, Crochet P, Dias A, Misra A, Ziprin P, Darzi A. Development of a virtual reality training curriculum for laparoscopic cholecystectomy. Br J Surg 2009; 96(9):1086-93.

66. van OA,Meijden, Schijven MP. The value of haptic feedback in conventional and robot-assisted minimal invasive surgery and virtual reality training: a current review. Surg Endosc 2009; 23(6):1180-90.

67. Koehler R, Amsdell S, Arendt E. The Arthroscopic Surgical Skill Evaluation Tool (ASSET). American Journal of Sports Medicine 2013;4(6):1229-1237.

68. Punch KF. Introduction to social research: quantitative and qualitative approaches. 2nd ed. London: Sage; 2005.

69. Fry H, Ketteridge S, Marshall S. A Handbook for Teaching and Learning in Higher Education: Enhancing Academic Practice. 3rd ed. London: Kogan Page; 2009.

70. Prosser M, Trigwell K. Understanding Learning and Teaching: The Experience in Higher Education. . Buckingham: SRHE/Open University Press; 1999.

71. Knowles M. The adult learner: A neglected species. Houston: Gulf; 1973.

72. Knowles M. The modern practice of adult education. New York: Cambridge: The Adult Education Company; 1980.

73. Lapadat J, Lindsay A. Transcription in Research and Practice: From Standardisation of technique to interpretive positionings. Qualitative Inquiry 1999; 5(1):64-86.

74. Bird CM. How I stopped dreading and learned to love transcription. Qualitative Inquiry 2005; 11(2):226-48.

75. Anderson LW, Krathwohl DR. A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives. New York: Longman; 2001.

76. Kolb D. Experiential learning: Experience as the source of learning and development. Englewood Cliffs, NJ: Prentice Hall; 1984.

77. Vince R. Behind and beyond Kolb's learning cycle. Journal of management 1998.

78. Honey P, Mumford A. The Manual of Learning Styles. Maidenhead: Peter Honey; 1982.

79. Piaget J. The Psychology of Intelligence. New York: Routledge; 1950.

80. Bruner JS. Towards a theory of Instruction. Cambridge, MA: Harvard University Press; 1966.

81. Vygotsky LS. Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press; 1978.

82. Sweller J. Cognitive load during problem solving: Effects on learning. Cognitive science 1988; 12(1):257-85.

83. Kirschner P, Sweller J, Clark RE. Why minimal guidance during instruction does not work: an analysis of the failure of constructivist,

discovery, problem-based, experiential, and inquiry-based teaching. Educational Psychologist 2006; 41(2):75-86.

84. Kerka S. Self-directed learning: Myths and realities (report). Washington DC: Office of Educational Research and Improvement 1994.

85. Brown G, Bull J, Pendelbury M. Assessing Student Learning in Higher Education. London: Routledge; 1997.

86. Gipps C. Beyond Testing. London: Falmer; 1994.

87. Ramsden P. Learning to Teach in Higher Education. London: Routledge; 1992.

88. Biggs J. Enhancing teaching through Constructive Alignment. Higher Education 1996; 32:1-18.

89. Biggs J. Teaching for Quality Learning at University. 2nd ed. Buckingham: Society for Research into Higher Education and the Open University Press; 2003.

90. Jenkins M, Browne T, Walker R. A longitudinal perspective between March 2001, March 2003 and March 2005 for Higher Education in the United Kingdom. http://www.ucisa.ac.uk/groups/tlig/vle/vle_survey_2005 doc 2007;October 2007.

91. Becher T, Trowler PR. Academic tribes and territories. 2nd ed. Buckingham: SRHE/Open University Press; 2001.

92. Becher T. Academic tribes and territories: Intellectual inquiry and the culture of disciplines. Buckingham: SRHE/Open University Press; 1989.

93. Jenkins A. Discipline-based educational development. International journal for Academic development 1996; 1(1):50-62.

94. Shortland S. Peer observation: a tool for staff development or compliance? Journal of Further and Higher Education 2004; 28(2):219-28.

95. Medical Research Council. Developing and evaluating complex interventions: new guidance. www.mrc.ac.uk 2006.

96. Armellini A, Jones S. Carpe Diem: seizing each day to foster change in e-learning design. Reflecting Education 2008 May 2008; 4(1):17-29.

97. Broglio K. Randomization in clinical trials: permuted blocks and stratification. JAMA 2018; 319(21):2223-4.

98. Costa ML, van Rensburg L, Rushton N. Does teaching style matter? A randomised trial of group discussion versus lectures in orthopaedic undergraduate teaching. Medical education 2007 February 2007; 41(2):0308.

99. Larvin M. E-Learning in surgical education and training. ANZ J Surg 2009; 79(3):133-7.

100. Shafi M. Second letter to the GMC chair regarding Hadiza Bawa-Garba. BMJ 2018; 360(k667).

101. Detsky AS, Baerlocher MO, Wu AW. Admitting mistakes: ethics says yes, instinct says no. CMAJ 2013 March 2013; 185(5):448.

102. GMC. Factsheet - Dr Bawa-Garba case - final. GMC 2018 19/04/2018.

103. Richard RD, Deegan BF, Klena JC. The Learning styles of Orthopaedic residents, faculty and applicants at an academic program. Journal of Surgical Education 2014; 71(1):1878.

104. Caulley L, Wadey V, Freeman R. Learning styles of first-year orthopaedic surgical residents at 1 accredited institution. Journal of Surgical Education 2012; 69(2):1878.

105. Quillin RC, Pritts TA, Young GB, Edwards MJ, Davis BR. Surgical resident learning styles have changed following the implementation of the 80-hour workweek. Journal of Surgical Research 2013; 179(2):0022.

106. Jack MC, Kenkare SB, Saville BR, Beidler SK, Saba SC, West AN, et al. Improving education under work-hour restrictions: comparing learning and

teaching preferences of faculty, residents and students. Journal of Surgical Education 2010; 67(5):1878.

107. Holloway I, Wheeler S. Qualitative Research in Nursing. Oxford: Blackwell science; 2002.

108. Chew-Graham C, May, C R. et al. Qualitative research and the problem of judgement: lessons from interviewing fellow professionals. Family Practice 2002;19(3):285-9.

109. Coar L, Sim J. Interviewing one's peers: methodological issues in a study of health professionals. Scandinavian Journal of Primary Health care 2006; 24:251-6.

110. Ozdalga E, Ozdalga A, Ahuja N. The Smartphone in Medicine: A Review of Current and Potential Use Among Physicians and Students. J Med Internet Res 2012; 14(5):128.

111. O'Sullivan DM, O'Sullivan E, O'Connor M. WhatsApp Doc? BMJ Innovations 2017 24 October 2017.

112. Whatsapp. WhatsApp. www.whatsapp.com 2018;2018(September 2018).

113. Davis E, Kamali A, De Faoite D, Hanson B, McNamara I. A MOBILE APP FOR COLLECTING OUTCOME MEASURES: FIRST USER FEEDBACK AMONGST TKA PATIENTS. Paper presented at: British Orthopaedic

Association (BOA) Annual Congress; 25-28 September 2018; International Convention Centre, Birmingham, England, United Kingdom. 2018.

114. O'Dowd-Booth C, Cameron P. THE ROLE OF COGNITIVE SIMULATION IN SURGICAL EDUCATION; THE ADVENT OF MOBILE APPLICATIONS. Paper presented at: British Orthopaedic Association (BOA) Annual Congress; 25-28 September 2018; International Convention Centre, Birmingham, England, United Kingdom.

115. Academy of Medical Royal Colleges/COPMeD. The Reflective Practitioner: Guidance for doctors and medical students. Academy of Medical Royal Colleges 2018 12/09/2018.

APPENDIX

APPENDIX ONE: QUALITATIVE SAMPLING FRAMEWORK

CONSULTANT	NUMBER	MALE/FEMALE	SPECIALIST REGISTER ENTRY DATE TRAUMA AND ORTHOPAEDICS
Alwyn Abraham	001	M	2006
Nandan Adla	002	M	2010
Patricia Allen	003	F	2001
Alison Armstrong	004	F	1997
Robert Ashford	005	M	2006
Alistair Best	006	M	2004
Maneesh Bhatia	007	M	2009
Bhaskar Bhowal	008	M	1999
Stuart Birtwistle	009	M	1999
Kevin Boyd	010	M	2002
Jason Braybrooke	011	M	2007
Andrew Brown	012	M	2002
Urjit Chatterji	013	M	2004
Lucy Cutler	014	F	2004
John Davison	015	M	1999
Colin Esler	016	M	1999
Andrew Furlong	017	M	2000
Omar Gabbar	018	M	
Steve Godsiff	019	M	1996
Tim Green	020	M	2000
Christopher Kershaw	021	M	1996
Ashwin Kulkarni	022	M	2010
Jit Mangwani	023	M	2011
Amit Modi	024	M	2005
Martyn Newey	025	M	1997
Radhakant Pandey	026	M	2000
Richard Power	027	M	1996
Phil Sell	028	M	1996
Subhash Tandon	029	M	1999
Grahame Taylor	030	M	1996
Aamer Ullah	031	M	2006
Clare Wildin	032	F	2002
Steve Williams	033	M	2004

From the consultants available, a convenience approach was utilised initially, as only consultants working in UHL NHS trust were sampled. Thereafter a purposive approach was used, aiming to achieve a range of male and female consultants, and a mix of new and older consultants (with respect to their date of appointment in post).

An investigation into the use of technology-enhanced learning environments in orthopaedic post-graduate medical education (Virtual Learning Environment).

Following normal stuff on purpose, consent and confidentiality describe intention to consider 3 broad topics....

1. Participation in the VLE/Moodle
2. Are there any barriers to using the VLE?
3. Nature of any future changes to the VLE which might improve motivation and participation

Ground rules for interaction, and expectation.

Ice breaker... Say your name for tape. Tell us your name and subspeciality

---

Question 1 to all ... What do you think makes you a good trainer?

How does that relate to broader training for your trainees?

Discussion points –

What constitutes good training?

What role does online learning play when you are training? Do you think that online learning *has* a role to play in learning / training?

What do you think trainees need from an online resource with regards to training?

Question 2 to all ... Have you ever accessed the trainee VLE?

Prompt to all Daily / Weekly / Monthly/ Never.

Discussion point 1... What areas of the VLE do you access while you're on the moodle?

Which aspects of the VLE do you find most interesting? Why?

Do you use any other moodles/ blogs/ wikis/social media (facebook or twitter for example)?

We would like to explore the factors that might encourage or discourage trainees from using the VLE.

Question 3. How do you find the VLE?

Prompts – What stops you from posting? What are the barriers?

What are the positive aspects of the VLE?

- Prompts – good range of lectures online? Useful information?

- Prompts – Lack of input from the consultants? Lack of time? Don't express myself in writing – prefer talking....

If we make changes to the VLE, would you be more enthusiastic about using the moodle?

We'd like you to make suggestions as to what form any changes to the VLE should take...

What factors might encourage you to participate more? Is there anything that we could do to encourage your participation? Make it easier for you to participate?

What changes would you like to see?

Prompts – Allocated time for the VLE? More cases? More subspecialty cases?

We are trying to develop an online Case Based Discussion (CBD) for the VLE. Your perspective on this would be helpful.

What should we consider .....? E.g. which cases can be used? Who will mark the CBD? What decides satisfactory input?

Some trainers have suggested this cannot be performed adequately online, and should be done face-to-face. Do you agree with this?

To close, question to all... How appropriate do you think it is for trainees to receive part of their training/education via an online learning resource like the VLE?

Do you think that what trainees require from training can be achieved this way? In whole? Or in part?

What role do you think online learning plays in training?

To close, thank you for you contribution.

To close, reiterate issue of confidentiality and respecting the privacy of other contributors.

An investigation into the use of technology-enhanced learning environments in orthopaedic post-graduate medical education (Virtual Learning Environment).

Following normal stuff on purpose, consent and confidentiality describe intention to consider 3 broad topics....

1. Participation in the VLE/Moodle
2. Are there any barriers to using the VLE
3. Nature of any future changes to the VLE which might improve motivation and participation

Ground rules for interaction, and expectation.

Ice breaker,... Say your name for tape. Tell us your name, and your level of training.

Question 1 to all ... What do you think makes a good trainer?

How does that relate to broader training?

Discussion points –

What constitutes good training?

What role does online learning play in your training? Do you think that online learning *has* a role to play in your learning / training?

What do you need from an online resource with regards to your training?

Question 2 to all ... How often do you access the VLE?

Prompt to all Daily / Weekly / Monthly/ Never.

Discussion point 1... What areas of the VLE do you access while you're on the moodle?

Which aspects of the VLE do you find most useful? Why?

Do you use any other moodles/ blogs/ wikis/social media (facebook or twitter for example)?

Do you use any other online learning resources?

How important is the VLE in your study/revision?

We would like to explore the factors that might encourage or discourage you from using the VLE.

Question 3. How do you find the VLE?

Prompts – What stops you from posting? What are the barriers?

What are the positive aspects of the VLE?

- Prompts – good range of lectures online? Useful information?
- Prompts – Lack of input from the consultants? Lack of time? Don't express myself in writing – prefer talking....

If we make changes to the VLE, would you be more enthusiastic about using the moodle?

We'd like you to make suggestions as to what form any changes to the VLE should take...

What factors might encourage you to participate more? Is there anything that we could do to encourage your participation? Make it easier for you to participate?

What changes would you like to see?

Prompts – Allocated time for the VLE? More cases? More input from the consultants? Exam revision? Credits?

We are trying to develop an online Case Based Discussion (CBD) for the VLE. Your perspective on this would be helpful.

What should we consider .....? E.g. which cases can be used? Who will mark the CBD? What decides satisfactory input?

Some trainers have suggested this cannot be performed adequately online, and should be done face-to-face. Do you agree with this?

To close, question to all... How appropriate do you think it is for trainees to receive part of their training/education via an online learning resource like the VLE?

Do you think that what we require from training can be achieved this way? In whole? Or in part?

What role does online learning play in training?

To close, thank you for you contribution.

To close, reiterate issue of confidentiality and respecting the privacy of other contributors.

University of Leicester

Version: 1.0

PARTICIPANT INFORMATION SHEET

Title of Project: An investigation into the use of technology-enhanced learning environments in orthopaedic post-graduate medical education (Virtual Learning Environment)

Please read carefully and ask if you do not understand or would like more information.

Please take time to read the following information carefully, and discuss it with others if you wish. You are invited to take part in a medical education research project. It is important for you to understand why the research is being done, and what it involves, before considering whether you would like to take part. Please ask us to clarify anything that is not clear, or if you would like more information related to the project. We will not ask you to confirm any interest until you have received sufficient time to reach a decision.

What is the purpose of the research?

The East Midlands Healthcare workforce Deanery has designed and developed a Virtual Learning Environment in collaboration with multimedia technologists and clinical educators. We want to research what learning occurs when trainees use it, and its usefulness in developing clinical knowledge, problem-solving and decision-making skills.

Why have I been chosen?

We would like to invite your participation because you are currently a Post-graduate specialist trainee in Trauma and Orthopaedics on the School of Surgery south rotation.

Do I have to take part?

No. However, if you do decide to take part, you will be asked to complete a consent form to confirm your agreement. You may still withdraw your consent at any time and without giving a reason up, even if you decide to take part and then change your mind.

What is involved?

The Virtual Learning Environment is already available for you to use. As part of the project, we

will aim to improve some of the areas of the VLE, including the online journal clubs and case based discussions. As part of our research we will also assess how often postgraduate orthopaedic trainees currently use the VLE, including the number of views and posts made by trainees on VLE. One of our research questions will also look at your credit scores and whether there is any correlation with participation on the VLE. We will therefore be asking your permission to access your credit scores for the years 2011/2012, and 2012/2013. Throughout the study we may invite you to feedback your experience during an interview or focus group. We may ask you about:

- How you found using the technology
- What you liked and what you disliked
- What you would change and what you would keep
- How it may affect your approach to learning orthopaedics
- What your thinking was behind some of the decisions you made whilst using it.
- Whether you see yourself using this technology throughout your training

What are the possible benefits of taking part?

Your involvement in this project will produce findings that provide a systematic and evidence-based approach to how medical educators can use VLE technology in the context of teaching trauma and orthopaedics.

What are the possible disadvantages or risks of taking part?

There are no foreseen disadvantages of taking part.

Will my taking part in this study be kept confidential?

Your participation will be kept strictly confidential to the researchers involved in the study, if you agree to take part in this research. Names, addresses and telephone numbers will be stored separately from other information you give us and only by the lead researcher. The results will be written up for publication in such a way that individual participants cannot be identified. Prior to publication, participants will have the opportunity to read the findings and if any problems are raised, the necessary changes made. Your anonymity is therefore assured. All names, addresses and telephone numbers will be destroyed once the study is complete.

What will happen to the results of the research study?

When the study is completed, the results will be used as part of higher degree thesis. The results of the study will also be presented at a meeting of Orthopaedic surgeons and medical education specialists, and if accepted, published in a medical journal. If this is case, you will be informed and a copy of the published article will be made available to you, if you wish. You will not be identified in any report/publication.

Who is organising and funding the research?

Miss Jennifer Nichols is organising this research as part of a study for a higher degree. The research is being supervised by one Orthopaedic surgeon (Professor J. Dias), and one Professor of Medical Education (Prof. Sue Carr). The University of Leicester and East Midlands Healthcare Workforce Deanery are supporting the work and none of the researchers are receiving any payment or reward if you take part.

Who has reviewed the study?

This study has been reviewed by the University of Leicester Research Ethics Committee.

If you would like to take part in the study please bring this information sheet and the consent form with you to the focus group. Please note that if you agree to take part you will be given a copy of this Participant Information Sheet and the Consent Form to keep.

Thank you for reading this.

Names of researchers

Miss Jennifer Nichols	Specialist Registrar Orthopaedics / Honorary Surgical Educator
Prof. J Dias	Professor of Orthopaedics
Prof. Sue Carr	Consultant Nephrologist/ Visiting Professor of Medical Education and Associate Medical Director (Clinical Education)

If you have any queries please telephone Jennifer Nichols on [redacted]

APPENDIX FIVE– LIST OF OPEN CODES

Node Summary: Virtual Learning Environment

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded
Node						
Nodes\\CBD - outrage						
						Aggregated: No
Document	3	8	498	9	0	0
Nodes\\CBD assessment						
						Aggregated: No
Document	8	11	830	11	0	0
Nodes\\CBD negatives - inhibited						
						Aggregated: No
Document	6	31	2123	36	0	0
Nodes\\CBD negatives - lack of feedback						
						Aggregated: No
Document	10	32	2627	36	0	0
Nodes\\CBD negatives - lack of moderator						
						Aggregated: No
Document	10	28	2174	29	0	0
Nodes\\CBD negatives - loss of FTF						
						Aggregated: No
Document	9	19	1409	19	0	0
Nodes\\CBD negatives - not learning						
						Aggregated: No
Document	16	54	4294	55	0	0
Nodes\\CBD negatives - poor knowledge by trainees						
						Aggregated: No
Document	16	54	4182	55	0	0
Nodes\\CBD negatives - poor trainee engagement						
						Aggregated: No
Document	11	41	2793	49	0	0
Nodes\\CBD negatives - poor trainer engagement						
						Aggregated: No
Document	9	31	2341	32	0	0

Nodes\\CBD negatives - repetition

Aggregated: No

Document	3	7	547	8	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded

Nodes\\CBD positives - exam

Aggregated: No

Document	9	15	770	15	0	0

Nodes\\CBD solutions - app

Aggregated: No

Document	1	2	77	2	0	0

Nodes\\CBD solutions - assessment

Aggregated: No

Document	11	24	1566	30	0	0

Nodes\\CBD solutions - credibility

Aggregated: No

Document	9	28	2061	36	0	0

Nodes\\CBD solutions - credits - positive

Aggregated: No

Document	4	4	378	4	0	0

Nodes\\CBD solutions - feedback

Aggregated: No

Document	12	52	3965	58	0	0

Nodes\\CBD solutions - higher order thinking

Aggregated: No

Document	13	34	2969	36	0	0

Nodes\\CBD solutions - live cases

Aggregated: No

Document	6	17	1225	24	0	0

Nodes\\CBD solutions - nominate moderator

Aggregated: No

Document	8	46	3128	49	0	0

Nodes\\CBD solutions - summary

Aggregated: No

Document	2	11	469	13	0	0

Nodes\\CBD solutions - validated

Aggregated: No

Document	2	3	234	3	0	0

Nodes\\CBD solutions - voluntary

Aggregated: No

Document	4	7	531	11	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded

Nodes\\CBD solutions - year groups

Aggregated: No

Document	2	11	733	11	0	0

Nodes\\ISCP negatives

Aggregated: No

Document	4	6	423	6	0	0

Nodes\\Online learning - balance

Aggregated: No

Document	10	21	1544	23	0	0

Nodes\\Online learning - ease of access

Aggregated: No

Document	13	28	1601	30	0	0

Nodes\\Online learning - factual

Aggregated: No

Document	13	25	1420	26	0	0

Nodes\\Online learning - feedback

Aggregated: No

Document	6	8	424	10	0	0

Nodes\\Online learning - interactive

Aggregated: No

Document	9	20	1247	22	0	0

Nodes\\Online learning - less inhibited

Aggregated: No

Document	1	1	33	1	0	0

Nodes\\Online learning - links

Aggregated: No

Document 5	10	504	10	0	0

Nodes\\Online learning - poor engagement

Aggregated: No

Document 3	3	229	3	0	0

Nodes\\Online learning - poor trainer engagement

Aggregated: No

Document 6	9	552	15	0	0

Nodes\\Online learning - slow

Aggregated: No

Document 1	1	44	1	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded

Nodes\\Online learning - standardise

Aggregated: No

Document 2	4	146	4	0	0

Nodes\\Online learning - time saving

Aggregated: No

Document 10	26	1509	28	0	0

Nodes\\Online usage - knowledge

Aggregated: No

Document 15	36	2324	44	0	0

Nodes\\Online usage - other websites

Aggregated: No

Document 16	41	2444	66	0	0

Nodes\\Trainer - approachable

Aggregated: No

Document 12	17	858	17	0	0

Nodes\\Trainer - time

Aggregated: No

Document 12	19	972	19	0	0

Nodes\\Trainer - training methods

Aggregated: No

Document 8	13	662	14	0	0

Nodes\\Training - assessments

Aggregated: No

Document	5	7	463	7	0	0

Nodes\\Training - challenges

Aggregated: No

Document	10	17	1161	17	0	0

Nodes\\Training - communication

Aggregated: No

Document	3	5	281	5	0	0

Nodes\\Training - Disinterested trainee

Aggregated: No

Document	3	4	277	5	0	0

Nodes\\Training - engaged trainer

Aggregated: No

Document	7	16	880	18	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded

Nodes\\Training - environment

Aggregated: No

Document	3	3	163	3	0	0

Nodes\\Training - evidence based

Aggregated: No

Document	4	4	291	4	0	0

Nodes\\Training - expectations

Aggregated: No

Document	3	5	213	6	0	0

Nodes\\Training - experience

Aggregated: No

Document	7	8	379	8	0	0

Nodes\\Training - extra

Aggregated: No

Document	1	1	37	1	0	0

Nodes\\Training - feedback

Aggregated: No

Document 9	21	1184	21	0	0

Nodes\\Training - Flexible

Aggregated: No

Document 1	4	309	4	0	0

Nodes\\Training - good attitude

Aggregated: No

Document 14	19	984	19	0	0

Nodes\\Training - holistic

Aggregated: No

Document 5	9	588	9	0	0

Nodes\\Training - knowledge

Aggregated: No

Document 10	16	825	17	0	0

Nodes\\Training - LA

Aggregated: No

Document 5	9	525	9	0	0

Nodes\\Training - leader

Aggregated: No

Document 3	3	152	3	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded

Nodes\\Training - learning

Aggregated: No

Document 9	20	1146	20	0	0

Nodes\\Training - learning from others

Aggregated: No

Document 10	24	1332	27	0	0

Nodes\\Training - learning styles

Aggregated: No

Document 6	10	639	10	0	0

Nodes\\Training - objectives

Aggregated: No

Document 3	10	444	10	0	0

Nodes\\Training - operating

Aggregated: No

Document 11	18	882	18	0	0

Nodes\\Training - pace

Aggregated: No

Document 6	8	356	9	0	0

Nodes\\Training - Proactive trainee

Aggregated: No

Document 10	19	1246	21	0	0

Nodes\\Training - progress

Aggregated: No

Document 9	22	1216	23	0	0

Nodes\\Training - rapport

Aggregated: No

Document 4	7	314	8	0	0

Nodes\\Training - relevance

Aggregated: No

Document 3	5	272	6	0	0

Nodes\\Training - repetition

Aggregated: No

Document 4	9	574	9	0	0

Nodes\\Training - structure

Aggregated: No

Document 3	7	348	7	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded

Nodes\\Training - uniform

Aggregated: No

Document 1	1	24	1	0	0

Nodes\\VLE negatives - computer access

Aggregated: No

Document 6	8	536	9	0	0

Nodes\\VLE negatives - learning styles

Aggregated: No

Document 3	15	751	15	0	0

Nodes\\VLE negatives - mandatory

Aggregated: No

Document 2	19	991	23	0	0

Nodes\\VLE negatives - navigation

Aggregated: No

Document 10	19	1009	24	0	0

Nodes\\VLE negatives - not fun

Aggregated: No

Document 4	5	207	6	0	0

Nodes\\VLE negatives - not interactive

Aggregated: No

Document 6	22	1299	24	0	0

Nodes\\VLE negatives - not needed

Aggregated: No

Document 4	5	315	9	0	0

Nodes\\VLE negatives - password

Aggregated: No

Document 8	10	609	10	0	0

Nodes\\VLE negatives - poor communication

Aggregated: No

Document 8	19	1156	27	0	0

Nodes\\VLE negatives - poor trainee engagement

Aggregated: No

Document 11	36	2358	46	0	0

Nodes\\VLE negatives - poor trainer engagement

Aggregated: No

Document 14	43	3147	54	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded

Nodes\\VLE negatives - prefer FTF

Aggregated: No

Document 12	38	2514	42	0	0

Nodes\\VLE negatives - relevance

Aggregated: No

Document 16	50	3359	57	0	0

Nodes\\VLE negatives - slow

Aggregated: No

Document 9	29	2671	37	0	0

Nodes\\VLE negatives - time

Aggregated: No

Document 18	64	4636	75	0	0

Nodes\\VLE positives - relevance

Aggregated: No

Document 11	24	1308	25	0	0

Nodes\\VLE positives - assessment

Aggregated: No

Document 3	5	304	5	0	0

Nodes\\VLE positives - CBD

Aggregated: No

Document 10	18	908	18	0	0

Nodes\\VLE positives - constructivist

Aggregated: No

Document 3	3	202	3	0	0

Nodes\\VLE positives - JSN

Aggregated: No

Document 2	3	135	3	0	0

Nodes\\VLE positives - professional development

Aggregated: No

Document 5	10	569	10	0	0

Nodes\\VLE positives - RSS

Aggregated: No

Document 2	2	81	2	0	0

Nodes\\VLE positives - structure

Aggregated: No

Document 1	4	142	4	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded
Nodes\\VLE positives - unique						
						Aggregated: No
Document	3	4	183	4	0	0
Nodes\\VLE solution - buddy						
						Aggregated: No
Document	1	1	85	1	0	0
Nodes\\VLE solution - communication						
						Aggregated: No
Document	3	7	456	7	0	0
Nodes\\VLE solutions - access						
						Aggregated: No
Document	8	17	1179	17	0	0
Nodes\\VLE solutions - alumni						
						Aggregated: No
Document	1	1	55	1	0	0
Nodes\\VLE solutions - home page						
						Aggregated: No
Document	8	12	868	12	0	0
Nodes\\VLE solutions - interactive						
						Aggregated: No
Document	13	51	3232	58	0	0
Nodes\\VLE solutions - learning						
						Aggregated: No
Document	14	46	3342	51	0	0
Nodes\\VLE solutions - links to teaching						
						Aggregated: No
Document	10	39	2617	39	0	0
Nodes\\VLE solutions - mandatory						
						Aggregated: No
Document	2	9	403	9	0	0
Nodes\\VLE solutions - money						

Aggregated: No

Document	3	10	544	10	0	0

Nodes\\VLE solutions - one site

Aggregated: No

Document	8	24	1280	24	0	0

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded	Proportion Coded

Nodes\\VLE solutions - ongoing cases

Aggregated: No

Document	8	14	980	16	0	0

Nodes\\VLE solutions - other resources

Aggregated: No

Document	10	50	3168	52	0	0

Nodes\\VLE solutions - participation

Aggregated: No

Document	12	28	1843	28	0	0

Nodes\\VLE solutions - professional development

Aggregated: No

Document	5	5	298	5	0	0

Nodes\\VLE solutions - prompts

Aggregated: No

Document	5	6	460	6	0	0

Nodes\\VLE solutions - relevant

Aggregated: No

Document	10	55	3185	56	0	0

Nodes\\VLE solutions - security

Aggregated: No

Document	3	3	178	3	0	0

Nodes\\VLE usage - CBD

Aggregated: No

Document	15	34	2200	40	0	0

Nodes\\VLE usage - factual

Aggregated: No

Document 11	27	1590	36	0	0

Nodes\\VLE usage - journal

Aggregated: No

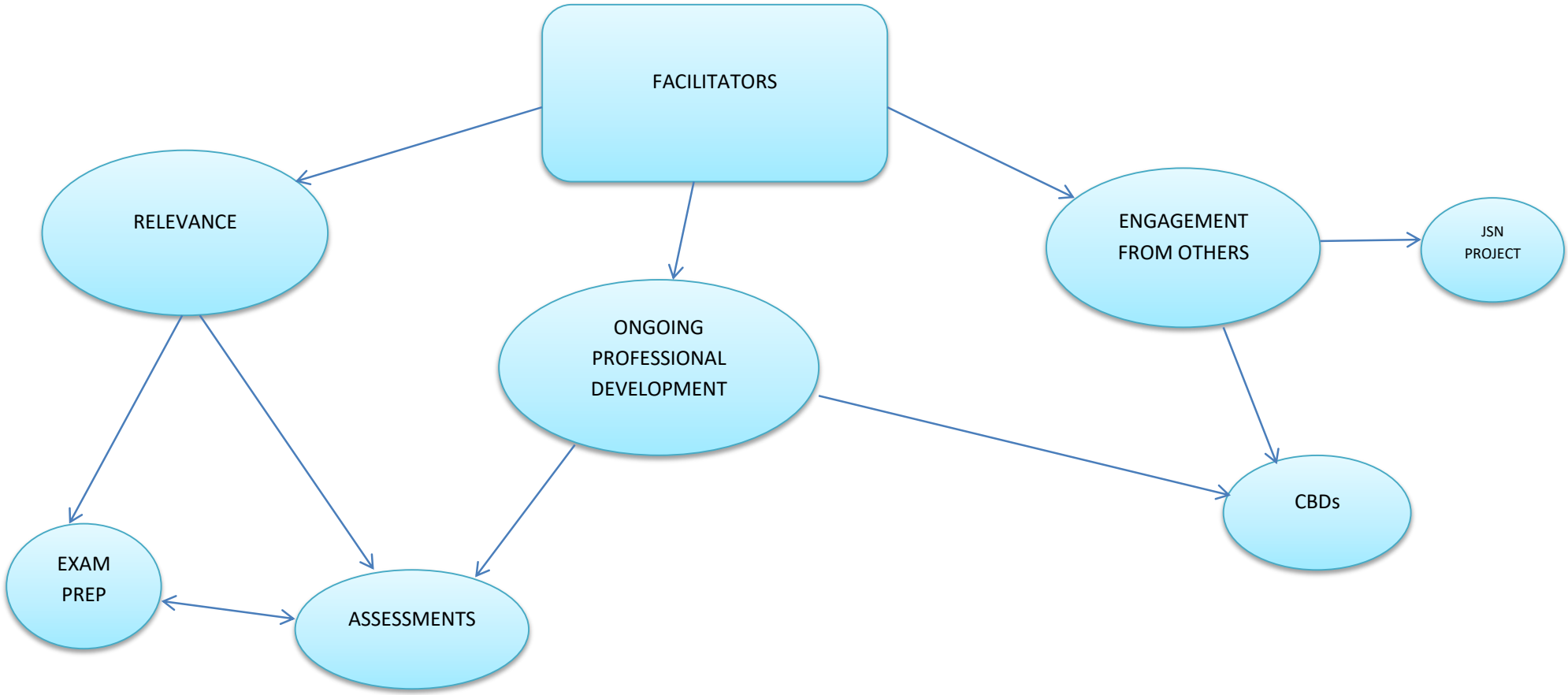
Document 8	16	1189	16	0	0

Nodes\\VLE usage - quizzes

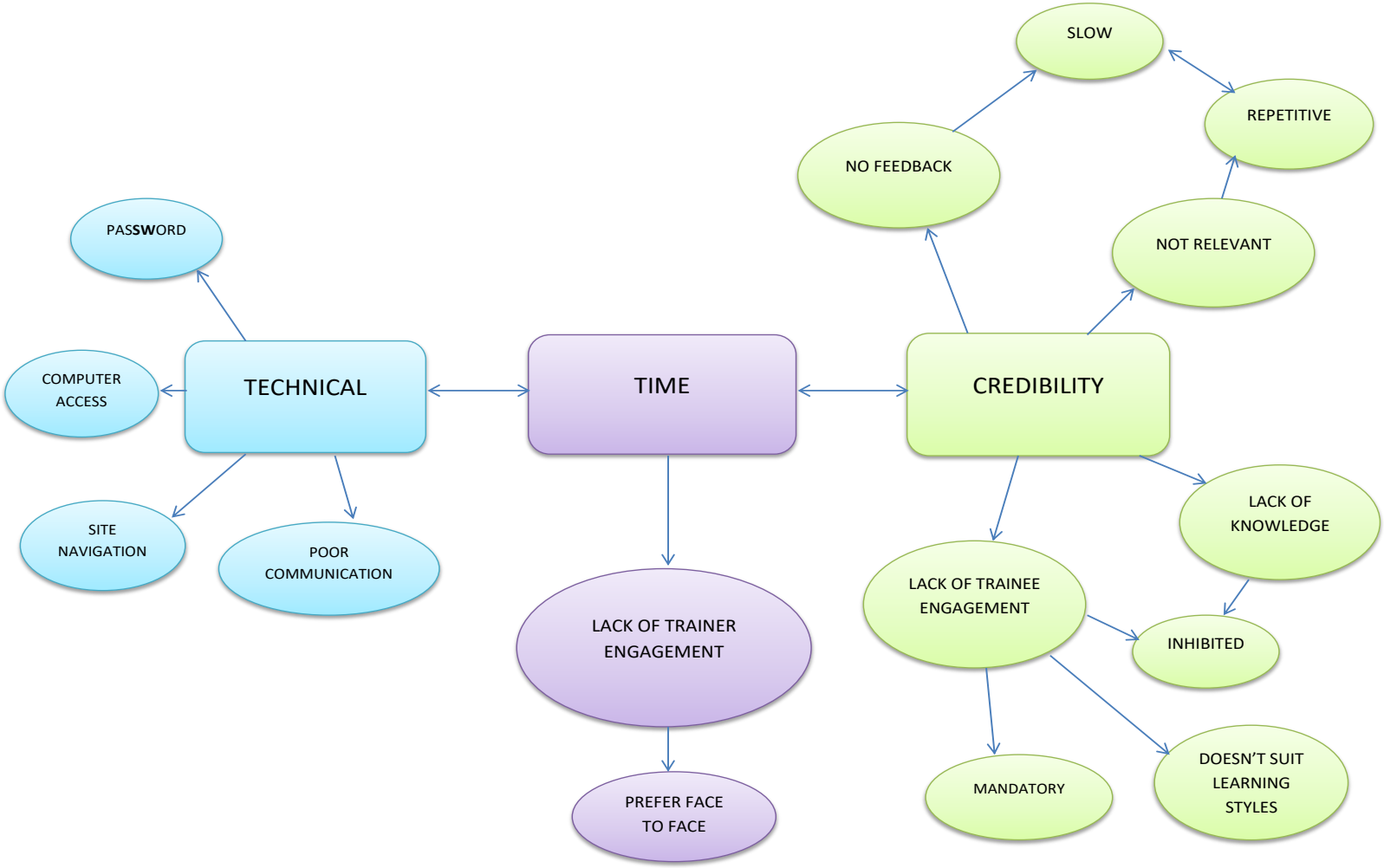
Aggregated: No

Document 3	3	169	3	0	0

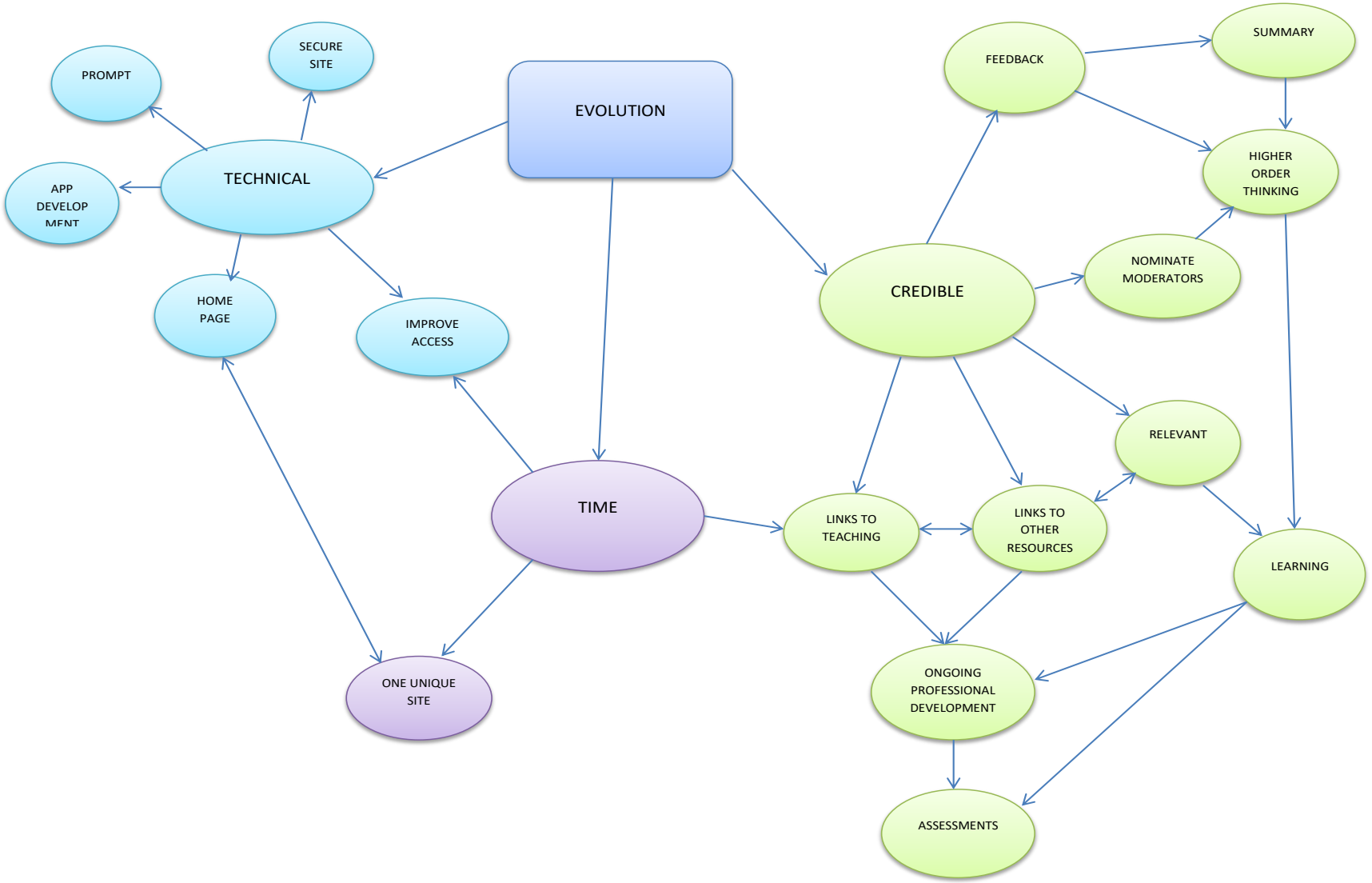
APPENDIX 6: FACILITATORS TO THE USE OF THE VLE



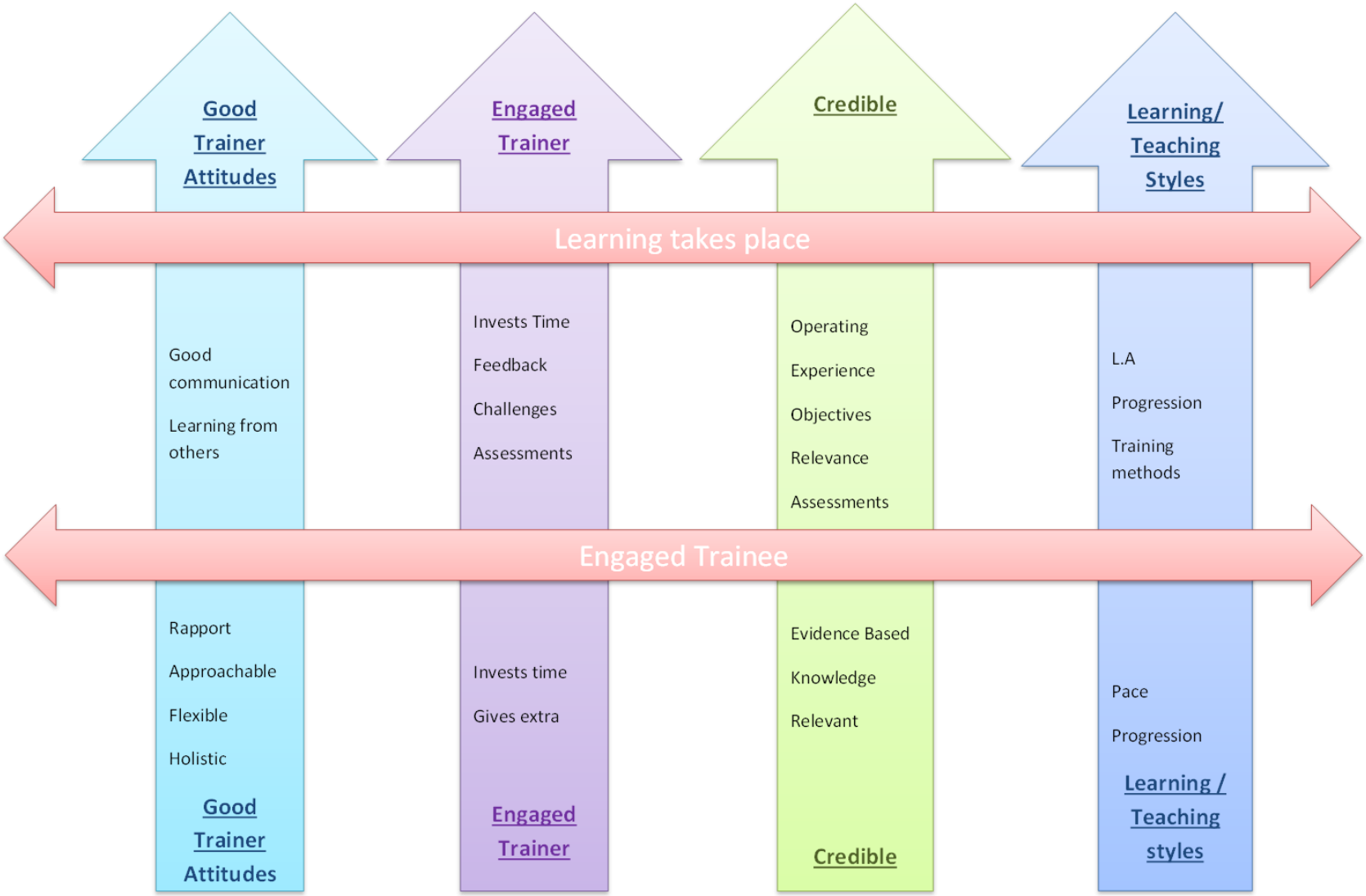
APPENDIX 7: BARRIERS TO USE OF THE VLE



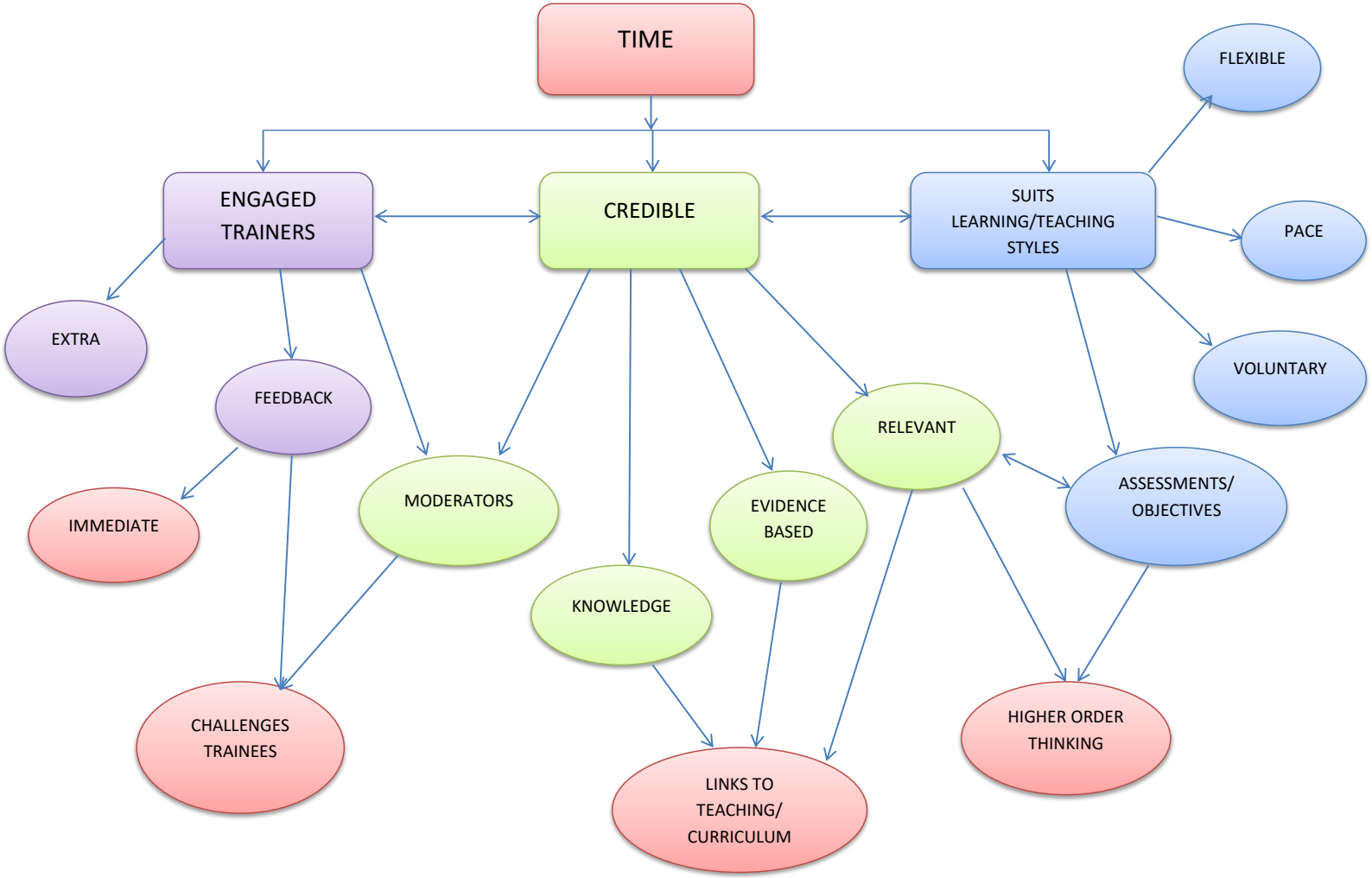
APPENDIX 8 – EVOLUTION OF THE VLE



APPENDIX 9: HOW DO TRAINEES ENGAGE WITH TRAINING?



APPENDIX 10: WHAT MAKES TRAINEES WILLING TO INVEST IN A TRAINING TOOL?



APPENDIX 11 – TRANSCRIPT OF "WELCOME TO ETOOL"

LC: *Hello and welcome to eTOOL; the East Midlands Trauma and Orthopaedic Online Learning resource.*

BB: *Hi, my name is Bhaskar Bhowal; I'm the training programme director for the East Midlands South Trauma and Orthopaedic rotation.*

LC: *I'm Lucy Cutler; the consultant lead for eTOOL.*

JN: *I'm Jenny Nichols*

VR: *I'm Veronica Roberts*

JB: *And I'm Jose Blanco. We are specialty trainees in trauma and Orthopaedics, and are the eTOOL site administrators.*

JN: *We've designed eTOOL to be user friendly, accessible, and to be an evolving set of rich online resources to help you with your study.*

VR: *We'll be encouraging you to participate in this professional community of practice.*

LC: *This site provides a space for consultants and trainees to communicate and collaborate, sharing their knowledge and experience. We hope you find eTOOL an enjoyable and useful site.*

APPENDIX 12 – TRANSCRIPT OF "INTRODUCTION TO ETOOL"

Hello and welcome to eTOOL: the East Midlands Trauma and Orthopaedic Online Learning tool. My name is Jose Blanco, and this video is a short introduction to the system, and your first steps within it. Your use of eTOOL must be approved by the deanery. If you email me, or any of the administrators to the details listed, a username and password can be issued. Typing "East Midlands VLE" into any search engine results in the above web address taking you to the Moodle front page. You can see that you are not presently logged in, but clicking on the hyperlink takes you to the login screen. Entering your username and password gives you user access. eTOOL can be accessed through a series of hyperlinks via the school of surgery, however, we have added a short cut through "my spaces" for Trauma and Orthopaedics. Welcome to the East Midlands Online Learning Tool. You can see a central greeting and information banner; keep an eye out for updates. On the right we have a series of RSS feeds, just updated to include the "Bone and Joint journal", amongst others. On the left of the screen is a navigation bar – clicking on each labelled arrow expands each subheading to make navigating to the information you need easier. Alternatively you can scroll down the screen. All the day to day study leave, educational, rota and timetable information for your rotation is to hand. More resources are being added to aid exam going trainees as well as to facilitate better integrated and focussed research projects. This is the discussion board tab. Please note forum posting rules and a short video guide to netiquette. We have regular discussions enhanced with video, audio and animations on multiple topics, but focussing specifically on the learning outcomes set out in the latest revision of the Trauma and Orthopaedic curriculum. Active contributors have the option of completing a reflective case based discussion with the lead consultant. These include the mandatory critical conditions outlined in the curriculum. Each user has a profile page, which allows them to store documents, add contact details, and more importantly, personalise with their photo, essential to enrich the social aspect of learning. We encourage all users to do this.

The eTOOL is a community of trainees and consultants that can change and evolve. We hope that increasingly it forms a part of your day to day practice of trauma and orthopaedics. Thank you.

Diagnostic Arthroscopy & Simple Arthroscopic Procedures

Arthroscopic Simulator Project

Trainee: [redacted]	Assessor: [redacted]	Date: [redacted]
Start time:	End time:	Duration:
Operation more difficult than usual? Yes / No (If yes, state reason)	Tourniquet Time:	

Score: See Summary Scores

	Competencies and Definitions	Level (see below) 1-4	Comments
I.	**Intra Operative Technique**		
IT1	Follows an agreed, logical sequence or protocol for the procedure (see IT9)		
IT2	Consistently handles tissue well with minimal damage	2	
IT3	Uses instruments appropriately and safely	2	
IT4	Proceeds at appropriate pace with economy of movement	2	
IT5	Anticipates and responds appropriately to variation e.g. anatomy	1	
IT6	Communicates clearly and consistently with the scrub team		
IT7	Clearly identifies common abnormalities such as meniscal and ligamentous tears e.g. the anatomy of the torn meniscus using hooks or probes	1	
IT8	Protects the articular surface	2	
IT9	Identifies and Assesses Patella and Trochlea	2	
	Identifies and Assesses Medial Femoral Condyle	2	
	Identifies and Assesses Medial Tibial Plateau	2	
	Identifies and Assesses Medial Meniscus	2	
	Identifies and Assesses Intercondylar Notch and Anterior Cruciate Ligament	2	
	Identifies and Assesses Lateral Femoral Condyle	1	
	Identifies and Assesses Lateral Tibial Plateau	1	
	Identifies and Assesses Lateral Meniscus	1	
IT10	Checks the final procedure has been completed & Documents appropriately	2	

Summary Score

Level at which completed elements of the PBA were performed		Total Score From Above
Level 1	Unable to perform the procedure under supervision	25/60
Level 2	Able to perform the procedure under supervision	
Level 3	Able to perform the procedure with minimum supervision (would need occasional help)	
Level 4	Competent to perform the procedure unsupervised (could deal with complications)	

Signatures:

Trainee:	Assessor(s):